FURUNO

INSTALLATION MANUAL

MODEL: **WEATHER RADAR**

TYPE: **WR2120**

FURUNO ELECTRIC CO., LTD.

www.furuno.com

⚠ SAFETY INSTRUCTIONS

The operator and installer must read the appropriate safety instructions before attempting to install or operate the equipment.

⚠ DANGER	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	Indicates a potentially hazardous situation which, if not avoided, can result in minor or moderate injury.

Warning, Caution   Prohibitive Action   Mandatory Action

DANGER

Radio Frequency Radiation Hazard

The radar antenna emits the electromagnetic radio frequency (RF) energy which can be harmful, particularly to your eyes. Do not look at the Antenna Unit from a close distance while the radar is in operation, or expose yourself to the transmitting antenna at a close distance.
The distances at which RF radiation levels of 10 W/m ^{2} exist are shown in the table below.
DO NOT approach closer than 9.1m (Safety standard is 10 W/m^2) when radar is transmitting.

NOTE: This value is applied when radar is installed in a public space. Value is defined as on human body surface over a 6-minute period with the flux density averaged from the measurement. Moreover, this measured value is measured by pointing the center of the antenna towards a human. However this is the worst value, definition required by actual regulation is written here as on safe side.

Distance from Antenna	9.1m
Power flux density	10 W/m ^{2}

WARNING

Do not open the radome.
Electrical shock can occur. Only qualified personnel should work inside the equipment.
Turn off the circuit breaker in the JCU if opening the radome is required.

Wear a hard hat and safety belt when mounting the Antenna Unit.
Serious injury or death can result from falls or dropped items while installing or servicing the radar components.

Do not use any other power except 100 to 240 VAC.
Connection of an incorrect power supply can cause fire or damage the equipment.

Turn off the power immediately if water leaks into the equipment or smoke or fire is coming from the equipment.
Failure to turn off the equipment can cause fire or electrical shock.

Do not operate the equipment with wet hands.
Electrical shock can occur.

Do not disassemble or modify the equipment.
Fire or electrical shock can occur.

Use only the specified power cable.
Fire or damage to the equipment can result if a different cable is used.

Use the power supply grounded certainly.
Electrical shock or defect of operation can occur.

When a thunderbolt is expected, do not approach a system or do not touch a hand.
There is a possibility of receiving an electric shock.
A worker's safety is guaranteed however the radar’s internal protection devices only protect against indirect lightning and surges to the radar components. In case of a direct lightning strike these protection devices may not protect radar or surrounding personnel.

Attach securely protective earth to the unit.
The protective earth (grounding) is required to the AC power supply to prevent electrical shock.

⚠ CAUTION

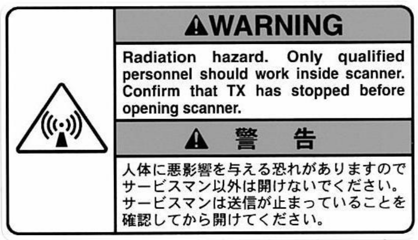
Do not put liquid-filled containers on the top of the equipment.
Fire or electrical shock can occur if a liquid spills into the equipment.

Establish best possible surrounding space for apparatus.
This helps eliminate performance degradation and failure.

Do impact the LCD glass.
Serious injury may occur due to broken glass.

WARNING LABEL

Warning labels are attached to the equipment. Do not remove any label.
If a label is missing or damaged, contact us for the replacement.



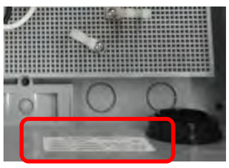
Name: Radiation Warning Label
Type: 03-142-3201-0
Code No.: 100-266-890-10

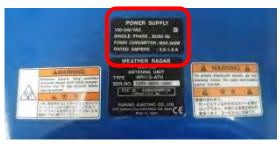
WR2120 restrictions

There are restrictions frequency band as follows to use at Switzerland, Lithuania and Slovakia.
Operate the WR2120 using one of the following four channels:
CH1: 9422.5MHz, CH2: 9427.5MHz, CH3: 9432.5MHz, CH4: 9437.5MHz

POWER SUPPLY LABEL

100-240 VAC
SINGLE PHASE, 50/60 Hz
POWER CONSUMPTION: MAX. 350W
RATED AMPERE: 3.5-2.4A (100-150VAC)
1.8-1.5A (200-240VAC)





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1. SYSTEM SUMMARY

RADAR (Radio Detection and Ranging) developed during World War II as a method to detect the presence of ships and aircraft (the military considered weather targets as noise). Since WWII, there have been many advances in radar technology (e.g., Doppler techniques). It is used on land, sea, and in space for both research and operational needs.

1.1. Type of Radar Bands

There are several different categories according to the wavelength of using on radar in the world. Type of bands are L, S, C, X, and K band.

L band radars: "L" for "long". This band is mostly used for clear air turbulence studies. It operates on 15-30 cm wavelength and a frequency of 1-2 GHz.

S band radars: "S" for "short". It is not easily attenuated and is useful for near and long range weather observation. It operates on 8-15 cm wavelength and a frequency of 2-4 GHz. Some weather services use it on a wavelength of just over 10 cm. The drawback to this band of radar is that it requires a large antenna dish and large, complex motors to power it. It is not uncommon for an S band dish to exceed 7.62 m in diameter.

C band radars: "C" for "compromise". The dish size does not need to as large so it is more affordable for TV stations. It operates on 4-8 cm wavelength and a frequency of 4-8 GHz. It is best used for shorter range weather observation because the signal is more easily attenuated by dry weather and rain. The frequency allows C band radars to create a narrower beam width using a smaller dish. C band radars also do not require as much power as an S band radar.

X band radars: "X" is derived from the XX2 secret band. It uses smaller wavelength, is more sensitive and can detect smaller particles. It operates on 2.5-4 cm wavelength and a frequency of 8-12 GHz. These radars are used for studies of cloud development because they can detect the tiny water particles and also used to detect light precipitation such as snow. X band radars also attenuate very easily so they are used for only shorter range weather observation. Also due to the small size of the radar it can easily transported, like the "Doppler on Wheels" radar. Most commercial airplanes are equipped with X band radar to pick up turbulence and other weather phenomenon.

K band radars: "K" for "kurz (German for short). This band is split down the middle due to a strong absorption line in water vapor and it is similar to the X band but is just more sensitive. It operates on 0.75-1.2 cm or 1.7-2.5 cm wavelength and a corresponding frequency of 27-40 GHz and 12-18 GHz.

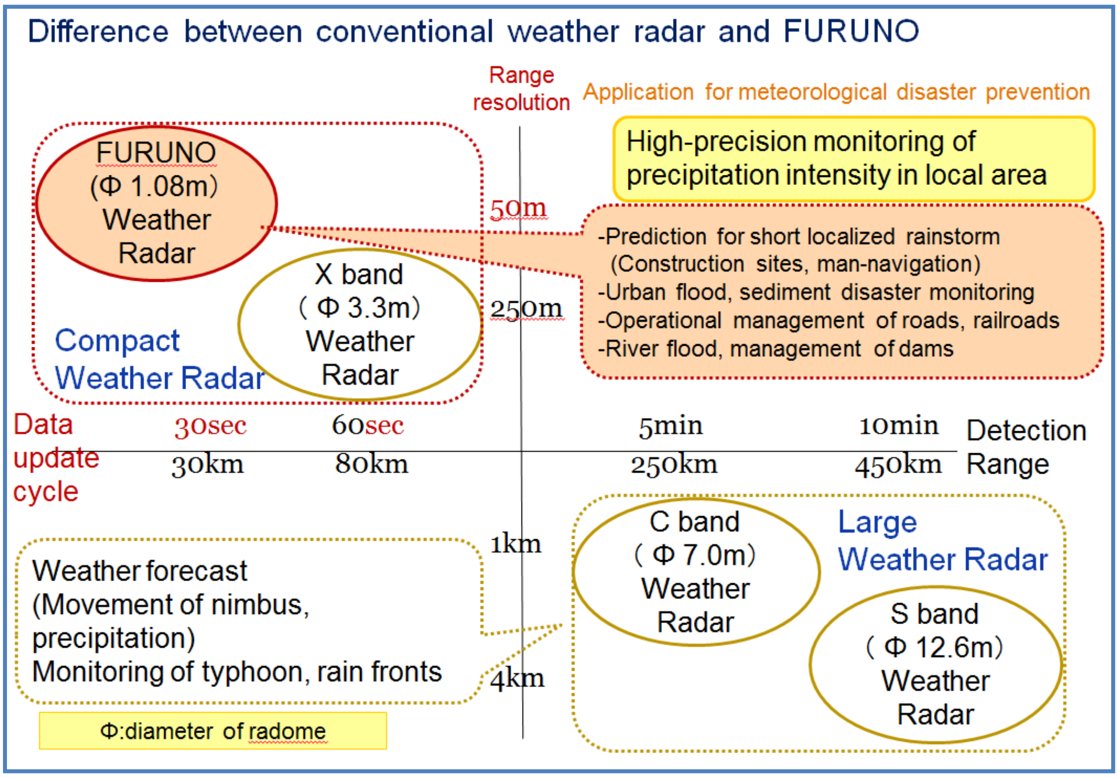
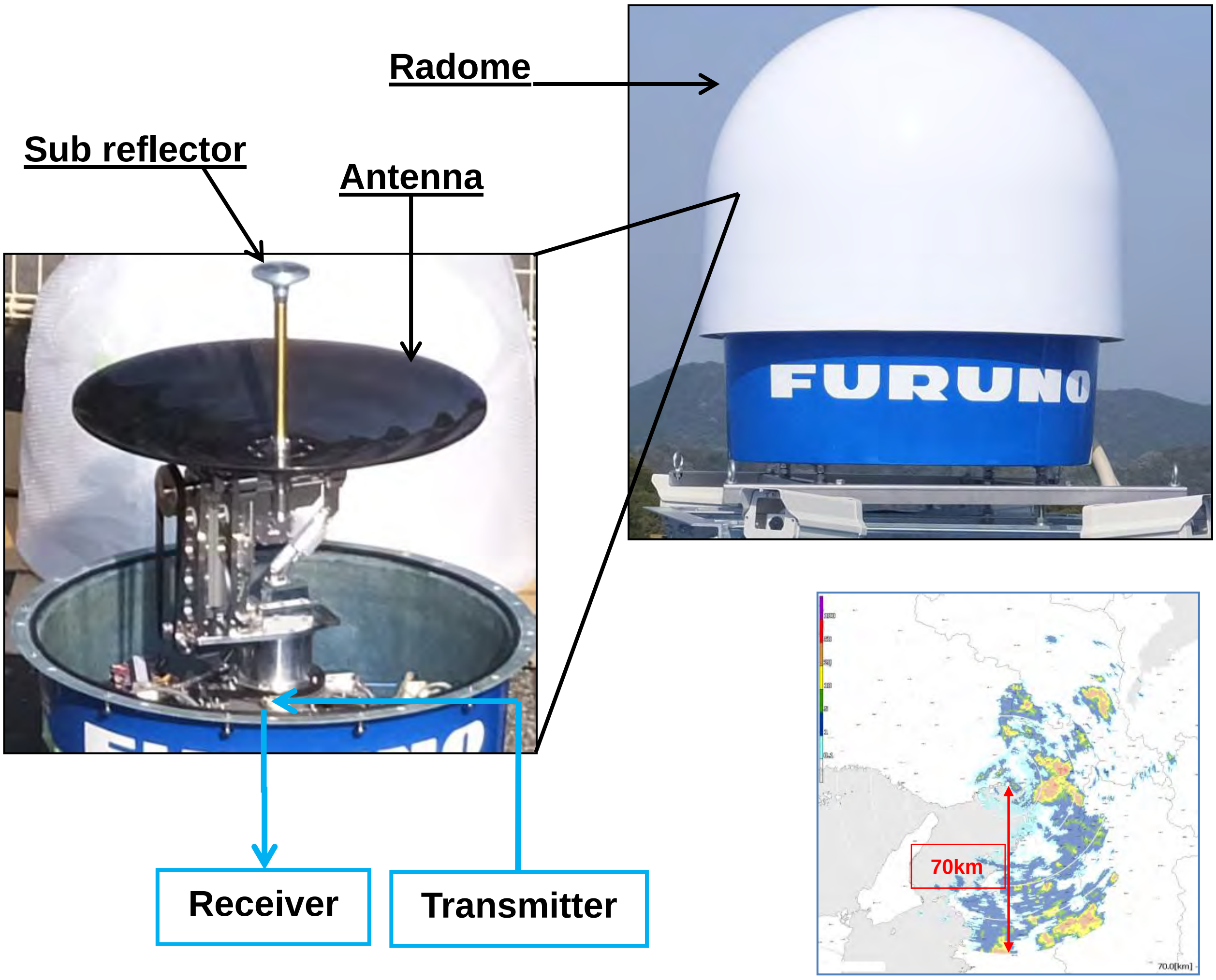


Figure 1.1: 3 general types of weather radar band

1.2. Anatomy of Weather Radar



Antenna: The main purpose of the antenna is to focus the transmitted power into a small pencil beam and also to receive and collect the returned signal.

Radome: Protects the antenna from high winds, dusts, and rain.

Sub reflector: Directs the signal from the transmitter onto the antenna and also directs the return signal from the antenna to the receiver.

Receiver: Detects the signal returned from a target.

Transmitter: Generates the microwave signal at the correct phase and amplitude. For X-band weather radar, the wavelength of the signal is approximately 3cm.

Types of Parabolic antenna -- Wikipedia

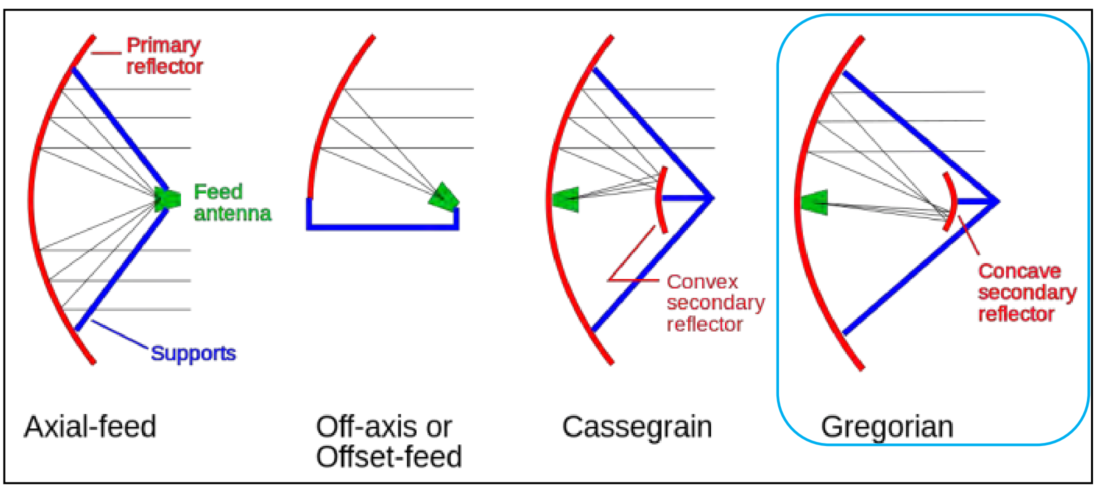
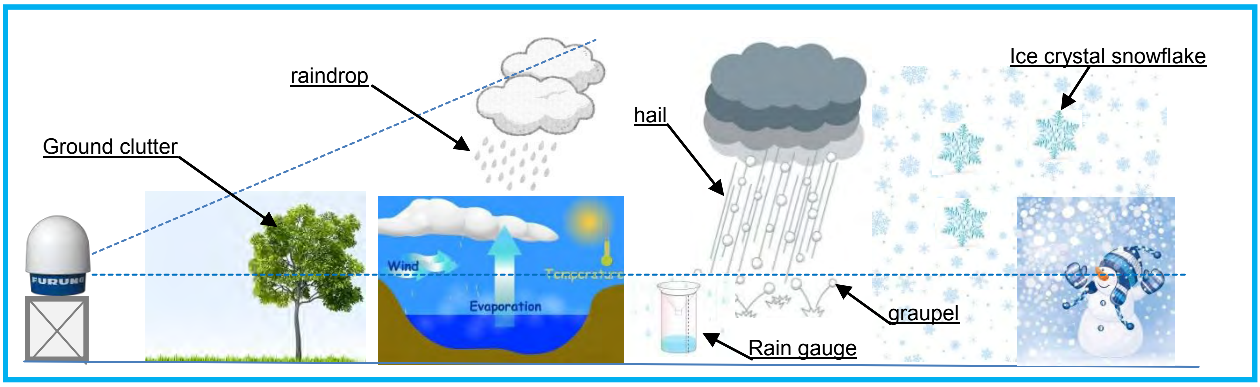


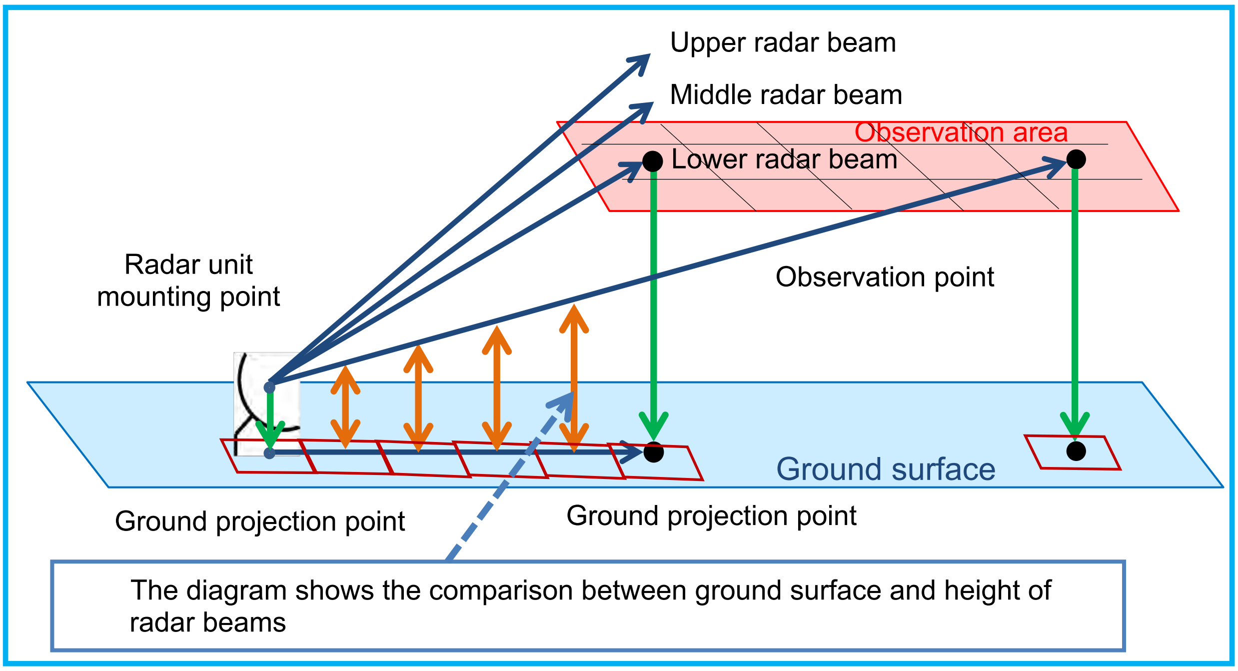
Figure 1.2: Antenna Type

1.3. Mechanical Operation

This system observes the development of rain clouds outputs the intensity of precipitation, the speed of rain clouds (Doppler speed) and observes rainfall phenomena. It is capable of high resolution rain observation, rain cloud, precipitation density and speed observation. The solid-state transmitter replaces previous aging devices such as a magnetron.

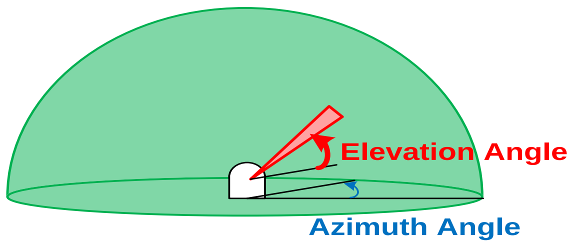


The area sampled by the radar increases with distance. The wider the beam the greater the likelihood of sampling a mixture of precipitation types and also a greater the likelihood of sampled both inside and outside a cloud. Obstacles can also block a portion of the radar beam resulting in an artificially high power return.



NOTE: Required accuracy for leveling

Although 0.4 degrees is an acceptable level, it may cause a 209.4m difference at a 30km distance from radar. For best target accuracy make mount level 0.0 to 0.1 degrees.



1.4. Multi-radar System

The single X-band weather radar can be difficult to avoid problems with blind areas due to buildings, mountains or strong signal extinction by heavy rain.

Furuno provide multi-radar system that consists of three radar systems. While two radar systems are detecting and tracking rain clouds and observing their movements, the other one is working as RHI sector scan mode at high speed and cutting through the clouds to observe their internal structures. It is very difficult to complete signal processing of all the radar systems on single PC because of the CPU performance. Therefore signal processing is distributed among the PC of each radar system, and all the data are gathered on the central PC and composited into one synchronized image.

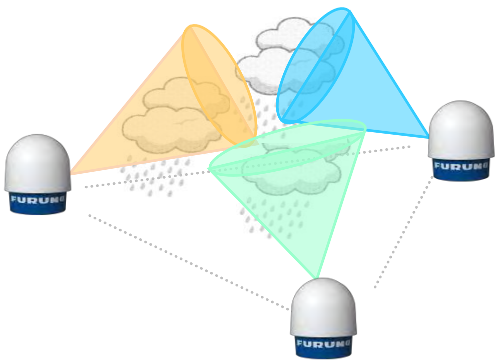


Figure 1.3: Image of using 3 radars

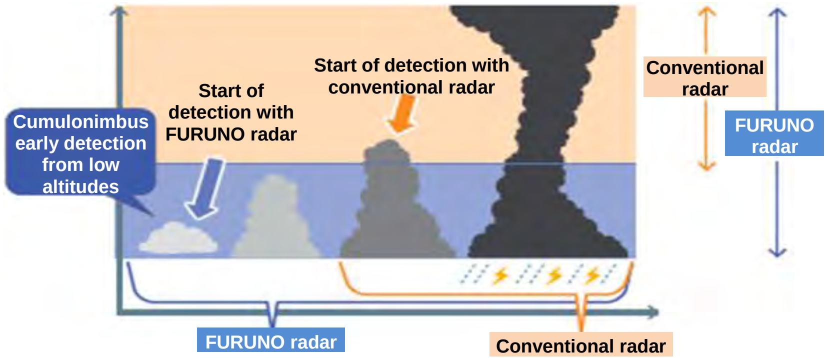


Figure 1.4: FURUNO radar detects cumulonimbus cloud faster than conventional radar

1.5. Side Lobe

The energy radiated from an antenna forms a field having a definite **radiation pattern**. A radiation pattern is a way of plotting the radiated energy from an antenna. This energy is measured at various angles at a constant distance from the antenna. The shape of this pattern depends on the type of antenna used.

To plot this pattern, two different types of graphs, rectangular-and polar-coordinate graphs are used. The **polar-coordinated graph** has proved to be of great use in studying radiation patterns. In the polar-coordinate graph, points are located by projection along a rotating axis (radius) to an intersection with one of several concentric, equally-spaced circles. The polar-coordinate graph of the measured radiation is shown in Figure 1.7.

The **main beam** (or **main lobe**) is the region around the direction of maximum radiation (usually the region that is within 3 dB of the peak of the main beam). The main beam in Figure 1.7 is northbound.

The **side lobes** are smaller beams that are away from the main beam. These side lobes are usually radiation in undesired directions which can never be completely eliminated. The side lobe level (or side lobe ratio) is an important parameter used to characterize radiation patterns. It is the maximum value of the side lobes away from the main beam and is expressed in Decibels. One side lobe is called **back lobe**. This is the portion of radiation pattern that is directed opposing the main beam direction.

The now following graph shows the **rectangular-coordinated graph** for the same source. In the rectangular-coordinate graph, points are located by projection from a pair of stationary, perpendicular axes. The horizontal axis on the rectangular-coordinate graph corresponds to the circles on the polar-coordinate graph. The vertical axis on the rectangular-coordinate graph corresponds to the rotating axis (radius) on the polar-coordinate graph. The measurement scales in the graphs can have linear as well as logarithmic steps.

Beam Width:

The angular range of the antenna pattern in which at least half of the maximum power is still emitted is described as a „Beam With”. Bordering points of this main lobe are therefore the points at which the field strength has fallen in the room around 3 dB regarding the maximum field strength. This angle is then described as beam width or aperture angle or half power (- 3 dB) angle - with notation Θ (also φ). The beam width Θ is exactly the angle between the 2 red marked directions in the upper pictures. The angle Θ can be determined in the horizontal plane (with notation Θ_{AZ}) as well as in the vertical plane (with notation Θ_{EL}).

Main and Side Lobes (Minor Lobes):

The pattern shown in the upper figures has radiation concentrated in several lobes. The radiation intensity in one lobe is considerably stronger than in the other. The strongest lobe is called **main lobe**; the others are (minor) **side lobes**. Since the complex radiation patterns associated with arrays frequently contain several lobes of varying intensity, you should learn to use appropriate terminology. In general, main lobes are those in which the greatest amount of radiation occurs. Side or minor lobes are those in which the radiation intensity is least.

Front-to-Back Ratio:

The front-to-back ratio of an antenna is the proportion of energy radiated in the principal direction of radiation to the energy radiated in the opposite direction. A high front-to-back ratio is desirable because this means that a minimum amount of energy is radiated in the undesired direction.

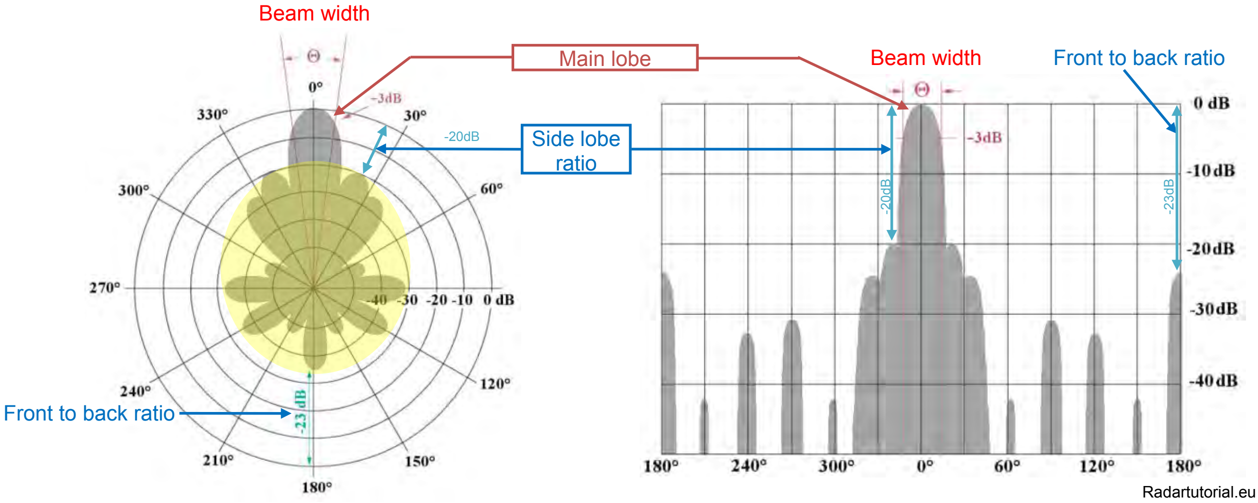


Figure 1.5: Antenna pattern in a polar-coordinate graph

Figure 1.6: The same antenna pattern in a rectangular-coordinate graph

Figure 1.7 shows the high level echo that appears side lobes.

- ➢ Azimuth direction:
  Antenna side lobes show both P0N (unmodulated pulse emission for radars) and Q0N (frequency modulation within each pulse) covered area.
- ➢ Range direction:
  Pulse compression (Range) side lobes show Q0N only. It improves sensitivity of long pulse but increase bling range. However this blind area can recover using un- modulated pulse.

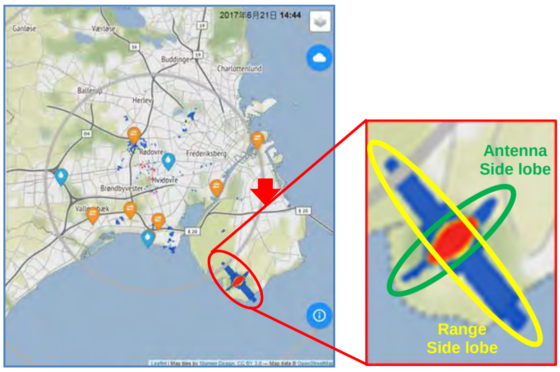


Figure 1.7: High level echo with side lobes

Pulse compression is useful for weather radar to increase the average transmitted power by transmitting a longer pulse but without reducing the range resolution of the radar.

Side lobe suppression is helping to eliminate the problem. For a radar pulse signal after compression, the narrower pulse main lobe is always accompanied by higher side lobes. So, all pulse compression radars suffer from range side lobes which cause energy from strong reflections to leak into adjacent range cells. High suppression of side lobes is not required in some other non-meteorological radar, but is important for meteorological radar because weather phenomena can have significant reflectivity gradients, and ground clutter echo can be much larger than medium rain. Furthermore, the side lobes of strong signal will falsely be recognized as an existence of small target. Therefore, range side lobes must be suppressed by a large amount to prevent contamination in adjacent range cells.

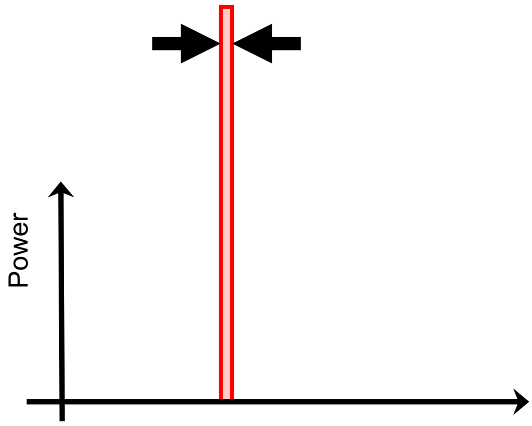


Figure 1.8: Ideal Condition

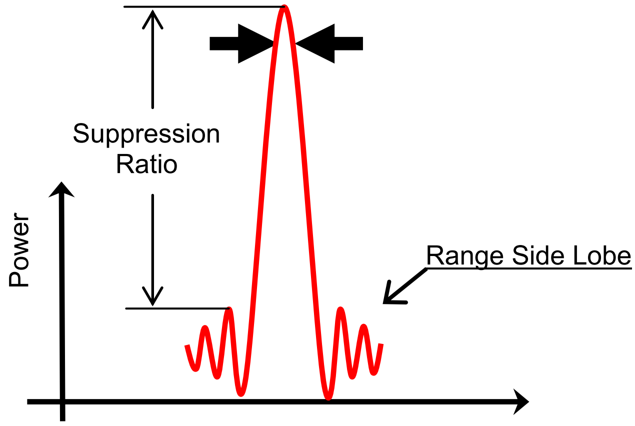
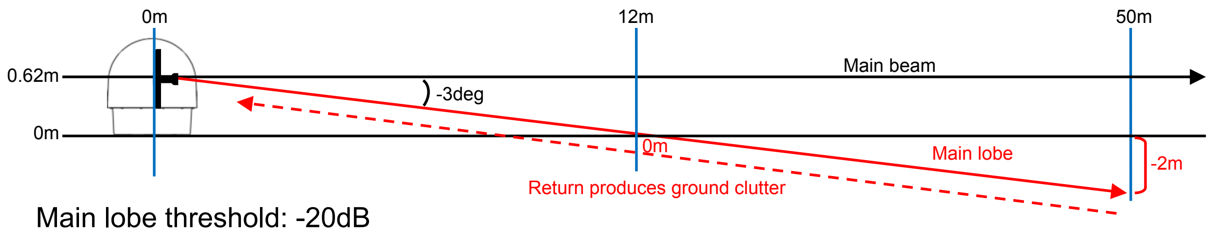


Figure 1.9: Actual Condition



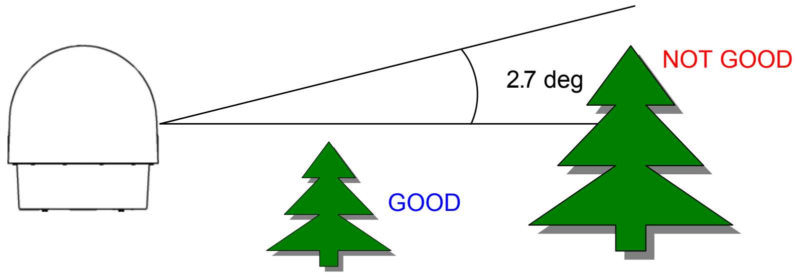
Main lobe threshold: -20dB

Figure 1.10: Distance of main lobe

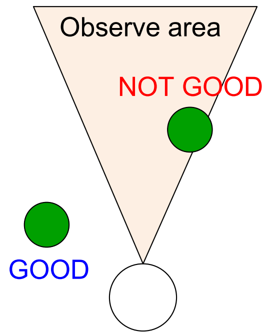
1.6. Location of Radar Installation

1. Confirm the observed region in relation the topography features:

In this example the radar must cover an altitude of 1500 meters maximum and a 70km distance radius within the rainfall forecast area. Therefore there should not be any structures or objects higher than radar around the installation point.



Side view



Top view

2. When installing antenna on building rooftop or a tall tower in urban area.

Mount the radar on the stand or tower, NOTE: it must be higher than any surrounding obstruction (building, structure) for proper radar operation. The tower must be designed strong enough to withstand heavy storms, winds and severe weather conditions.

Also note that a crane or aerial work platform vehicle might be necessary to mount the radar and install the tower. It is important to consider any additional space required for crane operation during installation or repair.

3. Lightning protection and grounding considerations:

Provide a lightning rod near or around the radar area to improve lightning protection performance based on JIS A 4201, JIS Z 9290 and IEC 62305. Refer to APPENDIX A.

The protection systems should include surge protectors/absorbers.

The grounding system will typically consist of an underground grid, radials, or rods which provide a ground resistance of not more than 1 ohm. It should have a connection point at the base of the tower. Refer to APPENDIX A for more detail.

4. Survey antenna surroundings:

Ensure no interference to any surrounding antenna (e.g.: Broadcast, mobile (cell) phone station, radio, BS/CS, etc.) and no obstacles should be around the antenna.

Moreover, secure a service space of 1 m or more around the antenna. In addition, strong reflections can damage the receiver if there are obstacles nearby.

5. Power supply requirements:

Radar needs 100VAC (up to 240VAC), single phase 50/60Hz with GND. The minimum electric current must be installed for voltage used, 100V is 10A, and 240V is 4.2A.

6. Telecommunication line and internet requirements:

Use telecommunication line for transferring weather observation data and operating the radar by remote. The minimum require continuous speed to transfer all data in real time is 8 Mbps or faster. A wireless network may have enough speed for just operating the system but we recommend you to use a fast speed network like a fiber optic network when possible.

7. Building/ground structure:

The installed location of the radar must have proper load bearing resistance and durability to support a tower or stand. However a structural plan from a professional architect and any required permits may still be required for building or ground installation of the radar tower/mount.

8. Human health considerations:

Build the radar stand at least 2 meters high if the radar is installed where people have easy access to radar. A sign board must also be placed at the entrance or ladder at radar access point.

9. Heating and cooling system:

Air conditioning is necessary to keep temperature stability for the room/cabinet (rack) of DPU.

10. Pseudo echo:

Set the sector blank to the obstacle direction nearby. When transmitting in the direction of the obstacle, some pseudo echoes will be indicated due to reflections, therefore set the sector blank until the pseudo echo disappear.

Note: DO NOT look at the antenna closer than noted below while radar is in operation. This energy can be extremely damaging to the human body, especially the eyes. Furthermore **DO NOT** points the antenna at any individuals closer than noted below while transmitting.

* As shown in Installation manual preface warnings (Table on page i, Radio Frequency Radiation Hazard), the danger distance of transmit radio wave is set to $10W/m^2$ value for safe standard, therefore do not go closer than 9.1m to the radar.

1.7. Radar System Certificate

Most countries by law have specific certificates for operating radar as a radio station. The radar frequency is in a shared radio spectrum with many other radio services, providing functions ranging from air traffic control to amateur radio operations. Although the radio frequency spectrum is not a physical resource, the use of a frequency at a given location usually precludes that same frequency from being used by others in the same geographic area. This need to have exclusive geographic use to prevent harmful interference has led to the current spectrum regulations and established spectrum use rules. Such rules grant licenses for spectrum use, and partitioning of spectrum for shared use between radio services.

These certifications are approved by the Ministry of Internal Affairs and Communications (Japan), Federal Communications Commission (USA), or other agencies of the specific country. It is important to apply when deciding the radar location because it will take time to get certification approval. It sometimes takes up to a year.

1.8. Requirement of Calibration

Calibration is the activity of checking or measuring and comparing with a specific standard reference instrument. It may also include adjustment of the system to bring it into alignment with the standard.

1.9. Peripheral Devices

- External HDD (Hard Disk Drive): Useful for saving large amounts of data. Use USB3.0 device type to transfer the data at high speed. Recommendations include using a 6TB storage device to save around one half years data (compressed).
- UPS (Uninterrupted Power Supply): Avoid risk of DPU crash by instantaneous power failure due to electric power company trouble, facility power or natural disaster such as thunderstorms. When possible use an outlet ON/OFF type selection device that allows individual device power to be set ON or OFF remotely via the internet.

Sample images:

2. SPECIFICATIONS

2.1. Antenna Unit

Parameter	Descriptions	Remarks
Unit name	WR2120-ATU	
Operating Frequency	9.4 GHz band	Carrier Frequency
Maximum range	70km	Displayable observation level : 70km
Doppler measurement	Max. ±64m/sec	
Power supply	100 to 240VAC, Single Phase, 50/60 Hz	
Power consumption	Below 250W	Max. 350W
Rated Ampere	1.5 to 3.5A	
Size	Φ980mm×H1068mm	Radome size
Weight	68kg (149.9 lb)	Weight of radome only: Upper 15kg, Bottom 11kg(incl. 12pcs of M10x35 stopper hexagon bolt) Weight of radar only: 42kg
Operating Temperature	-10 to +50 °C	Humidity 93% without condensation
Storage Temperature	-40 to +70°C	
Water & Dust proof	IP55	
Maximum wind survival	90 m/sec	
Occupied Band Width	Below 6 MHz	
Type of Emission	P0N, Q0N, V0N	
Amplifier	Solid state module	
Peak Power	100 W	each Horizontal and Vertical
Duty Ratio	Up to 10 %	
Pulse Width	Below 50μs	
Pulse Repetition Frequency	Below 2000 Hz	
Frequency Shift	Below 4 MHz	Except P0N
Antenna Type	Gregorian	Refer to Figure 2.1
Aperture Size	Φ750 mm	
Antenna Gain	more than 33.0 dBi	
Antenna Polarity	Dual polarimetric	Horizontal, Vertical
Beam Width	2.7 degree	Pencil beam
AZ Rotation Speed	0.5 to 16 rpm	Adjustable
Horizontal Scan Angle	360 degrees	Continuously-rotating
Vertical Scan Angle	-2 to 182 degrees	Adjustable
Resolution of Angle	0.1 degrees	
Precision of Angle	0.2 degrees	

*1 P0N : Sequence of pulses without modulation.
*2 Q0N : Sequence of pulses, frequency modulation within each pulse.
*3 V0N : Combination of P0N and Q0N.

2.2. Signal Processing Unit

Parameter	Descriptions	Remarks
Unit name	WR2120-SPU	
Data Output[*1]	Rainfall intensity R (mm/h), Reflectivity factor Zh (dBZ), Doppler velocity V (m/s), Doppler velocity spectrum width W (m/s), Cross polarization difference phase φdp (deg), Specific differential phase KDP (deg/km), Co-poral correlation coefficient ρHV, Differential reflectivity ZDR	
Scan modes	PPI, Volume scan, PPI/RHI (Sector Scan also availiable)	
Ground clutter Rejection	Enable	
Data Correction	Distance attenuation, Rain attenuation, Excessive Doppler velocity, Suppression of signal returns from lan, Clutter suppression	
Interface	LAN 1 port, Ethernet 1000 Base-T (Cat5e or more)	
Power supply	100 to 240VAC, Single Phase, 50/60 Hz	
Power consumption	Max. 650W include Antenna Unit	
Rated Ampere	2.7 to 6.5A	
Size	W756mm×D300mm×H750mm	
Weight	50kg (111lb)	
Operating Temperature range	-10 to +50°C	
Storage Temperature range	-20 to +60°C	
Water & Dust proof	IPX5	

[*1]: Detail of processing by the main unit.

2.3. Data Processing Unit

Receive data from Antenna Unit (ATU) to indicate a picture of rainfall in real time.

Hardware	
Parameter	**Descriptions**
Unit name	WR2120-DPU
Power supply	100t to 125VAC, 50/60Hz **Note:** Bundled AC power cable (Socket IEC C13 / Plug type B) is only for US and Japan. Do not use the bundled cable in other area, it may cause fire or damage the equipment. Please prepare AC cable by user to fit the site.
Power Voltage	100-240VAC
Power consumption	Max. 150W
Rated Ampere	0.8 to 2.0A
OS	Windows 10 IoT Enterprise 64bit
Internal LAN	2 port, 1000base-T
I/O	USB3.0×6 port
Size	W205 x D227x H88 (mm), Power supply unit: W141 x D193x H91 (mm)
Weight	2.5kg
Temp. range	0 to +50 °C
LAN Adapter	1000base-T adapter
Display Software	
For weather observation system	
Name	RainMap, RainPlay
Data indication	Rainfall intensity R (mm/h), Reflectivity factor Zh (dBZ), Doppler velocity V (m/s), Doppler velocity spectrum width W (m/s),
Status display	Indicate ATU and DPU status
File output	Save and output one scan period of data
For remote maintenance	
Name	TeamViewer GmbH
Version	TeamViewer Host (For remote server) 12
Function	Remotely operate the software, view and download the observation data.
Requirement	It must be connecting to internet

Notice of the data communication:

Condition of the data communication (Transfer efficiency: 50%)

Baud rate	Cycle (Data transmission possibilities)
1Mbps/min or more	4 elevations/ 5min.
4Mbps/min or more	2 elevations/ 1min.
8Mbps/min or more	4 elevations / 1min.

2.4. Accessories

Cables & Tube
Antenna Unit (radome) --- Signal Processing Unit

Items	Descriptions	Length	Qty
LAN cable	100Base-T (STP Cat5e or better), Length depends on measure value. Incl. LAN connector w/ cover	5m(*1)	2
AC Power cable	Shielded VCTF 2sq 3core or equivalent Incl. crimped Terminal	5m(*1)	1
Control cable	26pin cable (Both HDR-26pin)	5m(*1)	1
Control cable	14pin cable (Both HDR-14pin)	5m(*1)	1
Signal cable	3D-2W (Both SMA-P Connector)	5m(*1)	3
Protective tube	Protective tube conduit Inner diameter : 28 mm, IP65	10m(*2)	1
Box connector	IP65(Water/Dust proof) φ28	-	4

Accessories for installation (Fixed radome and stand)

Items	Descriptions	Qty
Security Lock	For SPU box with keyx2	1
M16 Hex Nut	Material : SUS304	12
M16 Flat Washer	Material : SUS304	12
M16 Split Lock Washer	Material : SUS304	8
M16x200mm Hexagon Bolt	Material : SUS304	4
M16 Large Flat Washer	Material : SUS304	4
M16x40mm High Nut	Material : SUS304	4
Lifting Tool	Material : SUS304	4
PXI Philips Screwdriver #1		1
SMA torque wrench	7mm	1

Accessories for maintenance

Items	Descriptions	Qty
Maintenance tool box	Size: L410x150x100 [mm]	1
M10 x400 Maintenance bolt	Holding the radome cover up above in order to access inside the radome when maintenance	8
M10 Hex nut	Fix the length of maintenance bold for lifting up the radome	8
Spring clamp	Holding the radome cover up above in order to access inside the radome when maintenance	8
Handle	Lifting radar out/in from radome	4

*1) Basic length of cable between ATU and SPU is 5m, NOTE: there are 10m, 15m and 20m options. These cables have extra length for inside equipment. (e.g.: 5m cable = 5m + approx.2m)
*2) Cut the tube into two pieces to adjust a length between ATU and SPU.
Note: For tower radar installations this depends on the overall installation environment and consultation will be necessary.

Figure 2.1: Maintenance tool

2.5. Construction Material list (Local contractor/client supply)

Cables & Tube
Signal Processing Unit --- Data Processing Unit

Items	Descriptions	Length	Qty
LAN cable	1000Base-T (STP Cat5e or better), Length depends on measure value. Incl. LAN connector w/ cover	by measure	2
AC power cable	Shielded VCTF 2sq 3core or equivalent. Incl. crimped Terminal	by measure	1
Protective tube	PF tube conduit Inner diameter: φ28 mm, IP55 (Water/Dust proof) or better	by measure	1
Box connector	IP65(Water/Dust proof) φ28	-	2

Basic expendable supplies

Items	Descriptions	Qty
Heavy Duty Cable Tie (2 types)	Nylon 6/6 w/ weather resistance 100mm, 150mm	Multi
Crimp terminal 2sq	φ4.3 for electric cable	Multi
LAN connector	RJ45 for LAN cable	Multi
Power cable 3 cores	For electric supply	Multi
LAN cable	1000Base-T, CAT5e or better, STP	Multi

Basic construction tools

Items	Descriptions
Hex key (Ball-head type)	M4 (3mm)
Ratcheting Wrench	M5 (8mm), M12 (19mm), M16 (24mm), Adjustable wrenches (up to 30mm)
Socket Wrench	M10 (17mm) for fixing radome top/bottom
Exclusive Philips Screwdriver #1	Multiuse
Philips Screwdriver #2	Multiuse
Slotted Screwdriver 3mm	Multiuse
Cable/Wire cutting scissors	Multiuse
Flat nippers	Multiuse
Wire Strippers	For electric wiring work
Ratchet Wire Crimper 2sq	For electric wiring work
LAN cable strippers	For LAN cable work
LAN Ratchet Crimper	For LAN cable work
LAN cable tester	For LAN cable work

3. PRIOR CONFIRMATION

3.1. Confirmation Items

1) The mount plate must be installed properly for Antenna Unit (radome).
2) Power cable (AC100V-240V) must be routed safely.
3) Power cable gauge should be selected depending on its length.
4) Frequency of AC power source must be 50Hz or 60Hz sine wave and single-phase current.
5) All engineers must wear safety appliances including helmet and safety shoes during an installation of Antenna Unit. It is dangerous that antenna could hit an individual by turning.
6) Secure a service space of 1 m or more around the radome. In addition, strong reflections can damage the receiver if there are obstacles nearby.
7) Set the sector blank to the obstacle direction nearby. When transmitting in the direction of the obstacle, some pseudo echoes will be indicated due to reflections, therefore set the sector blank until the pseudo echo disappear.

Note: **DO NOT** look at the antenna closer than noted below while radar is in operation. This energy can be extremely damaging to the human body, especially the eyes. Furthermore **DO NOT** points the antenna at any individuals closer than noted below while transmitting.

* As shown in Installation manual preface warnings (Table on page i, Radio Frequency Radiation Hazard), the danger distance of transmit radio wave is set to 10W/m^2 value for safe standard, therefore do not go closer than 9.1m to the radar.

3.2. Power Equipment

1) This equipment requires 1KVA x1 power line with grounded outlet (3 pin type).
2) The AC power cable attached to the DPU power supply is shipped with items conforming to the PSE standard (Japan) and UL standard (US). Please prepare the power cable according to the safety standards of the area to be equipped on the customer side.

3.3. Measurements

Notice: Measure the main AC power before powering on the radar.

Items	Descriptions			Remarks
Digital Multimeter	Voltage AC : 85 to 240V DC : 1 to 50V	Current AC : 1 to 10 A DC : 1mA to 1A	Resistor 0.1 to 10M ohm	Tester Lead Cables

3.4. LAN Equipment

1) Use Cat5e (or better grade) of 100Base-Tx LAN cable for transferring data from the Data Processing Unit to the output equipment.
2) Prepare a high speed broadband connection (approx.100Mbps) for remote maintenance access.
   *Low speed broadband may cause slow access on remote support system.

3.5. Peripherals Equipment

It has to be prepared by the local contractor or client supply.

1. Wired router

Router is using for internet purposes.

Function	Connect with an external network
WAN port	1000BASE-T, 1 port, MDI/MDI-X auto switch
LAN port	1000BASE-T, 4 port or more, MDI/MDI-X auto switch
Input voltage	AC100V-240V, Single phase, 50/60 Hz
Remarks	YAMAHA RTX810 or equivalent

2. SW HUB

Switching hub is for expanding network to several devices purpose.

Function	Connect with LAN
LAN port	1000BASE-T, 5 port or more, MDI/MDI-X auto switch
Input voltage	AC100-240V, Single phase, 50/60 Hz
Remarks	ELECOM EHC-G05MN-HJ or equivalent

3. Uninterrupted Power Supply

It provides enough power to keep the system running for few minutes when instantaneous voltage occurs and it will automatically shut down the pc safely. Some UPS can support by remote network.

Function	Connecting with all devices to keep the power safe.
Output voltage	More than 1,000VA
Input voltage	AC100-240V, Single phase, 50/60 Hz
Remarks	APC Smart-UPS series w/ network, Tripp Lite Smart 1000RMXL2U (AC83-147V) / SMX1000RT2U (AC182-278V) or equivalent

4. External data storage device

It is a purpose for saving more data.

Function	Save scan data
Capacity	3TB or more
Interface	USB3.0 (Note: Plug in USB3.0 cable in to the USB3.0 port of DPU)
Input voltage	AC100-240V, Single phase, 50/60 Hz
Remarks	WD 3TB or equivalent Note: Disable automatic sleep function (also called ECO mode). It is unsuitable for weather radar and will cause data loss. This is because is sleep mode initiates between data transfer intervals data will not transfer. Also the DPU cannot wake storage device from sleep mode. DPU would require restart before storage device will recover from sleep mode.

Please refer to UPS, Router, and other equipment documents separately.

4. PRECAUTIONARY ITEM

1) Use only single phase 100-240VAC commercial power supply.
2) DO NOT overhaul or modify.
3) DO NOT work on during electrical storm.
4) DO NOT scratch, cut, forcedly bend, pull, twist, bundle, or damage the power cable. Also do not put heavy items on top or around.
5) DO NOT touch inside equipment with a wet hand.
6) Connect ground conductor for equipment protection and electric shock prevention from lightning induction and ground leakage.
7) Cleaning instructions: Use dry soft cloth to wipe the surface. If it is difficult to remove stains use the cloth soak with a neutral detergent to clean surfaces. Please DO NOT use an alcohol or an organic solvent (e.g.: thinner) to clean surfaces.
8) When install the radar stand, level of stand should be within ±0.2 degrees.

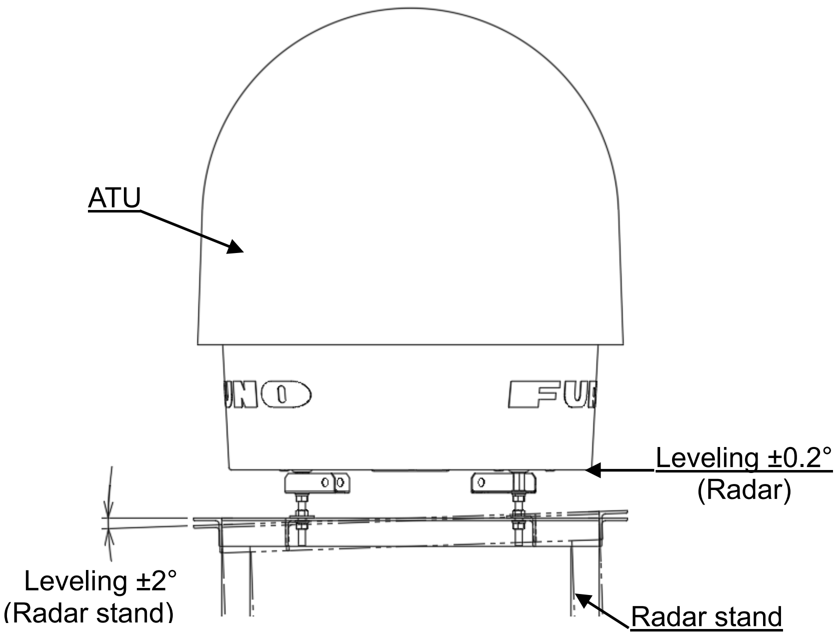


Figure 4.1

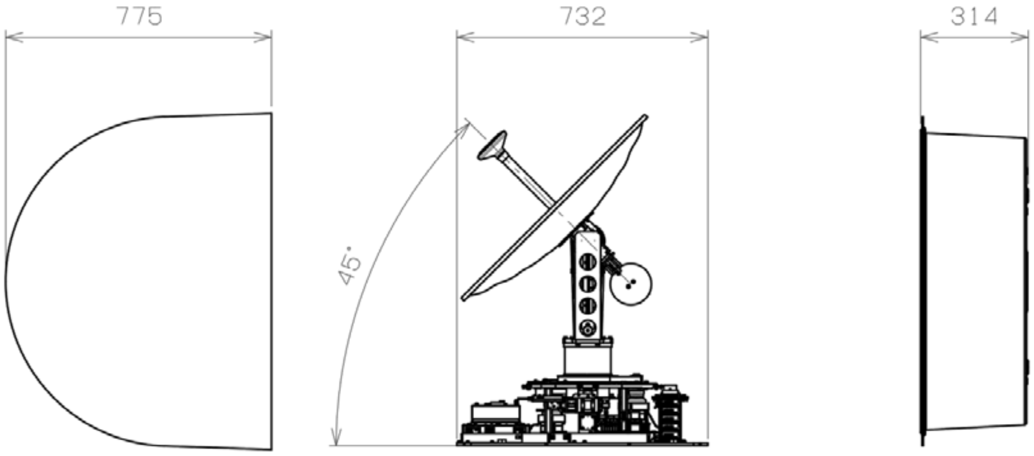
5. CONSTRUCTION

During the environmental survey all installation places for DPU, cables, pipes, and mounting plate should be carefully considered.

5.1. Antenna Unit

This radar can be divided into 3 parts as shown below.

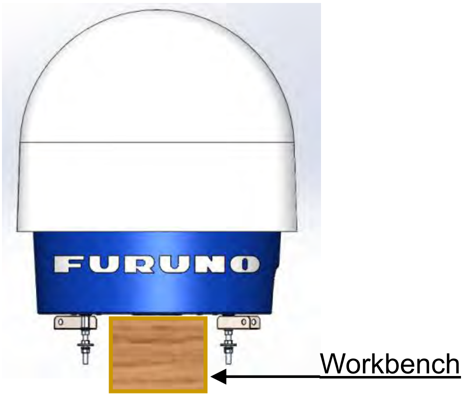
[mm]



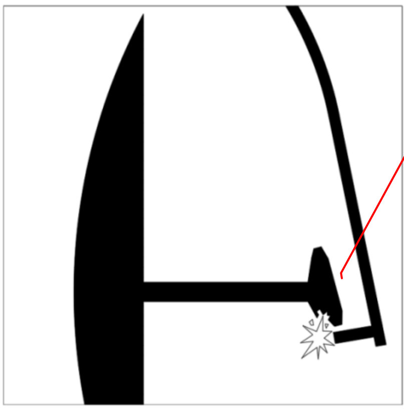
Top part of radome | Internal unit | Base of radome

5.1.1. Method to divide the unit

1) Put antenna unit on a workbench

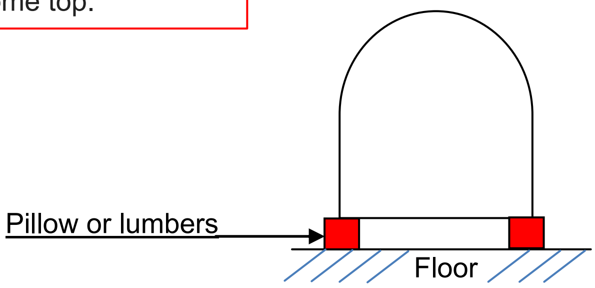


Loosen the 12, M10 bolts around the radome and remove the top part of the radome.
Lift up the top part of radome high enough to check the position of antenna. Because the antenna may hit the flange inside the top part of radome, change the position of the antenna feed arm upward if it is facing horizontally.
Use some pillows or lumber under the bottom edge of the radome top that will make easier to put hands under radome when lifting up. Do not place directly on the floor or it will be hard to lift up without space under the radome.

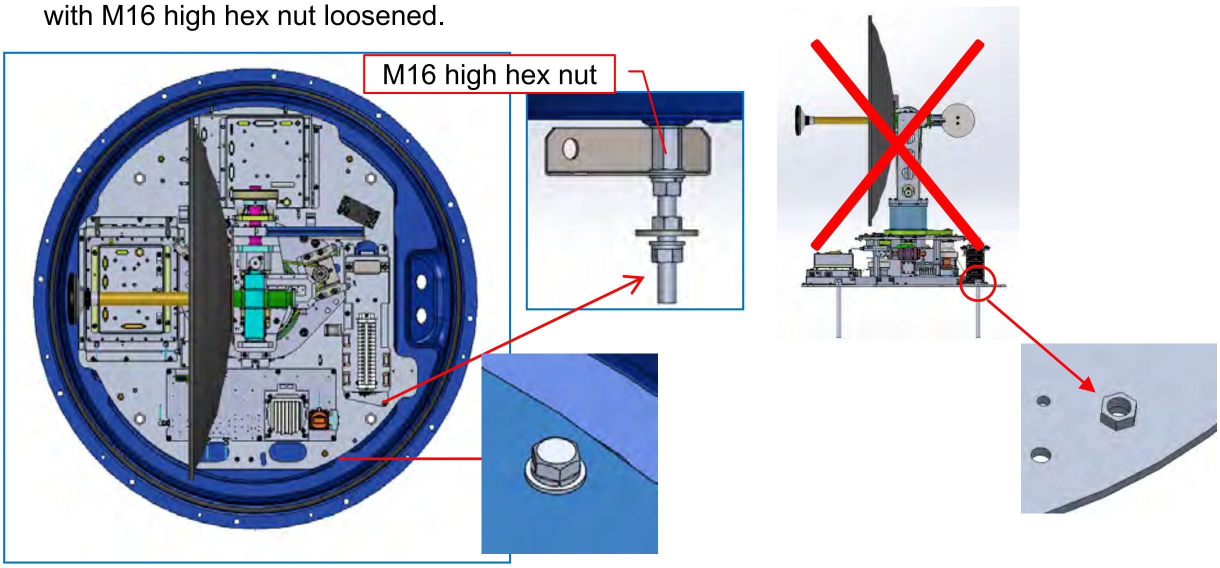


Antenna

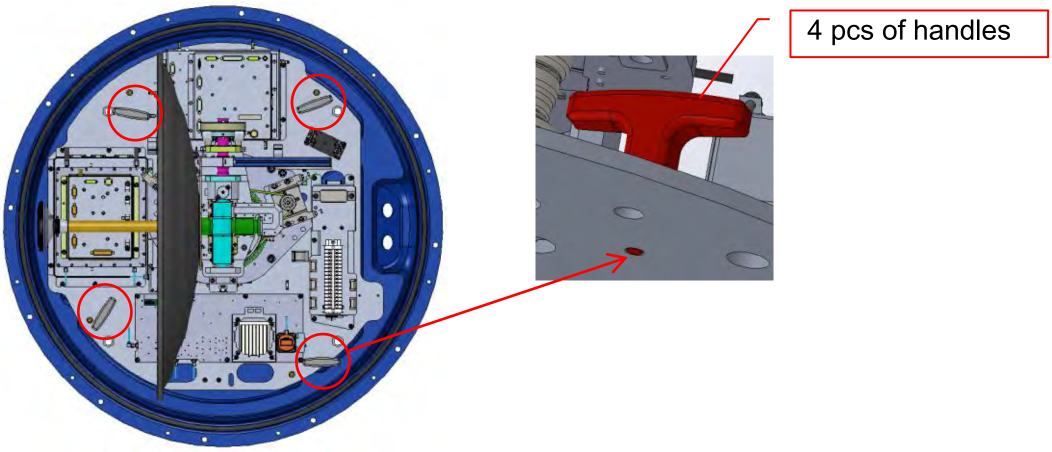
Caution: Move antenna to position feed arm vertically to ensure no contact when lifting radome top.



2) Remove internal unit from the base of radome by completely removing M8 hexagon head bolts and M16 hexagon head bolt set. The internal unit will get damaged if placed directly on the floor without removing the M16 hexagon head bolts. It may also damage them if placed on the floor with M16 high hex nut loosened.

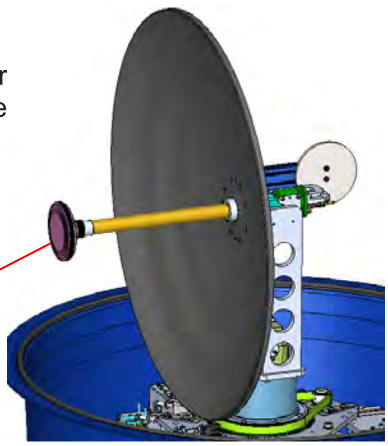


3) Mount 4 handles in the internal unit. Insert the handles until it hits to the bottom for not to come off when lifting unit. **Note**: Turn too much handles may damage radome base.



4) Hold handles to lift up the internal unit.

Note: Beware the antenna feed arm can easy to damage or break. Any deformation of the antenna arm can cause functional issues and degrade antenna performance.

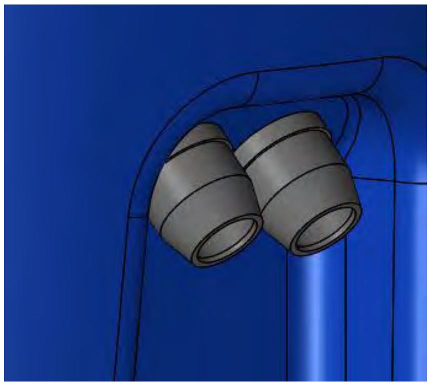


5) Follow the steps 1 to 4 in the reverse order to reinstate equipment to the original configuration. Beware to the following points:

- Do not remove handles during step 3.
- M16 high hex nut should be tightened in step 2.
  It may damage the internal unit if M16 high hex nut is not tightened when reinstalled.
- Do not damage the antenna feed arm when covering the radome in step 1.

5.1.2. Method of transport

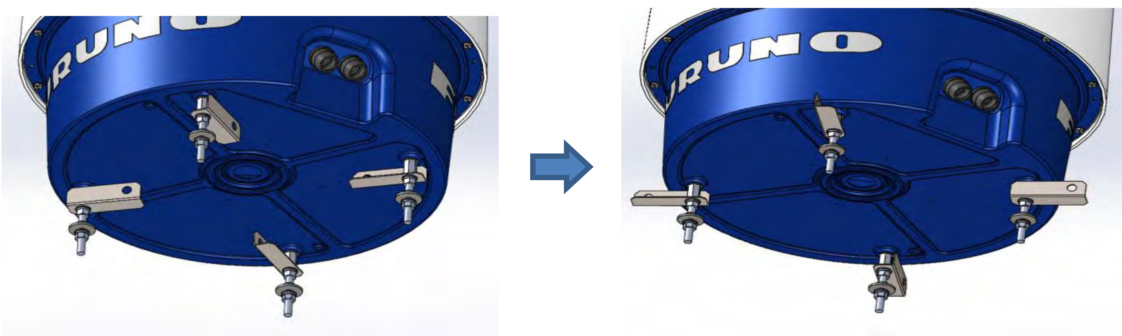
Hold flange area of radome when lifting by hand.

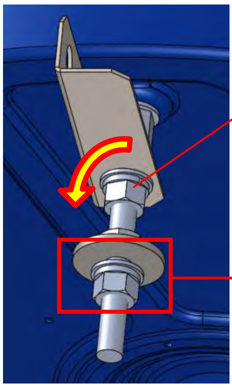


5.1.3. Lifting tool

Rotate lifting tools from storage (shipping) position to installation position before using it.

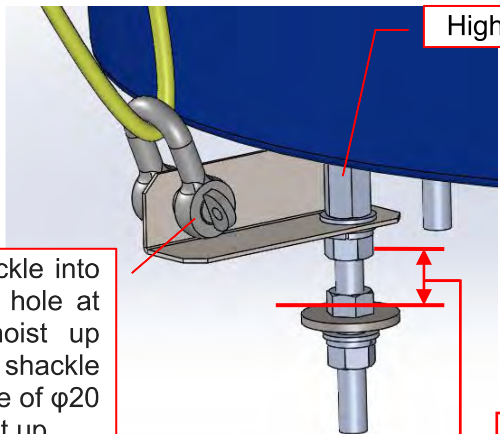
Note: Do not loosen the M16 high hex nuts. * If these are loosening, the internal unit may be damage while lifting.





Turn the lifting tool outward by slightly loosening M16 hex nut.

It might be easier to remove all under hex nut (flat-washer (L), regular flat-washer, split lock washer, and hex nut) before lifting the radome to insert into the base hole.



High hex nut

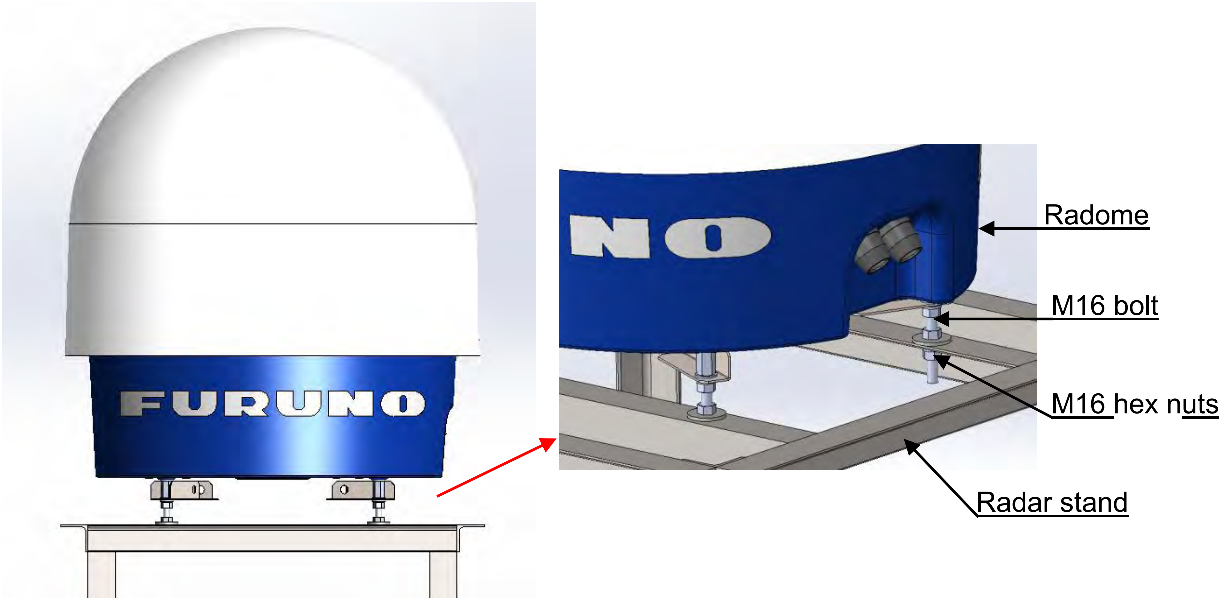
Hook shackle into lifting tool hole at φ20 to hoist up Hook the shackle on the hole of φ20 and hoist it up

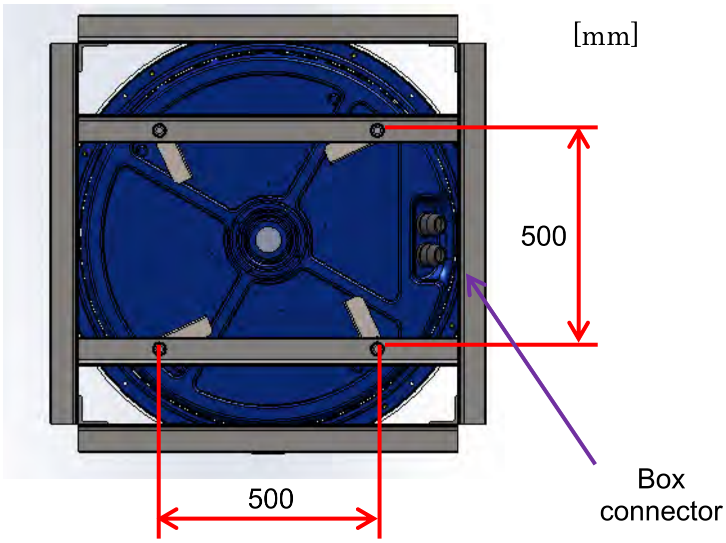
Use a soft protective cover to shield radome from Damages some kind of cotton cover to protect radome from scratch and damage

Set all 4 bolts with the same length between hex nut & hex nut might make easier for leveling.

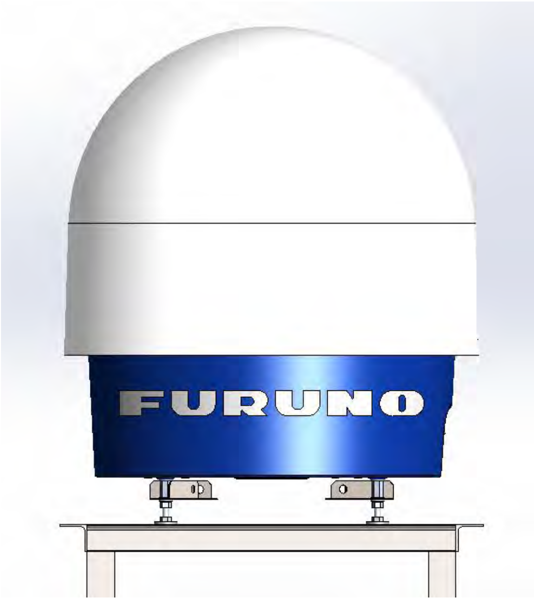
5.1.4. Mount the antenna unit

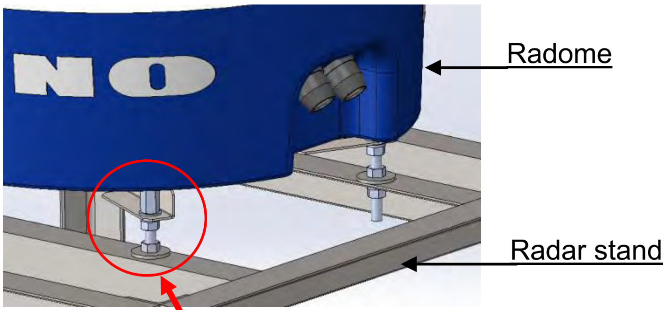
Example: Using a frame type of radar stand to mount the Antenna Unit.
Use 4 M16 bolts to adjust level while installing the radar stand. See Figure 5.2.





5.1.5. Leveling the antenna unit





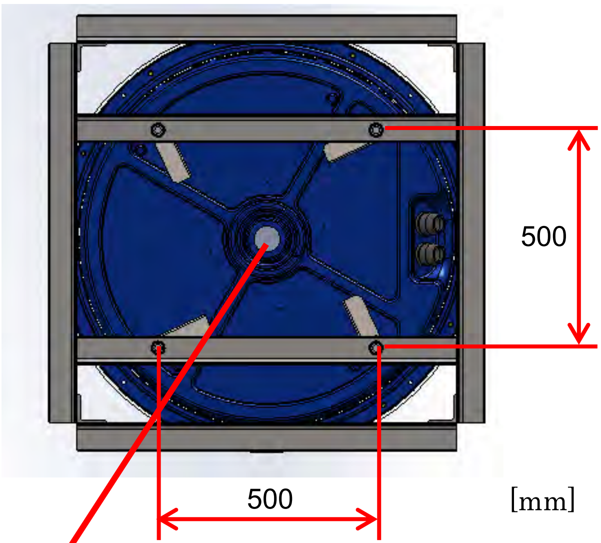


Fig. 5-1: Under the radar

M16
Hex nut 3pcs
High hex nut 1pc
Split lock washer 2pcs
Flat washer 5pcs
Flat washer (L) 1pc

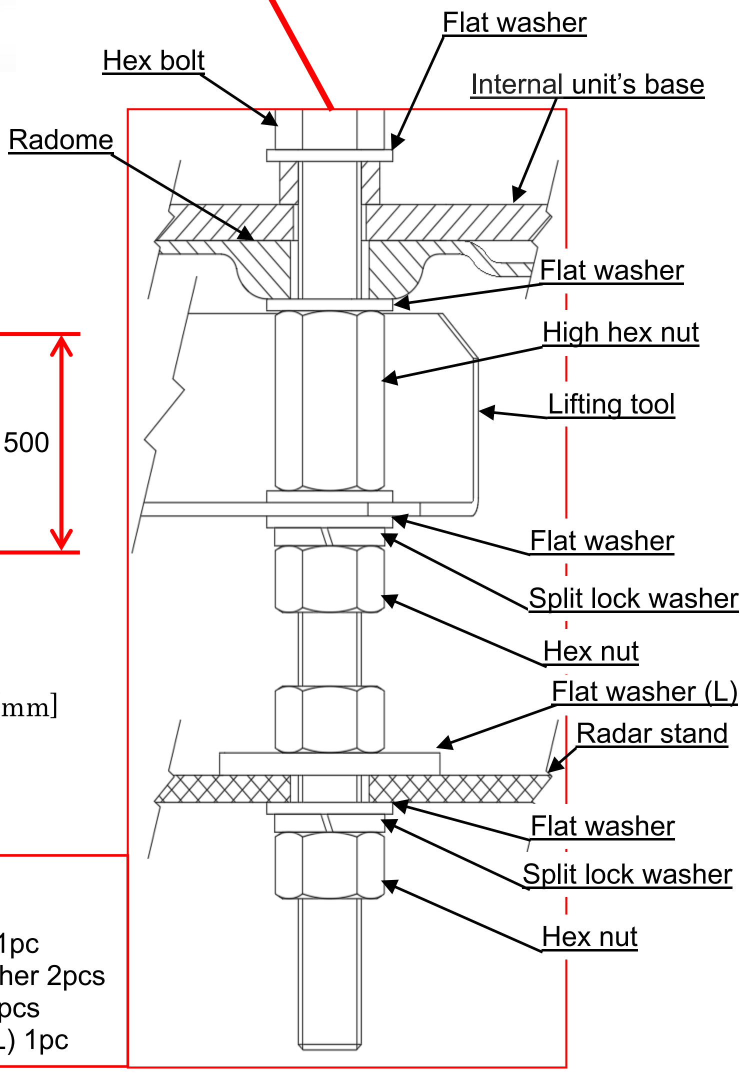
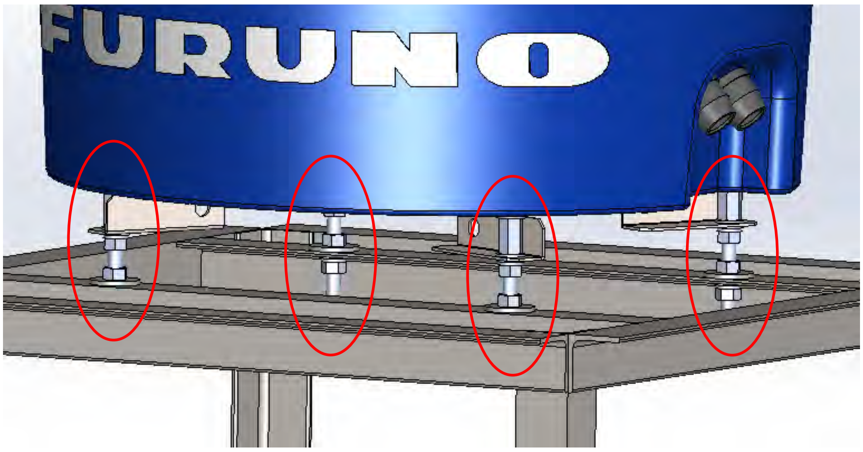
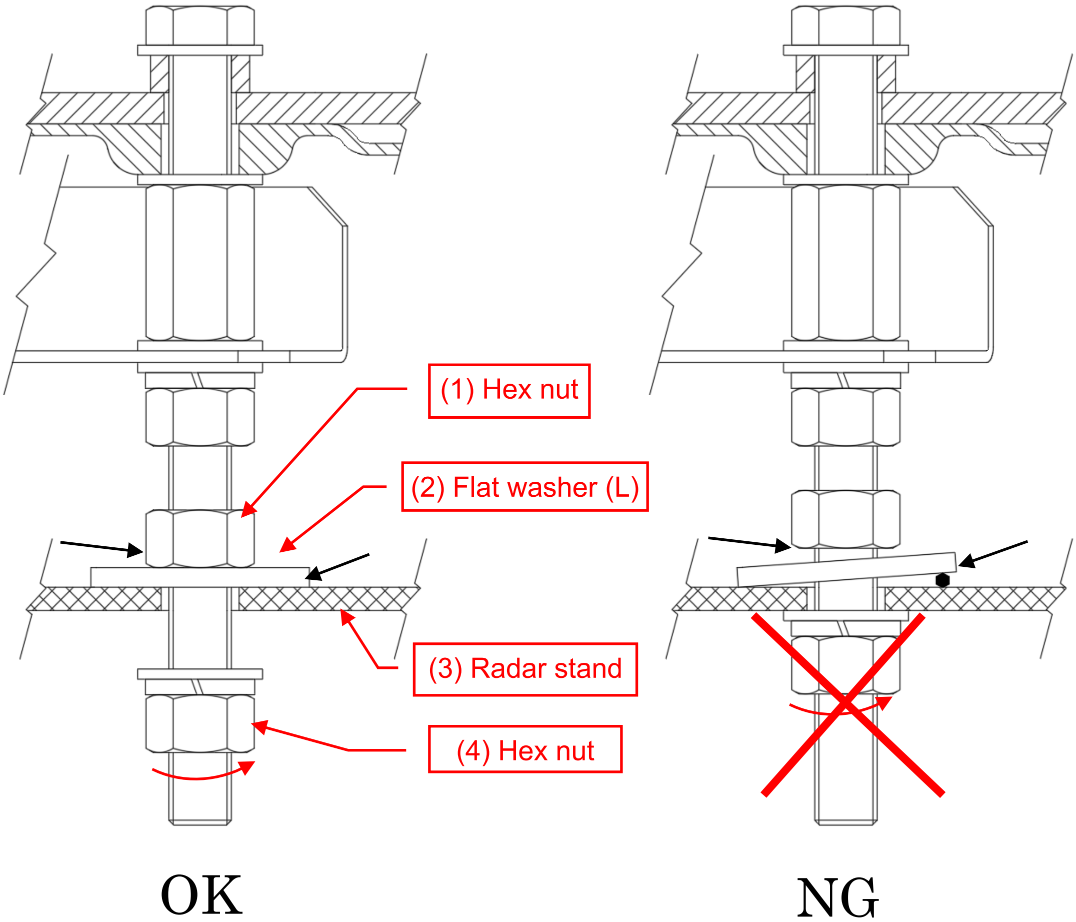


Figure 5.2: M16 bolt

Adjust level with using the bubble level installed under the radome. The bubble must be in the center between lines. If the bubble is on the line or over the line, it means the angle is over 0.3 degrees. The level adjustment will be completed after all M16 hex nuts are tightened.

Confirm all four hex nuts that are securely tightened and without having any strain to radome or stand after leveling the radar. (1) Hex nut, (2) flat washer (L) and (3) radar stand should not have any gap when tightening the (4) Hex nut.





Note for NG:

Do not tighten (4) hex nut before (1) hex nut and (2) Flat washer touch firmly to (3) Radar stand. Otherwise the chassis of the antenna unit may be distorted and broken.

Also any foreign matters should be removed before fastening the (1) hex nut.

5.1.6. Opening the radome temporary

When open radome temporary, please use long tension bolts to secure top of radome for maintenance work if it is not possible to remove the top radome. One set of tension bolts is in the maintenance tool box. Put these bolts from bottom through top holes of radome. Ensure to keep bolt distances balanced as shown below:

Caution: DO NOT open top of radome during strong wind or radome may become airborne, causing harm to individual(s) or radar.

(1) Loosen all fixed bolts
(2) Rotate top radome to right and align each thru-hole (radome base) with associated nut insert (radome top) as shown in image 5.3.
(3) Setup hex nut about 10mm from end of a maintenance bolt.
(4) Insert the maintenance bolts into each thru-hole from bottom radome up into top radome nut insert. Lift up the radome top until M10 hex nut (Step (3) contacts radome base.
(5) Attach a spring clamp on each maintenance bolt to secure all bolts.

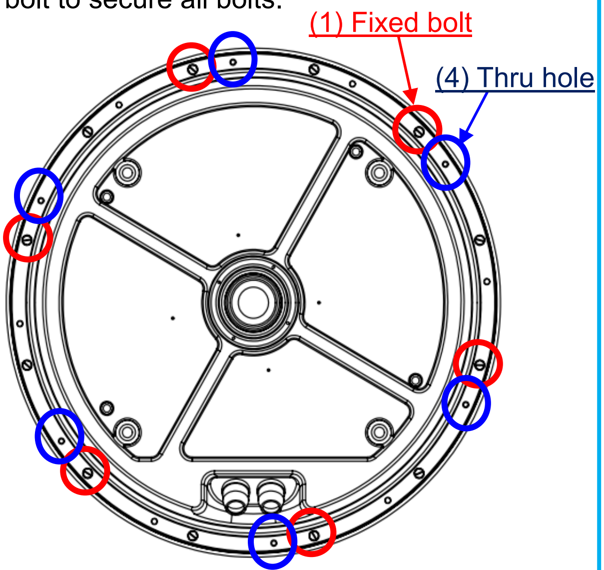
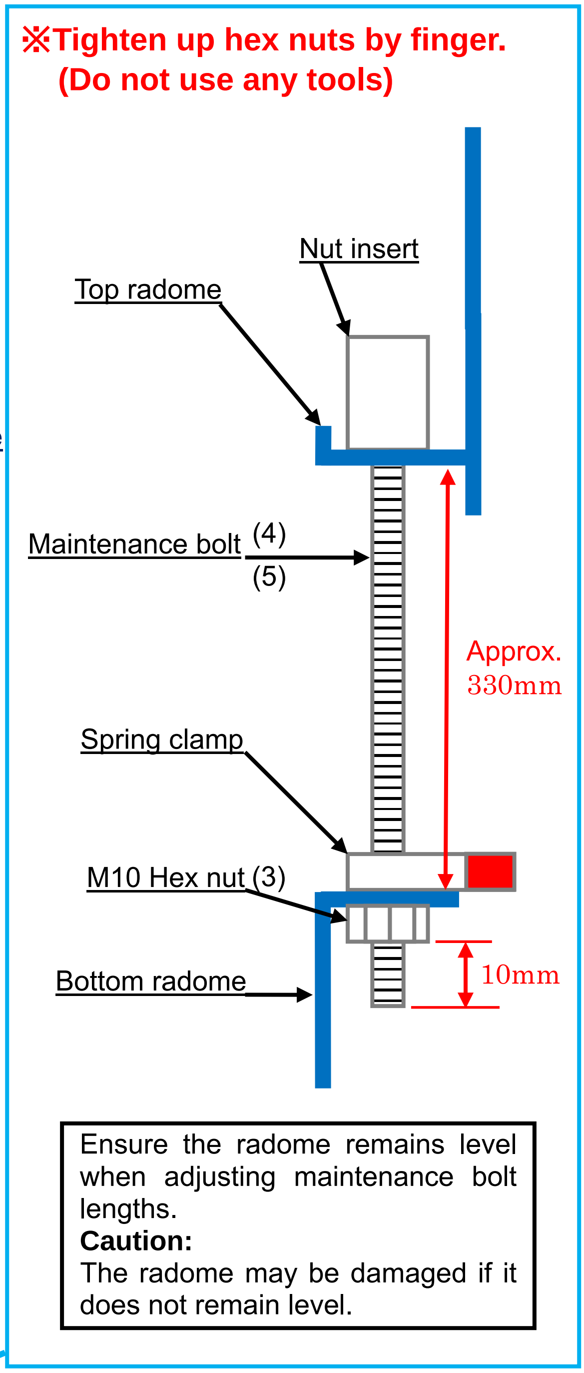


Image 5.1: Bottom view of radome
(6 maintenance bolts)



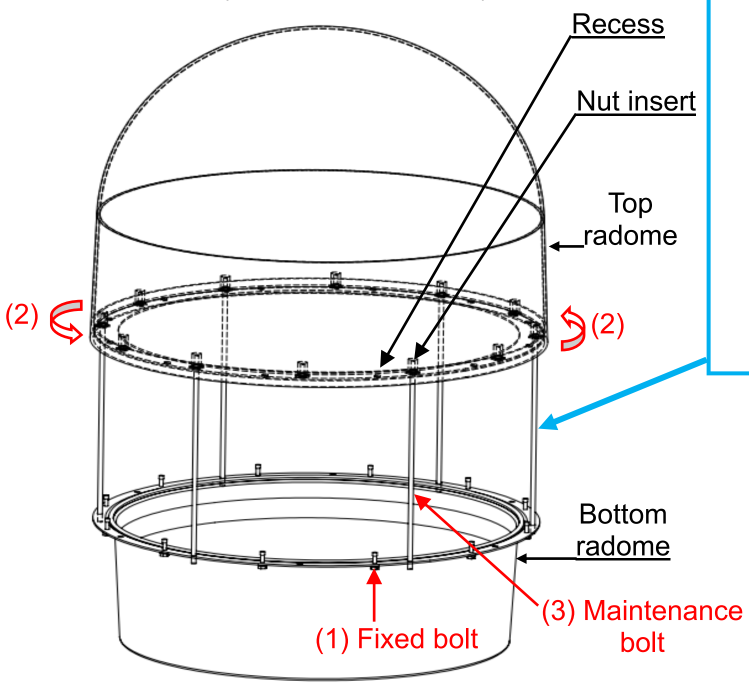


Image 5.2: Side view of radome
(6 maintenance bolts)

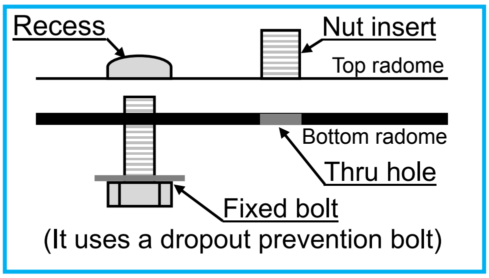
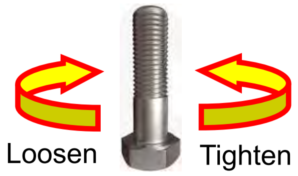
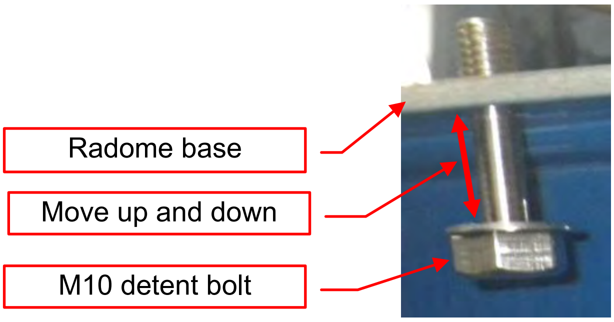


Image 5.3:
Side view of after rotating radome top to the right

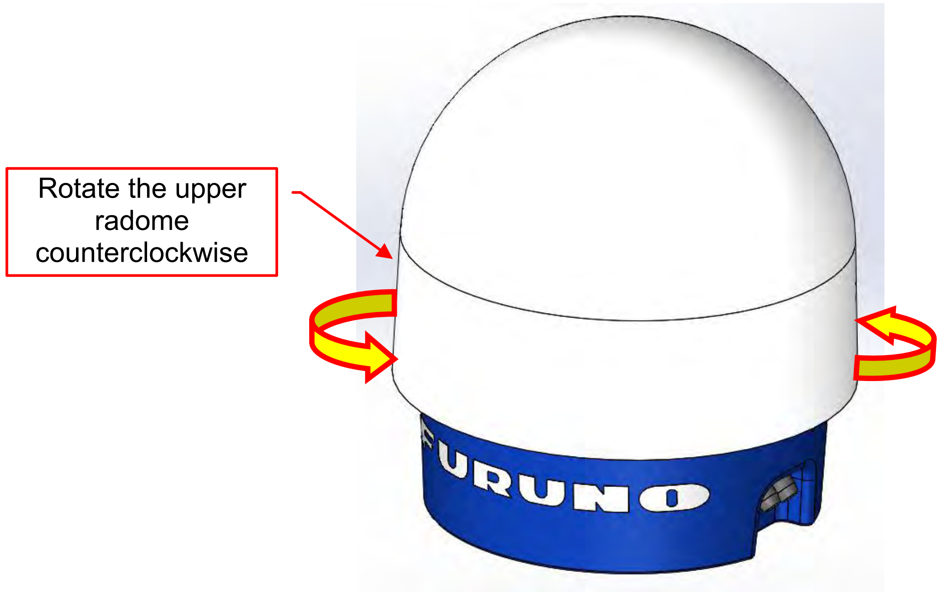
1. Loosen the 12, M10 bolts that attach the bottom of radome. This M10 bolt has a detent structure, loosen the bolt until it moves freely up and down.

   The bolt will come out if keep turning it loosen. The missing bolt can be replaced by putting the bolt in a smaller side of hole and tighten it.





2. Lift up the radome slightly and rotate it counterclockwise around 30 degrees, the fixed hex nut will fit in to the recess part of top radome. The nut insert can be seen from the thru hole.



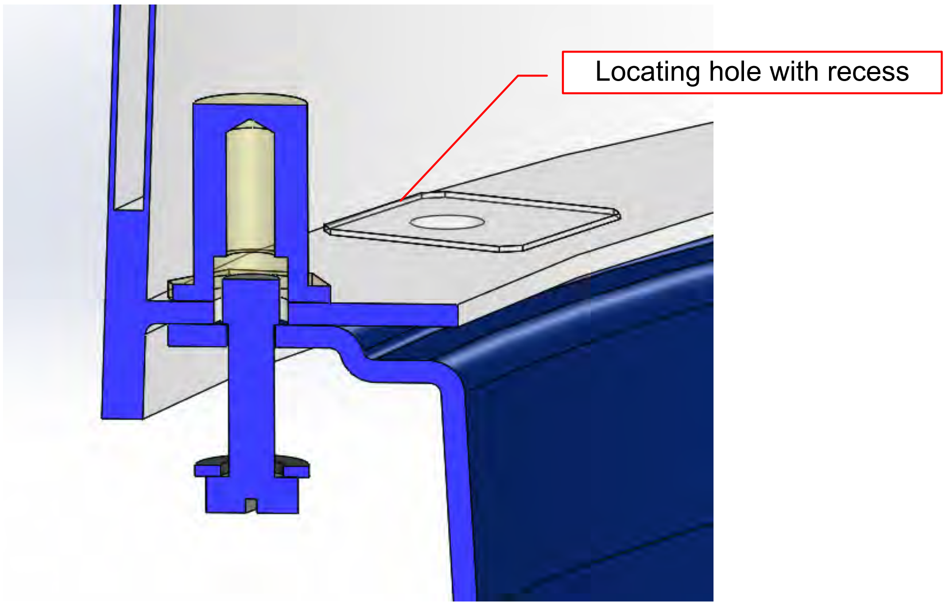


Figure 5.3: Before rotating top of radome

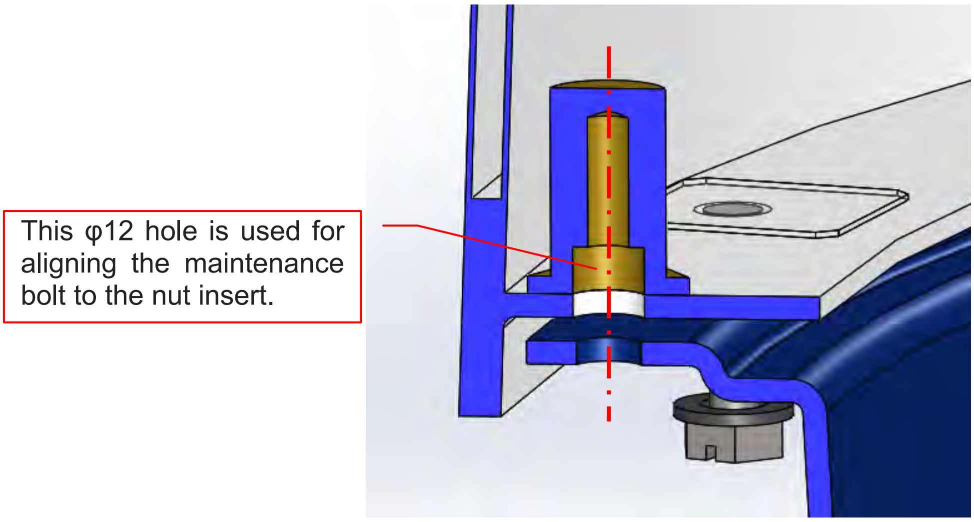
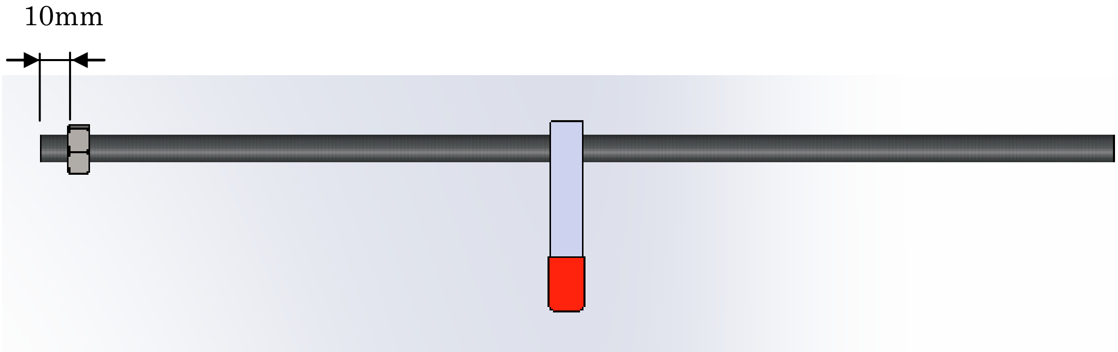


Figure 5.4: After rotating top of radome

3. Normally 4 maintenance bolts will be enough while windless. It can insert up to 8 bolts to set radome stable against the wind conditions.
   Set the hex nut to make10 mm space from the end, and fasten the spring clamp around the center of bolt as shown below.



4. Insert each maintenance bolt into thru hole from the bottom radome to fix them by the nut inserts.

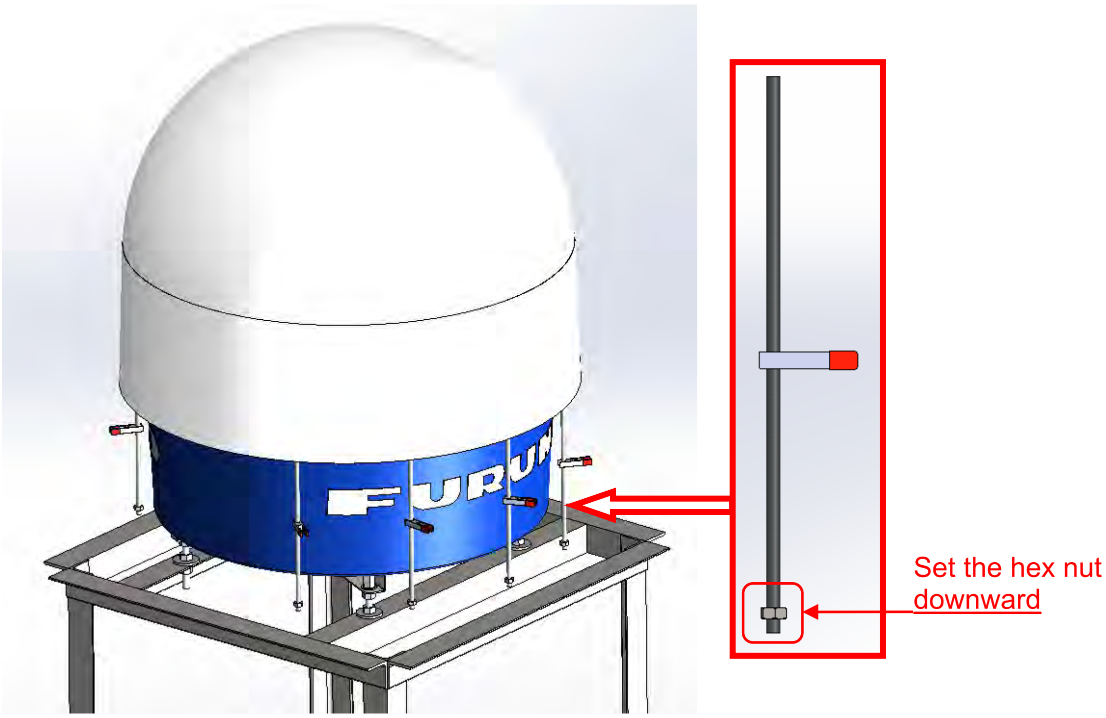
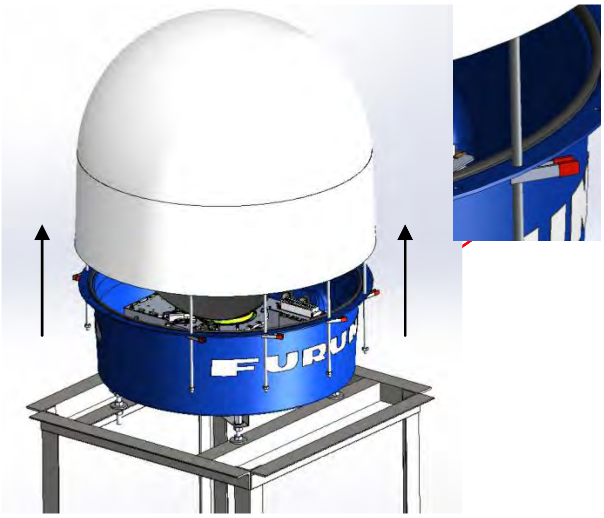
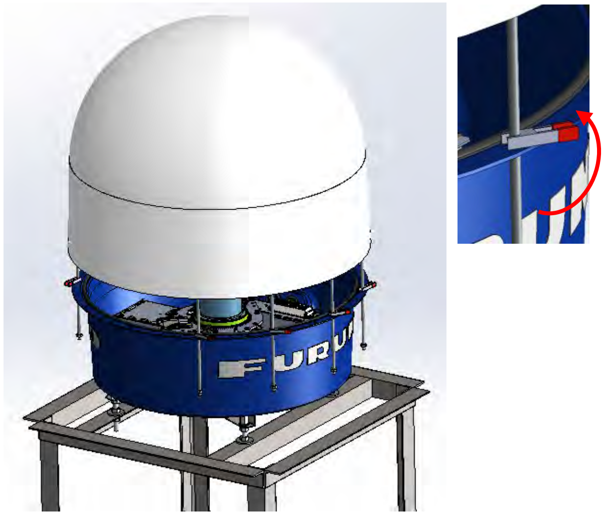


Figure 5.5: This image example uses 8 bolts.

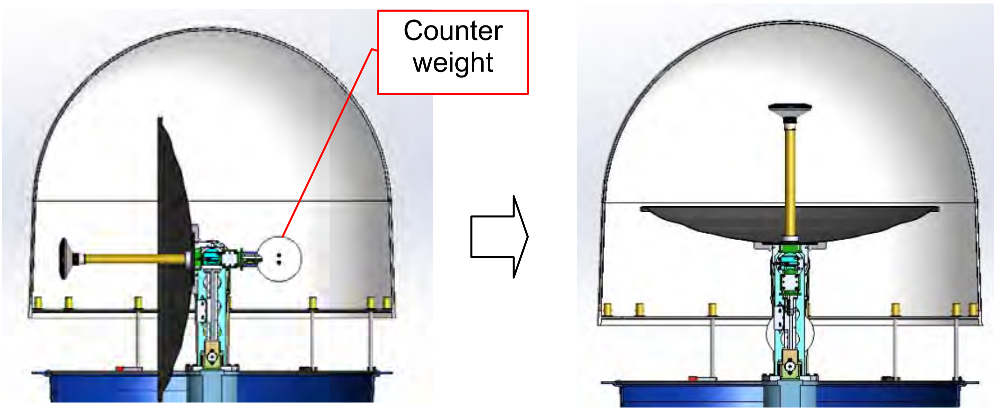
5. Lift the radome top until spring clamp contacts the radome base flange.



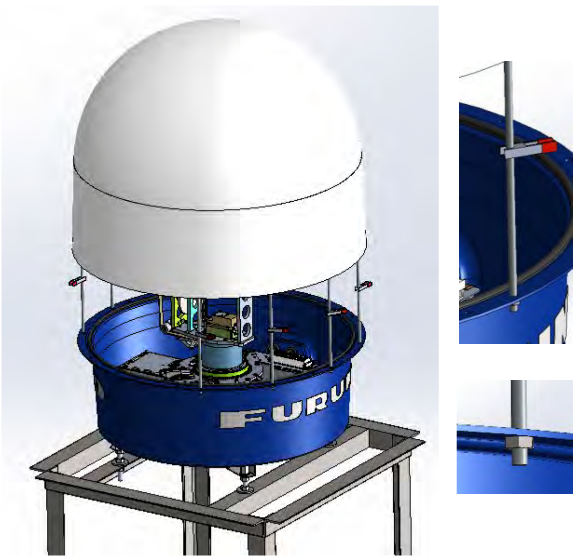
6. Remove spring clamp from bottom of radome and reattach it at top of the flange.



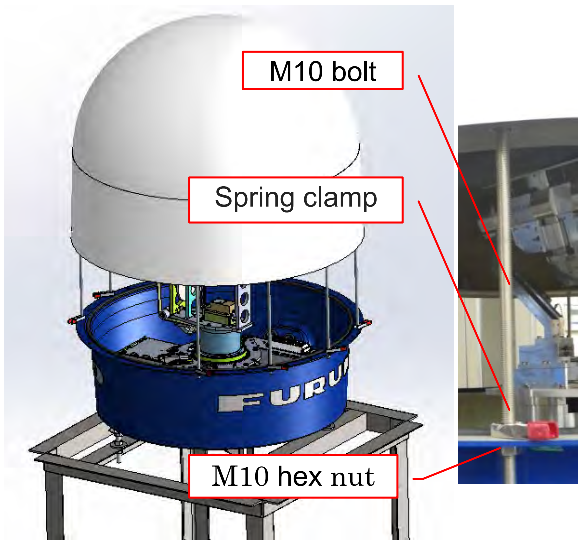
7. Check antenna orientation. If the antenna is facing at horizontal direction, then rotate the antenna to a counter weight down to face up around at 90 degrees (upward).



8. Lift up the top of radome until the M10 hex nut contacts radome base flange.



9. Fasten the spring clamp above the base flange.



10. For reducing from the wind-induced movement, fasten the spring clamp above the base flange and tighten bottom hex nut by hand.
    * Do not damage the radome gasket when fasten the spring clamps.
    * Use the spring clamp properly as examples shown below.

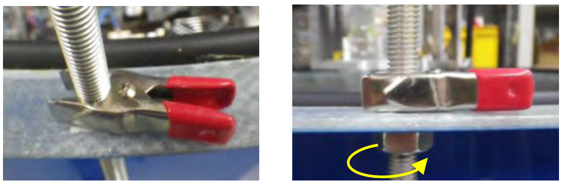


Figure 5.6: Fasten properly by spring

Bad examples:

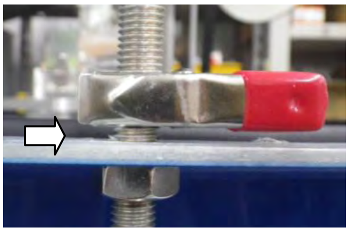
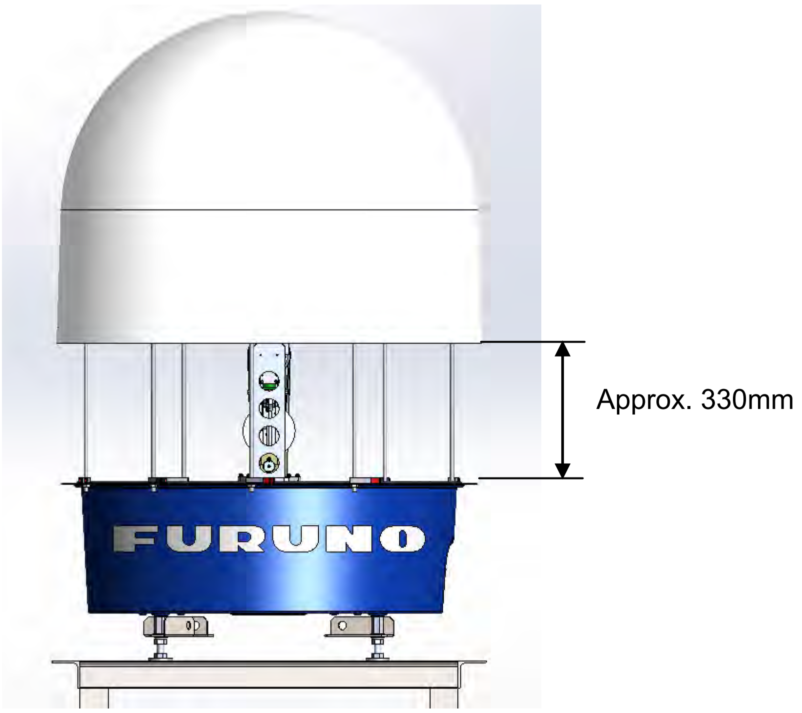


Figure 5.7:
Space between spring clamp and radome base flange

Figure 5.8:
Spring clamp is inclined

Figure 5.9:
Fasten spring clamp only partially



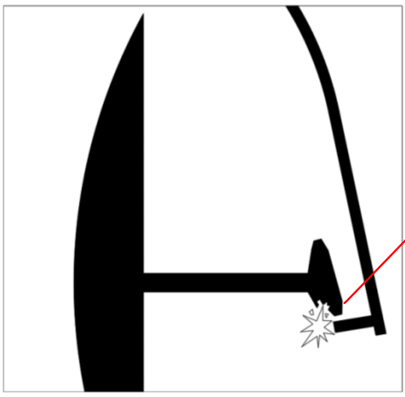
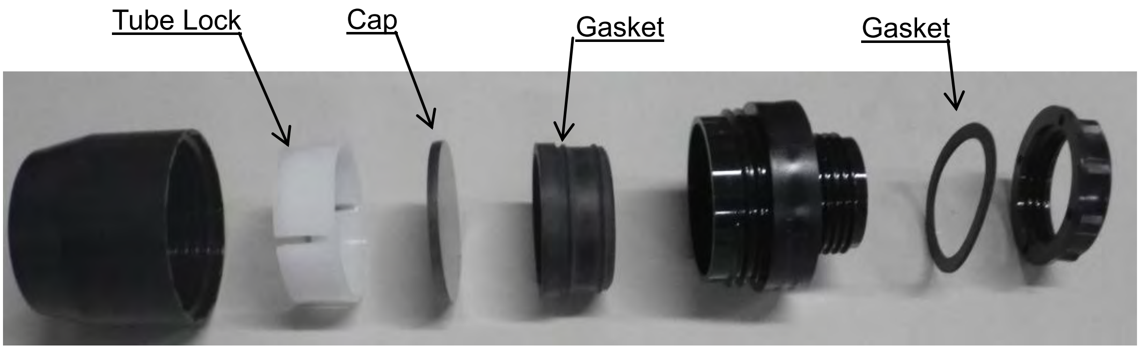


Figure 5.10:
Antenna inside radome

Aviod contact between the antenna feed arm and the radome internal flange when lifting radome top.

5.1.7. Box connector

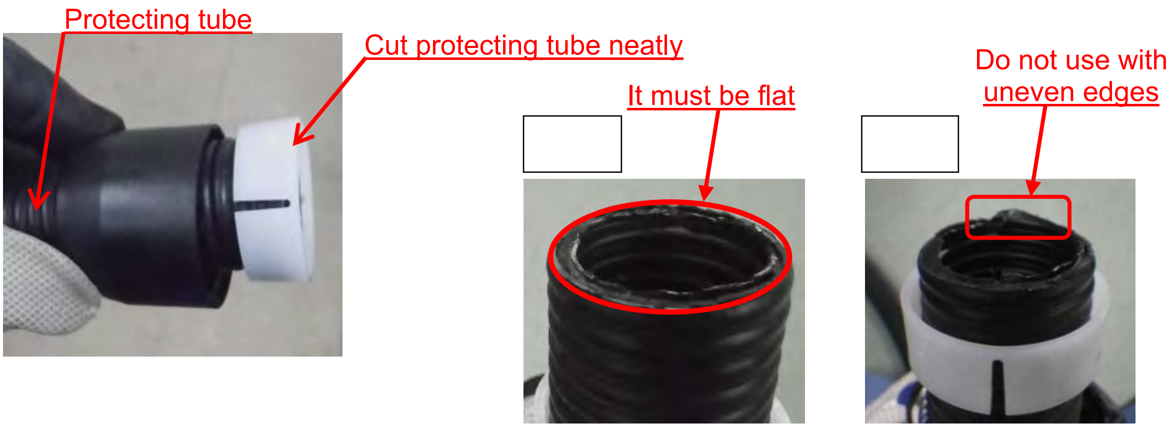
Parts of the box connector for protecting tube. It is water and dust resistance product (IP55).



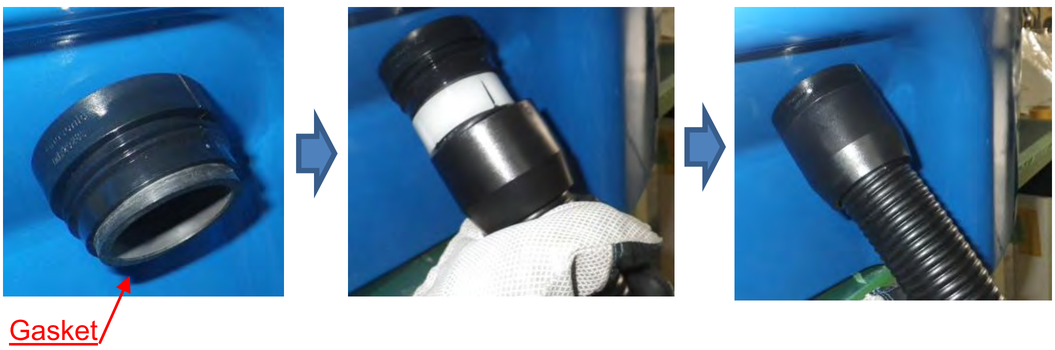
(1)

Remove a cap.

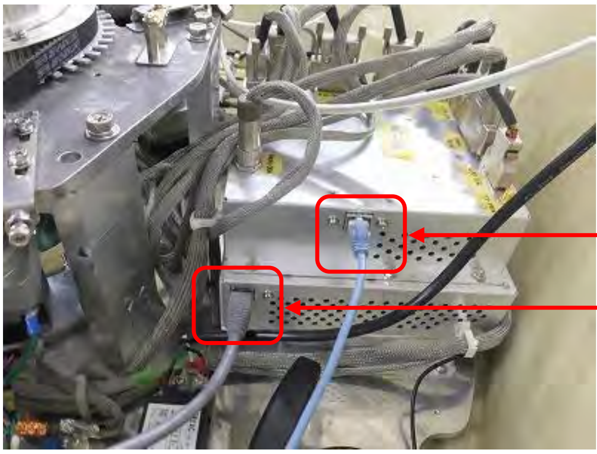
(2)



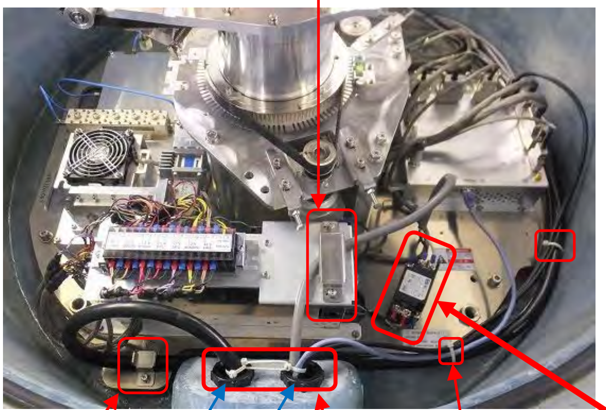
(3)



Note: Tighten up the disuse box connector with a cap inside.



2. Connect LAN cable for MONI-CON and SPU



3. Wire the power filter

Caution: Make sure all electric current is off.

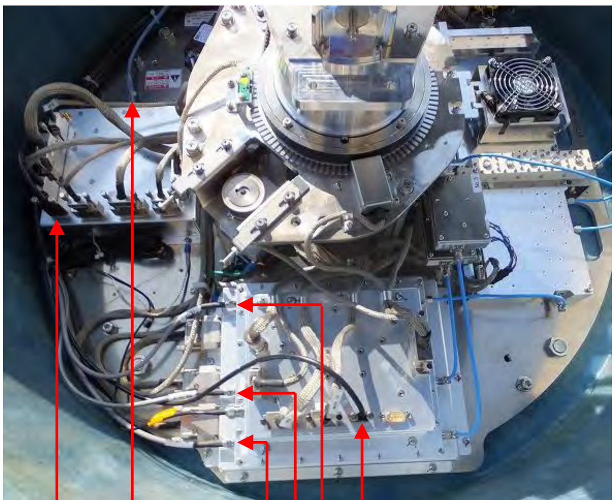
1) Fix / Connect AC power cable (3pin)
2) Confirm wiring on the circuit diagram of power filter label before connecting.
3) Connect the LINE side to match the line color of LOAD side.

<Wire color>

Type		JIS
P/L	Line	Black
N	Neutral	White
E	Ground	Green

P/L: Phase/Live
N: Neutral
E: Earth / Ground

Figure 5.11: Power filter



4. Insert the cable into the protective tube (2 pcs).

Protective Tube A1:
- AC Power cable (3cores)
- LAN cable
- Control (HDR) cable x2

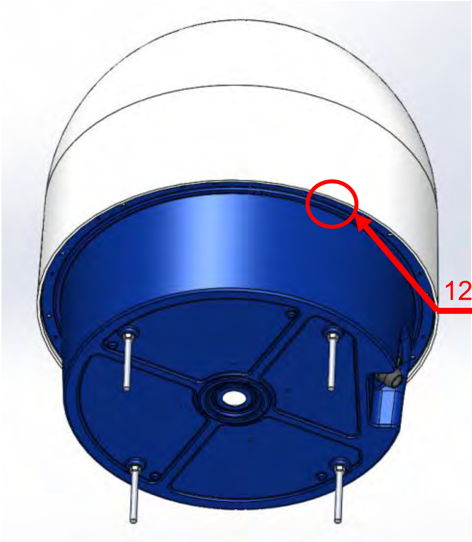
Protective Tube A2:
- Signal (SMA) cable (x3/set)

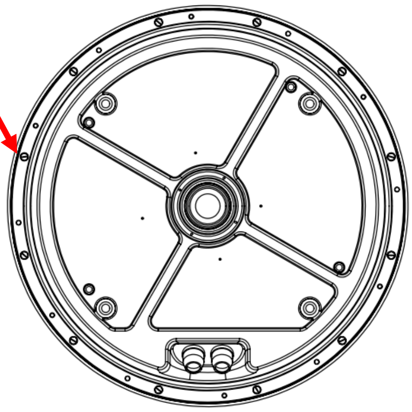
(*1) Attach cables tightly using cable ties while leaving extra cable length for strain relief at all connections.

(1) HDR cable: 26 pin
(2) LAN cable: MONI-CON
(3) SMA cable: Rx_IF_H
(4) SMA cable: Rx_IF_V
(5) SMA cable: Tx_IF
(6) HDR cable: 14 pin

5. Cover the top of radome

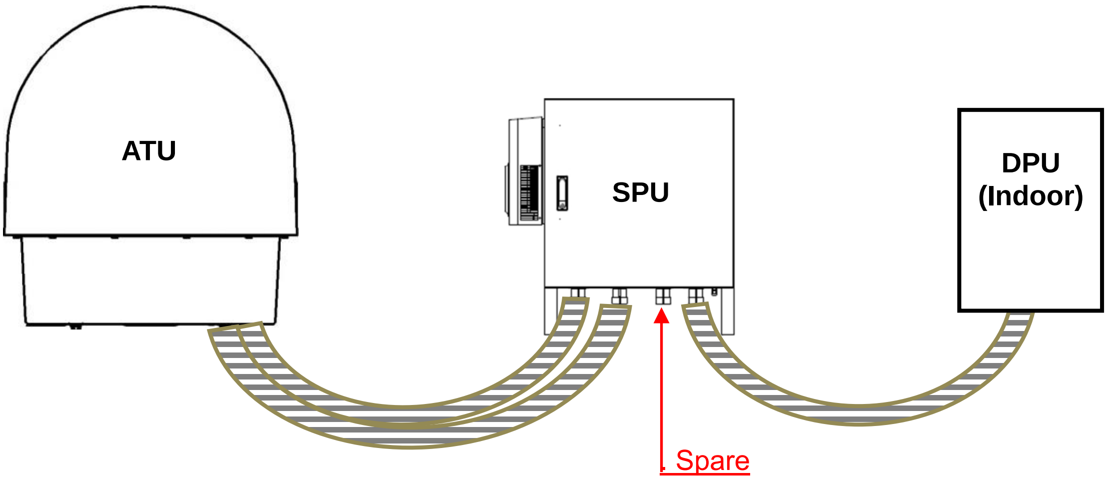
- Fix the bottom part of radome by 12 pcs of M10x35 stopper hexagon Bolt. These are using a dropout prevention fixed bolts.





6. Protective tube connection

Every location must have to measure a length in between ATU ⇔ SPU ⇔ DPU for adjusting the length of protective tube.



5.2. Signal Processing Unit (Store into storage box)

In a case of using M10 bolt and nut to fix on steel stand.

1. Fix the storage box on the ground or fixed steel using M10 bolt x4pcs.

Top view of storage box

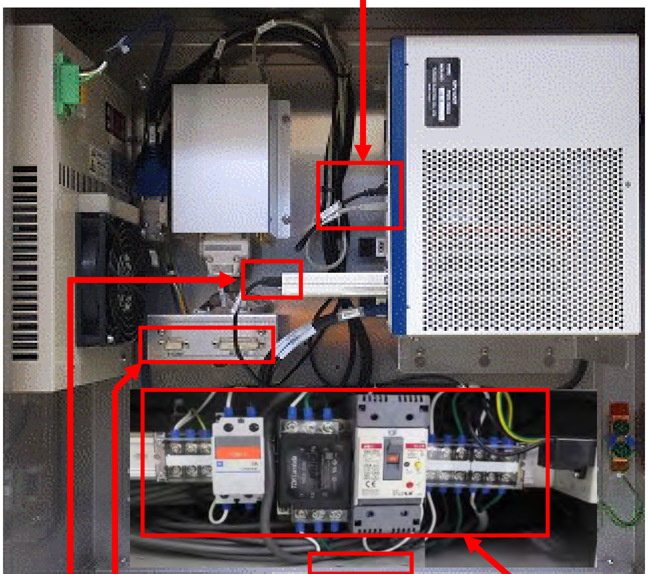
2. (2) LAN cables

2. Connect the cable from Display Unit

Caution: Make sure an electric current is not flow

(1) Connect the AC power cables (3pin) to the terminal base (TB1)

(2) Connect LAN cable (U3 LAN 1) to the 1 LAN socket of PXI and the other side of LAN cable connect to DPU



.

3. Connect the cable of the Antenna Unit

(1) Connect the AC power cables (3pin) to the terminal base (TB2)

(2) Connect and fix the control cable (HDR 14pin connector) to each S-COM connector, and control cable (HDR-26pin connector) to RF-CONT SIG connector.

(3) Fix with the torque wrench (74Z-0-0-21) after connecting 3 signal cables (TX IF, RX IF V, RX IF H) to SPU – UNIT connector.

TB2 Air Conditioner			SPU			TB3		TB4			Surge TB3		
L	N	E	L	N	E	L	N	L	N	E	L	N	E
TB1			TB2			Breaker (B)		TB3			TB4		
L	N	E	L	N	E	L	N	L	N	E	L	N	E
ATU			B / TB1		TB3	TB2		B		TB2	Main Power		

MONI-CON	LAN	DPU

3. (2) Control cables

3. (3) Signal cables

4. **Pull outdoor cable into protective tube** (10 pcs)

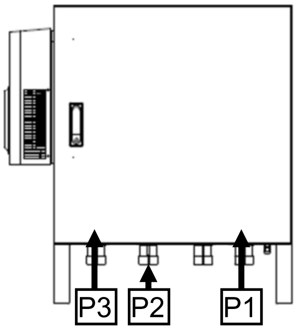
<u>Cables pull between SPU and DPU</u>

Protective Tube 1 (P1): AC power cable (3pin)
LAN cable x2

<u>Cables pull between SPU and ATU (radome)</u>

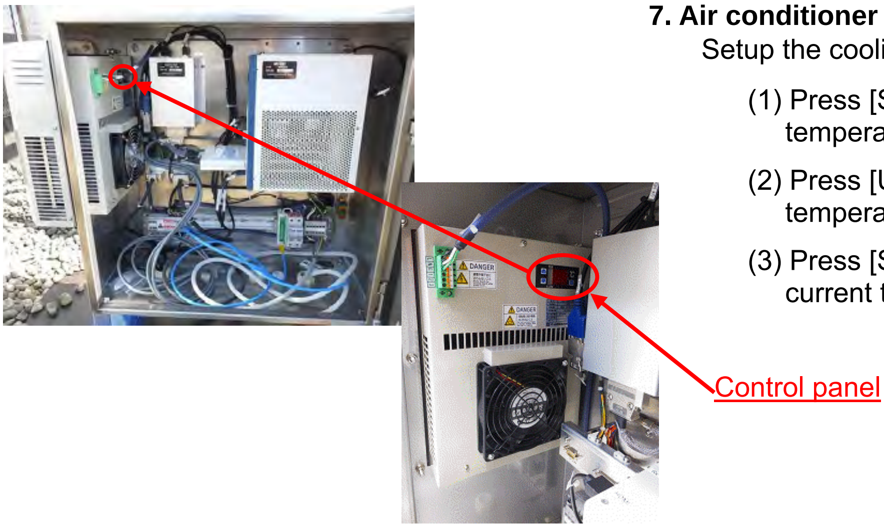
Protective Tube 2 (P2): AC power cable (3pin)
Control cable (both end HDR-26pin connector)
Control cable (both end HDR-14pin connector)
LAN cable x1

Protective Tube 3 (P3): Signal cable (SMA 3 pcs)



5. **Make the power plug**
   - Plug in 3 pin earthed power plug that running through the SPU into near DPU.
   -

6. Activation test
- Turn ON the circuit breaker.
- Follow the instruction to test it.



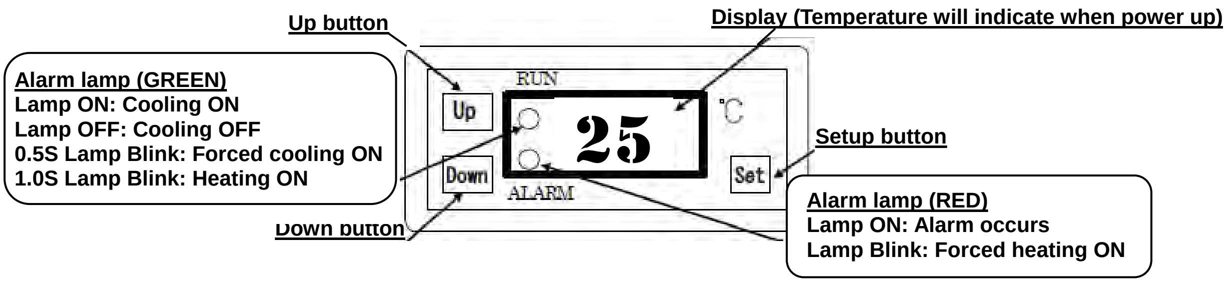
7. Air conditioner temperature setting

Setup the cooling temperature to **25**°C.

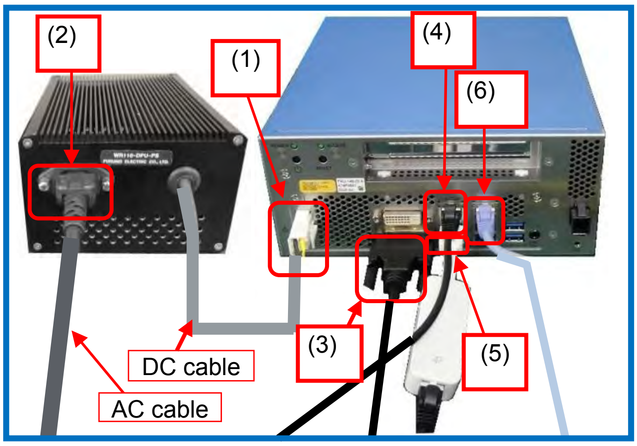
(1) Press [Set] button to indicate a temperature of setting.

(2) Press [Up], [Down] button Setup a temperature to 25 Celsius degree.

(3) Press [Set] button to indicate a current temperature.



5.3. Data Processing Unit



1. Setup Data Processing Unit

(1) Connect DC power cable of DPU-PS to DPU.

(2) Connect AC power cable to DPU-PS and connect AC power cable to electrical outlet.

Note: Power “ON” ATU first and then power “ON” DPU.

Note: By default DPU will boot up automatically and RainMap (radar software) come up automatically when DC power supplied.

(3) Connect display to DVI port, And connect keyboard and mouse to USB port.

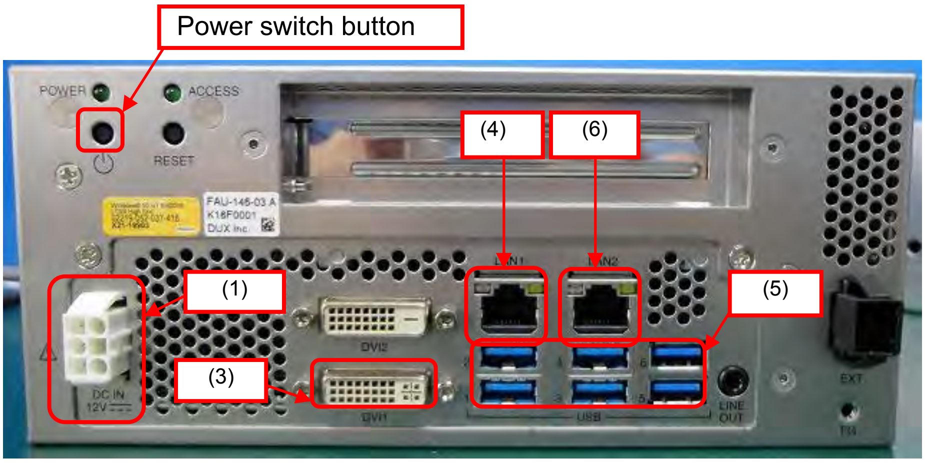
(4) Connect LAN cable from ATU (SPU module inside the ATU) to LAN1 port.

(5) Connect LAN cable from MONI-CON (inside the ATU) to USB port via bundled USB-LAN adapter.

(6) Connect LAN cable from router to LAN2 port for using Internet. And the router and the LAN cable for Internet is local supply.

Notice:

1) Bundled cable is dedicated for Japan and US use and can be used up to 125V. Appropriate power cable should be prepared for each site location.
2) Do not use the same IP address on ATU.
3) Do not put heavy object on the DPU. It may deform the DPU chassis.

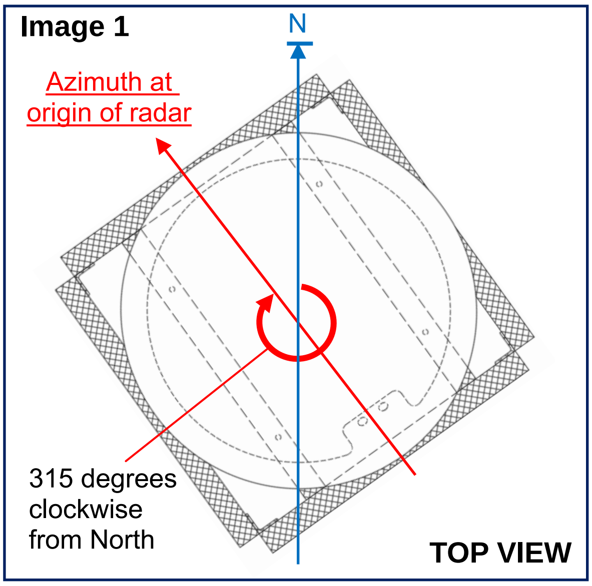


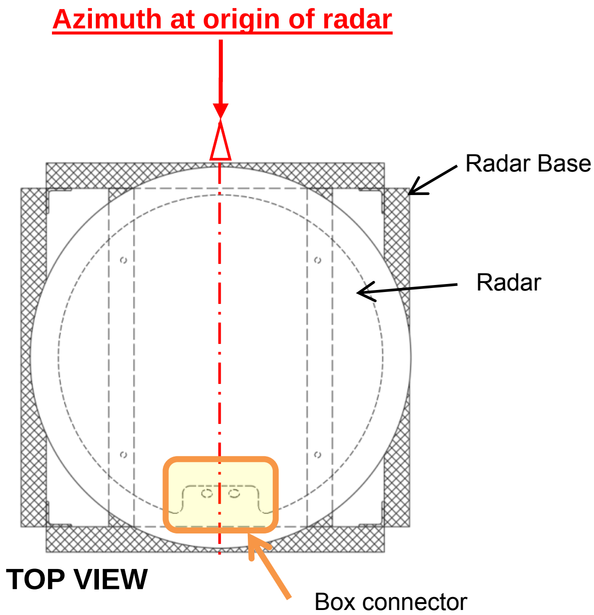
6. INITIAL SETTING OF AZIMUTH

The installed radar orientation and actual geographical azimuth are normally different causing an incorrect initial echo indication. An azimuth adjustment is required for proper echo orientation. Determine actual radar antenna azimuth (see orientation diagram below) and then determine geographical azimuth by using a magnetic compass (It is necessary to convert it from magnetic azimuth) , GPS heading system or solar measuring tool. Enter RainMap software and select menu setup, “Azimuth Offset”. The unit resolution is 0.01 degree of the measured value.

Measurement range: +0 to 360 degrees.

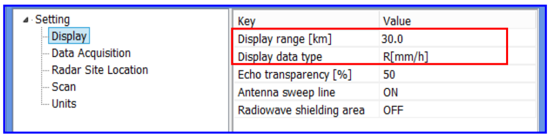
e.g.: Enter the value of “Azimuth Offset” to 315 degrees when the origin of radar is as below image 1.



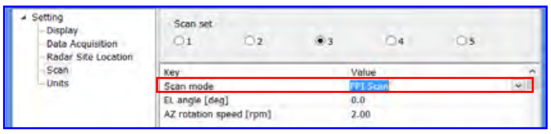


Notice: Ground clutter rejection must be “OFF” during this operation.

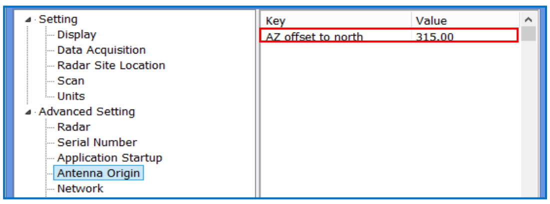
1) Turn ON DPU power. Enter User name as **radar**, and password as **radar**.
2) Remain a safe distance from radar. Radar transmit radio wave can damage human body especially eyes within the danger zone.
3) Connect ATU/SPU to main power outlet.
4) Use a map with local geographical features of installed radar unit (e.g. Google map).
5) Setup “Display range [km]”, “Data Type”, in [Display] setting menu of RainMap.



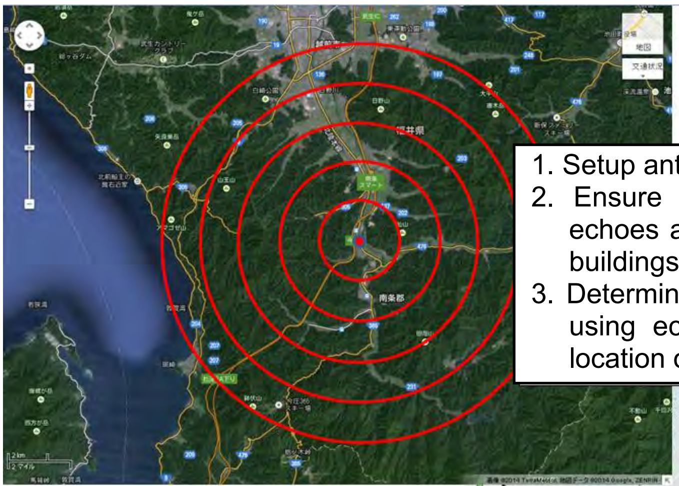
6) Setup “PPI elevation” in [Scan] setting menu of RainMap.



7) Setup “AZ offset to north” based on difference between physical radar orientation and measured azimuth in [Antenna Origin] setting menu of RainMap.

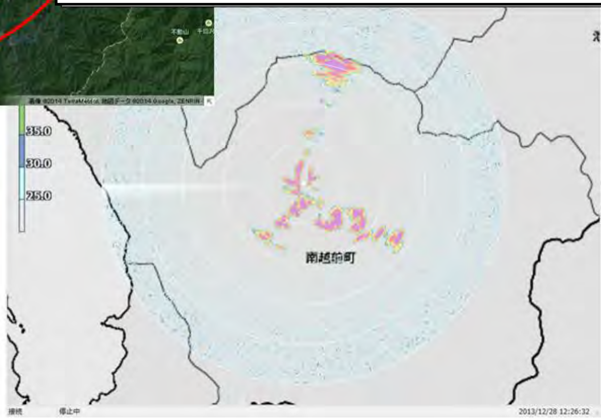


<Image screen>



1. Setup antenna elevation up to 5 degrees.
2. Ensure only the higher mountain radar echoes are displayed exclude surrounding buildings.
3. Determine correct echo indication azimuth using echo characteristics and mountain location on map.

Zh echo
Elevation 5 degree
Range 10km
No.32 P0N transfer
GCR OFF



Note: Elevation angle written here is one example. It depends on geographical feature where radar is located. For another example, if it is in a flat country like Denmark, a water tower in Lund, and Sweden, it used -1 degree, 10 km range and was able to detect coastline and the city boarders of Copenhagen.

1) Click [STBY] in [Radar operation] to Stop TRX.
2) Add a map file to RainMap and display on screen (or use other PC to see a map).
3) Locate a characteristic geographical feature like a mountain line ridge or form, note distance, and relative bearing on map.
4) Set radar to a higher elevation until no echo is received from lower buildings or structures, possibly 5 degrees (in some cases 3 to 7 degrees may be required) in RainMap.
5) Set a distance to more easily confirm the geographical feature “6)” in “Range [km]” in [View] setting menu of RainMap.
6) Setup “Reflective Intensity [H]” in “DataType” using [View] setting menu of RainMap.
7) Confirm echo after starting [TX] from [Radar operation]. Purple observations indicate strong echoes that may be from mountains.
8) Click [STBY] in [Radar operation] before making any changes to setting. To change “Azimuth Offset” angle in [RDR Parameter] service menu of RainMap, compare shape of echo with “6)” and “10)”. Echo indication will be rotated clockwise if a large value entered in “Azimuth Offset”. (Available range: -360 to 360)
9) Repeat steps “10)” to “11)” until an echo aligns with the geographic feature
10) Click [STBY] in [Radar operation] after finished “12)”.
11) Set 0 degree at [Elevation] in [View] setting menu of RainMap.
12) Set a distance suitable for the area at “Range [km]” in [View] setting menu of RainMap.
13) Select “Rainfall Intensity” at [DataType] in [View] setting menu of RainMap.
14) Finish setup.

7. ANTENNA POINTING ADJUSTMENT

This tool is to adjust the antenna position precisely by observing the solar noise after setting offset value to [AZ offset to north] in section 6.

Note: ATU must install horizontally for adjusting elevation by solar measurement. If adjust the elevation in a tilted state, the error may become larger on the opposite side in the sun direction.

7.1. Software Items

The following conditions are necessary to use the software.
Display screen resolution: FHD (1920×1080) or higher.

The following software must be installed in DPU.

1) LabVIEW™ Run-time Engine 2017
2) Solar_position.exe
3) Antenna_position_analysis.exe

- If software has not been installed in DPU, click “setup.exe” inside “Installer_with_runtime” folder to start installation. (Windows needs to restart after installation). “Solar_position.exe” and “Antenna_position_analysis.exe” will install into DPU.
- If software does not exist in DPU, please contact Furuno directly for assistance.

7.2. DPU Time Setting

Set correct value for time zone, time, and date in Windows™.
Process:
Open [Control panel] -> [Time & Date] -> Change to correct [time & date] and [Time zone]
Note: This procedure requires administrative rights.

7.3. Solar Position Simulator

1. Click “Solar position simulator.exe” to startup the software.

2. Check the time indication
   “UTC_Date(YYYY/MM/DD)”
   “UTC_TIME(hh:mm:ss))”.
   Check time setting of PC if incorrect (See section 7.2.)

3. Input radar site latitude and longitude information in the RainMap ([setting] -> [antenna]).

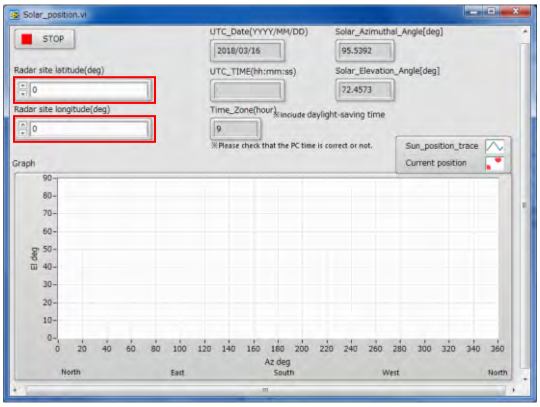


Figure 7.1

4. Latitude and longitude will be displayed on the screen graph.
   - Blue line means solar position and orbit.
   - Red point means solar position (atmospheric refraction included in measurement) with current time.
     Note: Red point will only indicate during day time, and not available during night time.
   - The angle of current solar azimuth and elevation is shown with the number of degree.

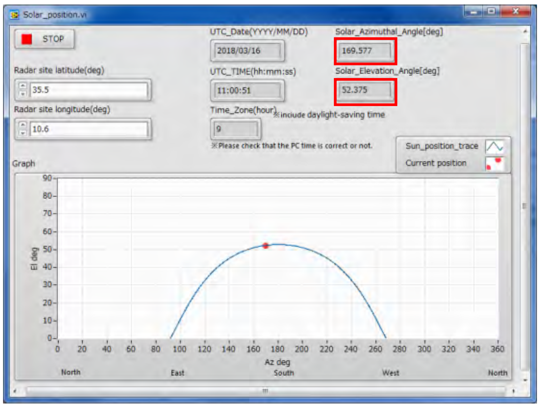


Figure 7.2

7.4. Antenna Position Analysis Operation

1. Click "Antenna_pointing_Analysis.exe" on your DPU desktop or installed folder to start software.

2. Drag & Drop the observed data folder icon (observed from solar_position) into [Radar_data_path] or click folder icon to choose the data folder.

3. Click [⇨] mark in the menu bar to start the program to see a graph of observed data files (.scn, .rhi, .sppi). (Refer to operator's manual for file type descriptions.

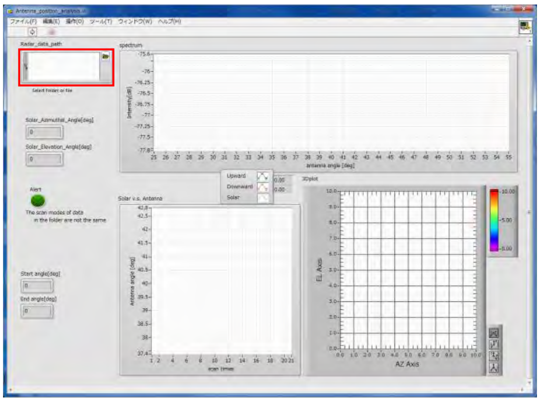


Figure 7.3

4. The right sample screen shot is a solar scanning result using Sector RHI scan.

5. The [Spectrum] graph is the solar radiation intensity.

6. Graph of [Solar_Azimuthal_Angle] and [Solar_Elevation_Angle] will be calculated in the value of the solar altitude and azimuth during observed time.

7. It determines the precise antenna position by comparing the peak of solar radiation intensity and the calculated solar altitude value.

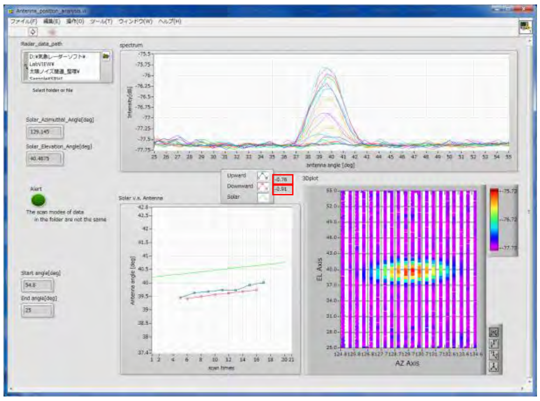


Figure 7.4

8. Figure 7.5 shows two or more observed measured solar data points (All data must be acquired using same scan mode).

9. The [solar vs. antenna] graph shows the Sector RHI upward elevation point plot peak in blue color and the downward plot peak in red color. (Antenna moves up and down to scan solar radiation)
It is determined by solar radiation peak value that estimated the Gaussian (normal) distribution spectrum.
It simply and precisely checks the antenna graph.

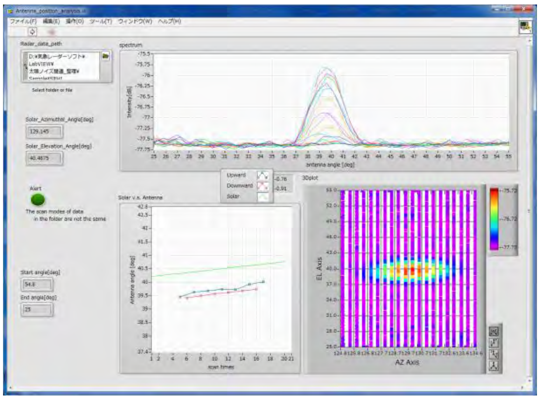


Figure 7.5

Sector PPI will rotate clockwise and counterclockwise during antenna scan.

10. Graph of [3D plot] displays multiple observed data. It can capture the solar intensity in 3 dimensions using sector scan:
Color indicates solar radiation intensity / Horizontal indicates azimuth / Vertical indicates elevation.

7.5. Solar Observation

It is necessary to change the RainMap settings for observing solar radiation.
Press [Alt] + [Ctrl] + click [setting] menu of RainMap for using the advanced setting.

1. Setup TX Sector Blank for all angles shown below:
   Blank area 1: ON
   AZ start angle [deg]: 0.00
   AZ end angle [deg]: 360.00
   EL start angle [deg]: -2.00
   EL end angle [deg]: 182.00

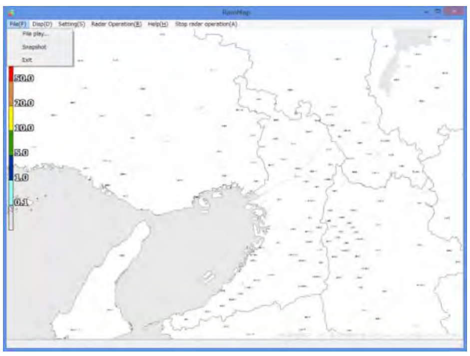


Figure 7.6

7.6. Antenna Pointing Adjustment

Adjust the antenna using solar measurement when installing the radar, after maintenance, or repair the antenna drive system. The following information explains the process of adjusting antenna using dedicated software.

Requirements for use:

1) The weather at radar site area must be clear and/or sunshine.
   (Clouds, rain and any obstacles prevent proper adjustment)
2) ATU must be installed horizontally. Otherwise it will deviate further in the direction other than the sun if adjust the value obtained by solar measurement.

Process outline:

1) Scan Azimuth by [Sector PPI].
2) Deviation azimuth analysis and adjustment.
3) Confirm that azimuth deviation is revised by [Sector PPI].
4) Scan Elevation by [Sector RHI].
5) Deviation elevation analysis and adjustment.
6) Confirm that elevation deviation is revised by [Sector RHI].
7) Re-confirm that azimuth deviation is revised by [Sector PPI].
8) Turn OFF the Sector Blank and restore observation setting to the original.

1. Confirm the current position (Azimuth & Elevation) of the sun by Solar_position.exe. (See section 7.3)

2. Measure the Sector PPI first and then RHI next especially if sun is getting close to maximum altitude.

   a) Sector PPI

   Measure the azimuth of sun using Sector PPI. Setup Sector PPI scan from scan setting as follows:
   AZ rotation speed: 0.5
   AZ start angle: Current solar azimuth angle of sun -15 deg.
   AZ end angle: Current solar azimuth angle of sun +15 deg.
   EL angle 0 : Current solar elevation of sun ±1 deg.
   (Predict elevation 1 minute after sun moves)
   EL angel 1 : Same as EL angle 0.

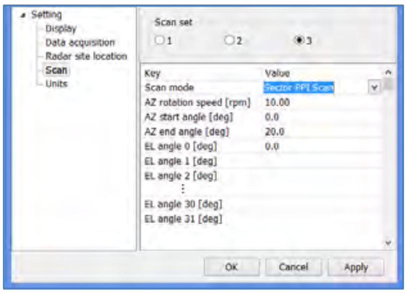


Figure 7.7

   b) Sector RHI

   Measure the azimuth of the sun using Sector RHI. Setup Sector RHI scan from scan setting as follows:
   EL rotation speed: 0.5
   AZ start angle: Current solar azimuth angle of sun ±1 deg.
   (Predict the azimuth of 1 minute after the sun moved)
   AZ end angle: Same as AZ start angle
   AZ step angle: 2.00
   EL start angle: Current solar elevation angle of sun -15 deg.
   Note: Minimum elevation must be higher than 25 deg. (If this elevation is lower, then it means it did not measure accurately
   EL end angle: Current solar elevation angle of the sun +15 deg.

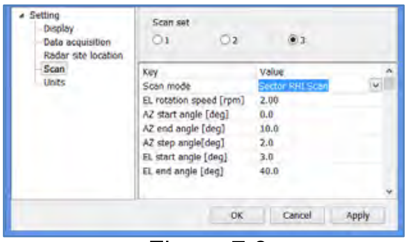


Figure 7.8

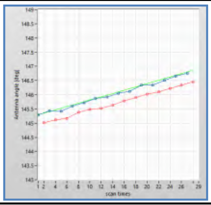
3. Start observation by clicking [TX].

4. Click [STBY] to stop radar after getting 20 data files. It has to take twice (e.g: 1st start on 10:00am, 2nd start on 10:30)

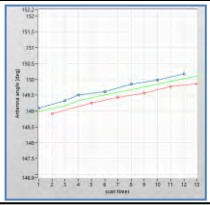
5. After observed around 20 data files, save them into the following folder below:
   - Folder for Sector PPI: “sppi_before” (Use current offset value that set in Section 6), “sppi_after” (After offset adjustment)
   - Folder for Sector RHI: “rhi_before” (Use current offset value), “rhi_after” (After offset adjustment).

6. Drag & Drop a folder (sppi_before, sppi_after, rhi_before, rhi_after) into [Antenna_position_analysis.exe] to check the graph.
   - Refer to section 7.4 for instructions.
   - Solar radiation spectrum has difficulty to check when sun is blocked by clouds or position of sun is poor during scan.

Before offset adjustment Using current offset value (sppi_before)



After offset adjustment Green line comes between blue and red lines (sppi_after)



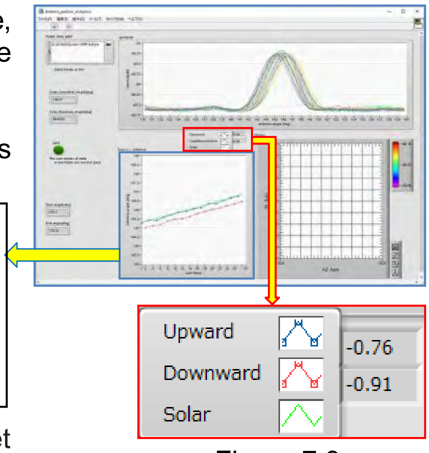


Figure 7.9

7. Add the average values of the figure 7.9 to the original offset value if need to change the value.
   e.g.: [Upward -0.76] subtract [Downward -0.91] divided by 2 = -0.84

8. Add the average values of SPPI and SRHI as follows:
   Press [Alt] + [Ctrl] + click [setting] menu of RainMap, [Setting] > [Advanced Setting] > [Zero position offset] >
   a) Sector PPI into [AZ offset to north]
   b) Sector RHI into [Origin EL position offset correction [deg]]

   Note: Take a screenshot of the original value before change the setting of offset value.

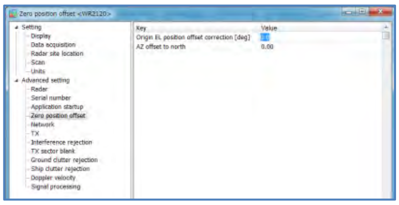


Figure 7.10

9. Repeat from step 2 to 6 to observe data of "SPPI after".

10. Do the same things for Sector RHI start from step 2. Go to the next step when all adjustment is completed.

11. Confirm the RainMap echo indication either using Sector PPI scan and Sector RHI scan. Repeat the process 9 if it did not update.

Note: Do not forget to do the [Auto ground clutter mapping] after changed value of the [AZ offset to north] and [Origin EL position offset correction]. (Refer to the Operator's manual for operation)

7.7. Uninstall the Software

Follow the instruction below to uninstall the [Solar_Position_tools], [LabVIEW^{TM} Run-time Engine 2014] software.

1. Open [Program and function] in [Control Panel].
2. Choose the name of software to uninstall.
3. Click the Uninstall button
4. Complete

Note: Choose [National Instruments Software] to uninstall [LabVIEW^{TM} Run-time Engine 2014].

7.8. Conclusion

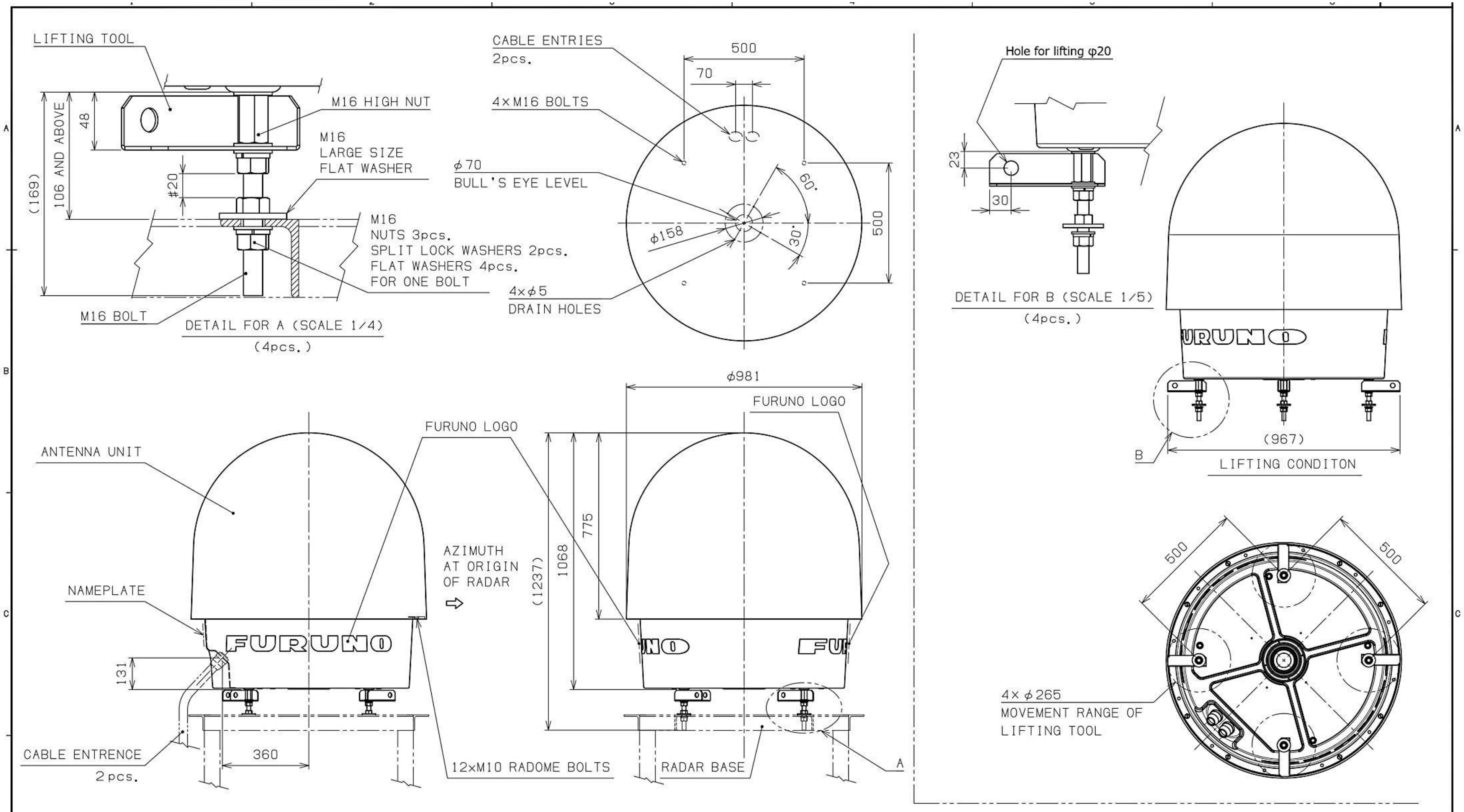
Calculation of the solar positon:

This software uses "Astronomical algorithms" created by Jean Meeus to calculate algorithms of the solar positon.
The accuracy of this algorithm on longitude is +/- 72 degrees of range within 0.0167 degrees. However accuracy depends on atmospheric temperature, pressure, and humidity. Therefore under certain circumstances accuracy may be very poor.
Currently the solar azimuth value is properly corrected when refraction of atmospheric conditions are properly considered.

Reference: U. S. Department of Commerce / National Oceanic & Atmospheric Administration / NOAA Research / Earth System Research Laboratory (ESRL)
https://www.esrl.noaa.gov/gmd/grad/solcalc/calcdetails.html

8. OUTLINE DRAWING

1) Antenna Unit



NOTE

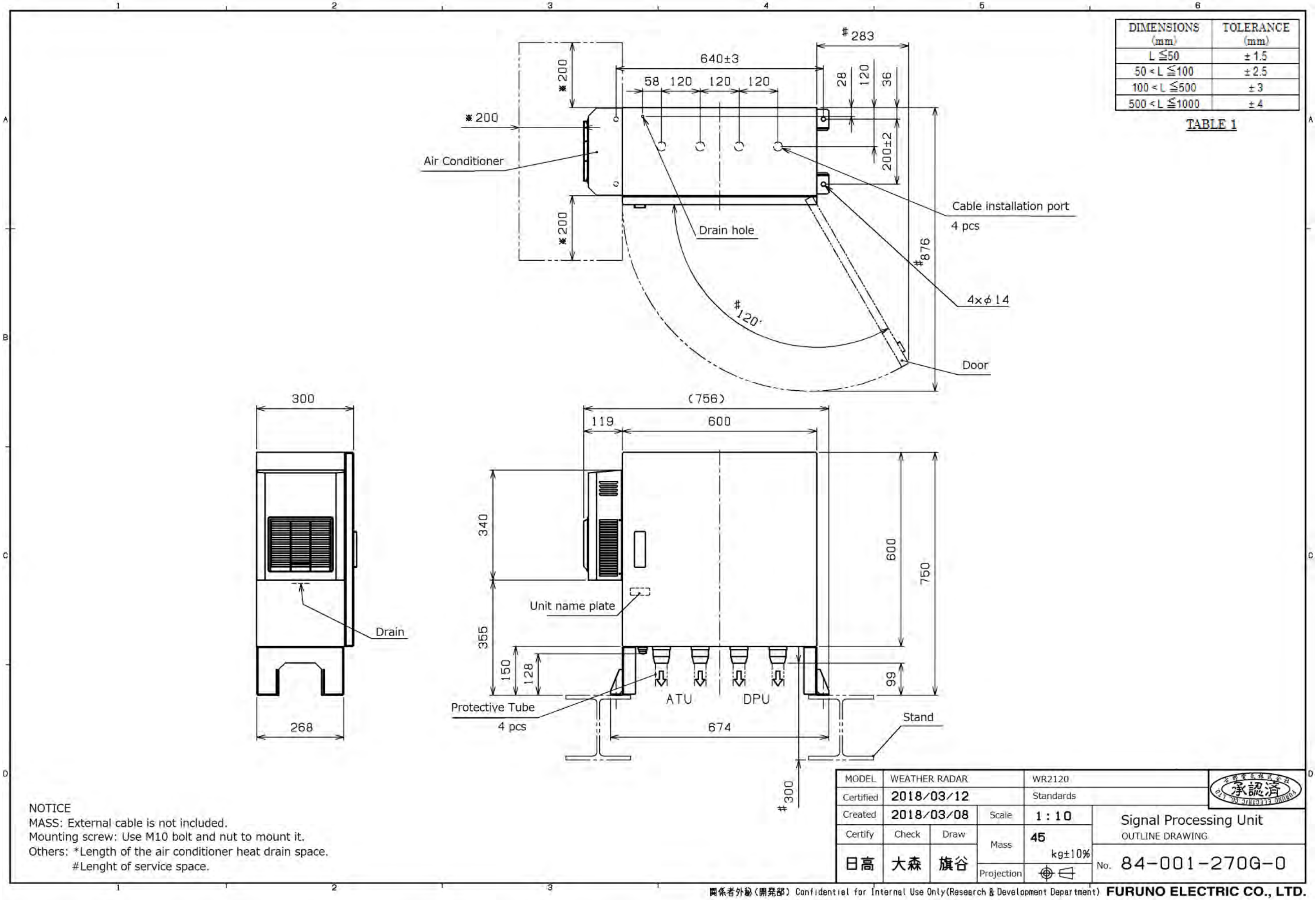
1. Table1 indicates tolerance of dimensions which is not specified.
2. Mass of lifting tools are included in mass.
3. Turn the lifting tool outward to take out the lifting holes when lifting radome.
4. Turn the lifting tool to store inside than the outside diameter of radome after mounted.

TABLE 1

DIMENSION(mm)	TOLERANCE(mm)
L≦50	±1.5
50<L≦100	±2.5
100<L≦500	±3
500<L≦1000	±4
1000<L≦2000	±5

DRAWN 14/Jun/2018 M. HATAYA		TITLE WR110-ATU
CHECKED 14/Jun/2018 G. OMORI		
APPROVED 14/Jun/2018 G. OMORI		
SCALE 1/15	MASS 68 kg±10%	NAME ANTENNA UNIT
DWG. No.	REF. No. 84-001-300G-0	

2) Signal Processing Unit (Storage box)



4) Data Processing Unit

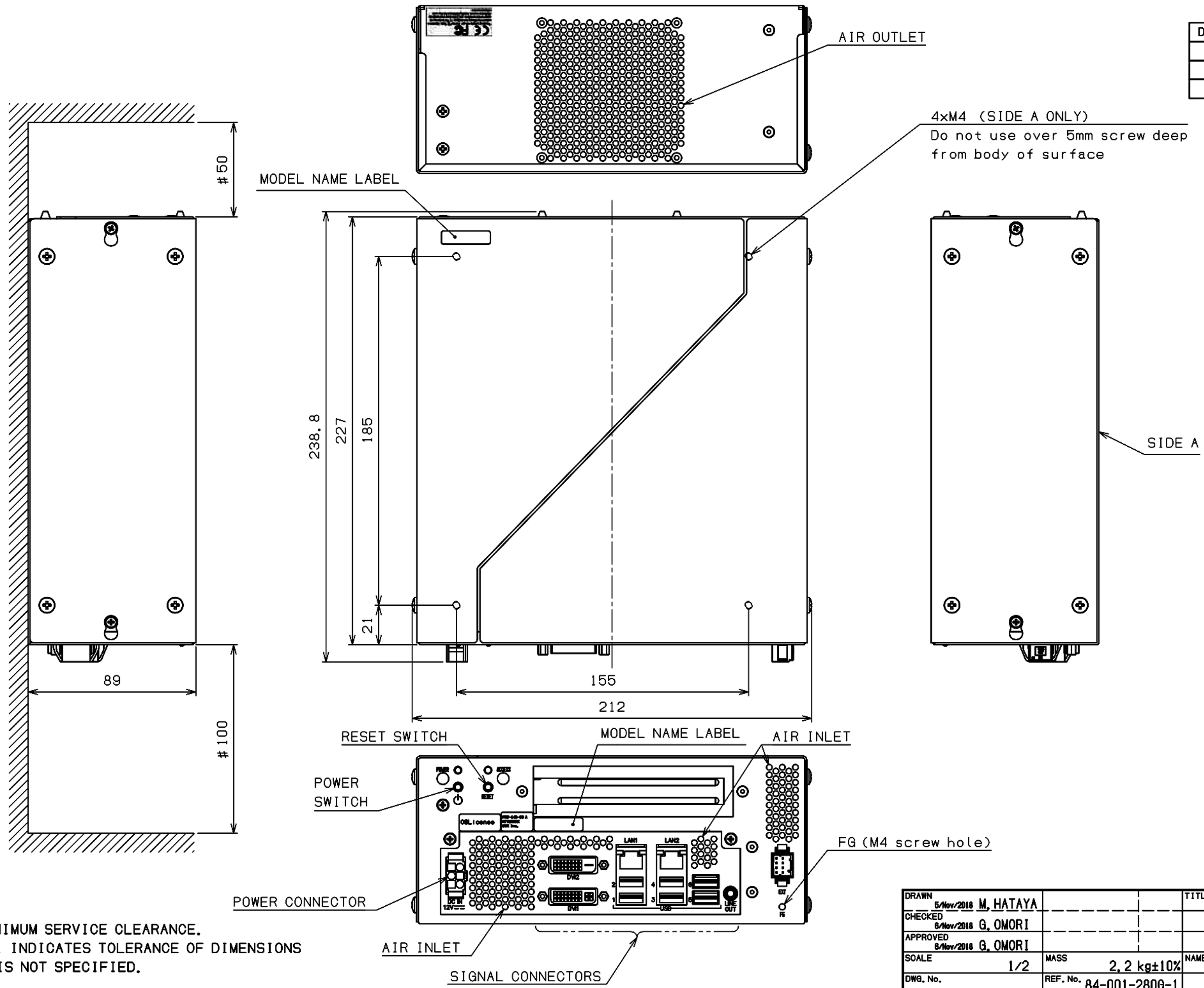


TABLE 1

DIMENSION(mm)	TOLERANCE (mm)
L≤50	±1.5
50<L≤100	±2.5
100<L≤500	±3

NOTE
1. #: MINIMUM SERVICE CLEARANCE.
2. TABLE1 INDICATES TOLERANCE OF DIMENSIONS WHICH IS NOT SPECIFIED.

DRAWN 5/Nov/2018 M. HATAYA		TITLE	WR110-DPU
CHECKED 6/Nov/2018 G. OMORI			
APPROVED 6/Nov/2018 G. OMORI			
SCALE 1/2	MASS 2.2 kg±10%	NAME	DATA PROCESSING UNIT
DWG. No.	REF. No. 84-001-2806-1		OUTLINE DRAWING

Confidential for Internal Use Only(Research & Development Department) FURUNO ELECTRIC CO., LTD.

5) Data Processing Unit (DPU Power Supply)

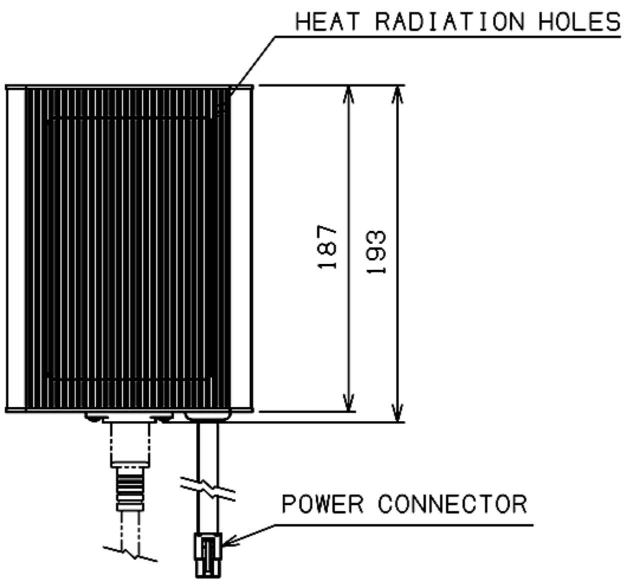
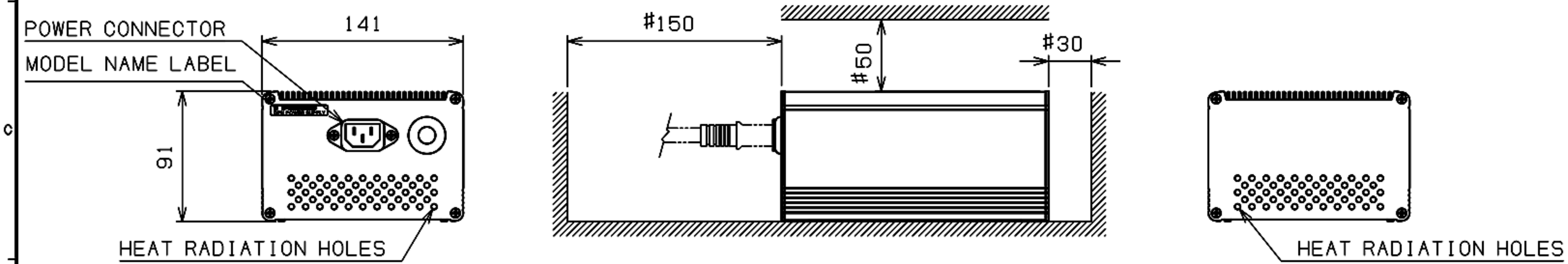


TABLE 1

DIMENSION(mm)	TOLERANCE (mm)
L≤50	±1.5
50<L≤100	±2.5
100<L≤500	±3

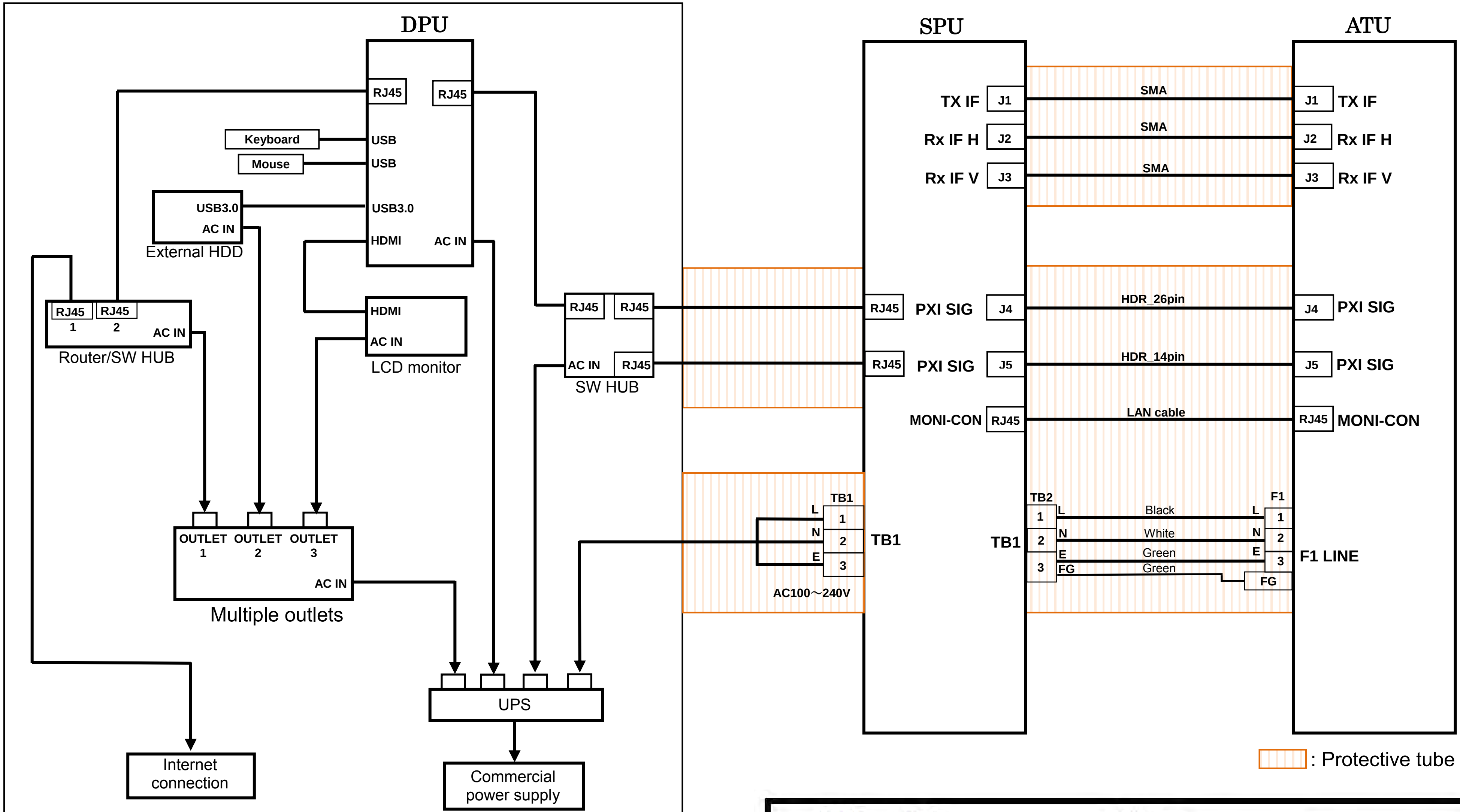


NOTE

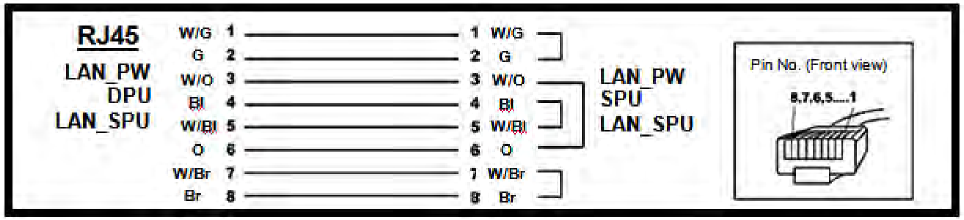
1. #: MINIMUM SERVICE CLEARANCE.
2. TABLE1 INDICATES TOLERANCE OF DIMENSIONS WHICH IS NOT SPECIFIED.

DRAWN 5/Nov/2018 M. HATAYA		TITLE	WR110-DPU-PS
CHECKED 6/Nov/2018 G. OMORI			
APPROVED 6/Nov/2018 G. OMORI			
SCALE 1/4	MASS 1.5 kg±10%	NAME	DPU POWER SUPPLY
DWG. No.	REF. No. 84-001-281G-1		OUTLINE DRAWING

9. SYSTEM DIAGRAM

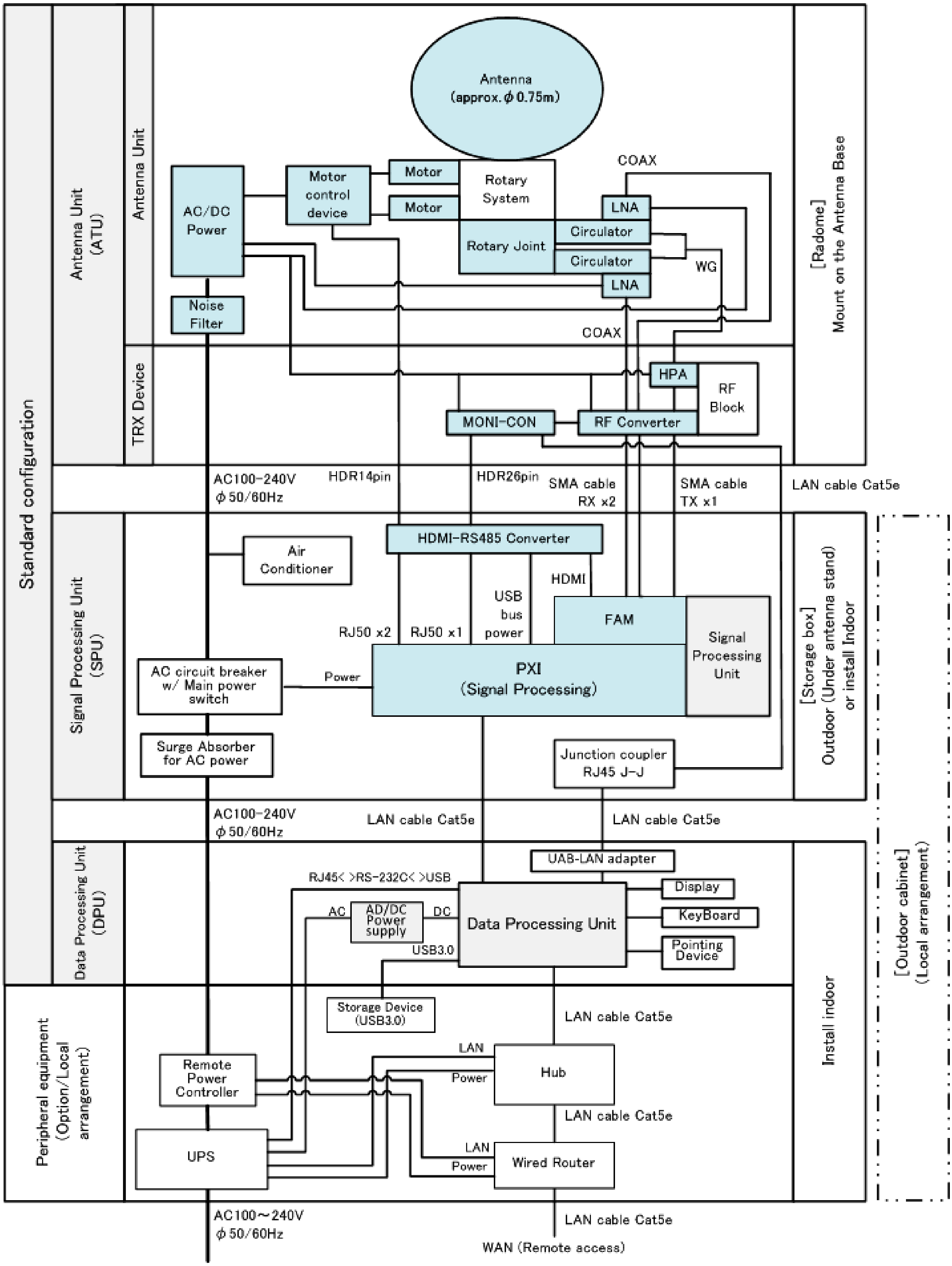


Note: All equipment in this frame except DPU (incl.keyboard) is the local supply.



Notice: All cables and protective tube between DPU side and SPU should be prepared at local.

WR2120 Configuration:



APPENDIX:

A. LIGHTNING PROTECTION ASSESSMENT

1. Introduction

This document outlines lightning protection based on the international standard IEC (International Electrotechnical Commission) 62305 series. The series consists of four documents as shown below:

IEC 62305 series: Protection against lightning
IEC 62305-1:2010 Part 1: General principles
IEC 62305-2:2010 Part 2: Risk management
IEC 62305-3:2010 Part 3: Physical damage to structures and life hazard
IEC 62305-4:2010 Part 4: Electrical and electronic systems within structure

2. Risk Assessment

2.1. Specific procedure to evaluate the need of protection

According to IEC 62305-1, the risk shall be considered in the evaluation by protection requirements against lightning. For each risk to be considered the following steps shall be taken:

– Identification of the components R_X which make up the risk;
– Calculation of the identified risk components R_X;
– Calculation of the total risk R;
– Identification of the tolerable risk R_T;
– Comparison of the risk R with the tolerable value R_T.

If $\mathrm{R} \leq \mathrm{x}R_T$, lightning protection is not necessary.
If $\mathrm{R} > R_T$, protection measure shall be adopted in order to reduce $\mathrm{R} \leq \mathrm{x}R_T$ for all risks to which the structure is subjected.
The procedure to evaluate the need for protection is given in the Figure A-1.

According to IEC 62305-2, risk components are as shown in the Table A-1.

Table A-1: Risk components (IEC 62305-2)

Components	Risks for weather radar	Remarks
Source of damage	S_1: flashes to the structure S_2: flashes near the structure S_3: flashes to the lines connected to the structure S_4: flashes near the lines connected to the structure	
Types of damage	D_3: failure of electrical and electronic systems	
Types of loss	L_2: Loss of service to the public L_4: Loss of economic value	Tolerance for L_2 and L_4: $R_T = 10^{-3}$ $[y^{-1}]$
Risks	R_2: risk of loss of service to the public R_4: risk of loss of economic values	

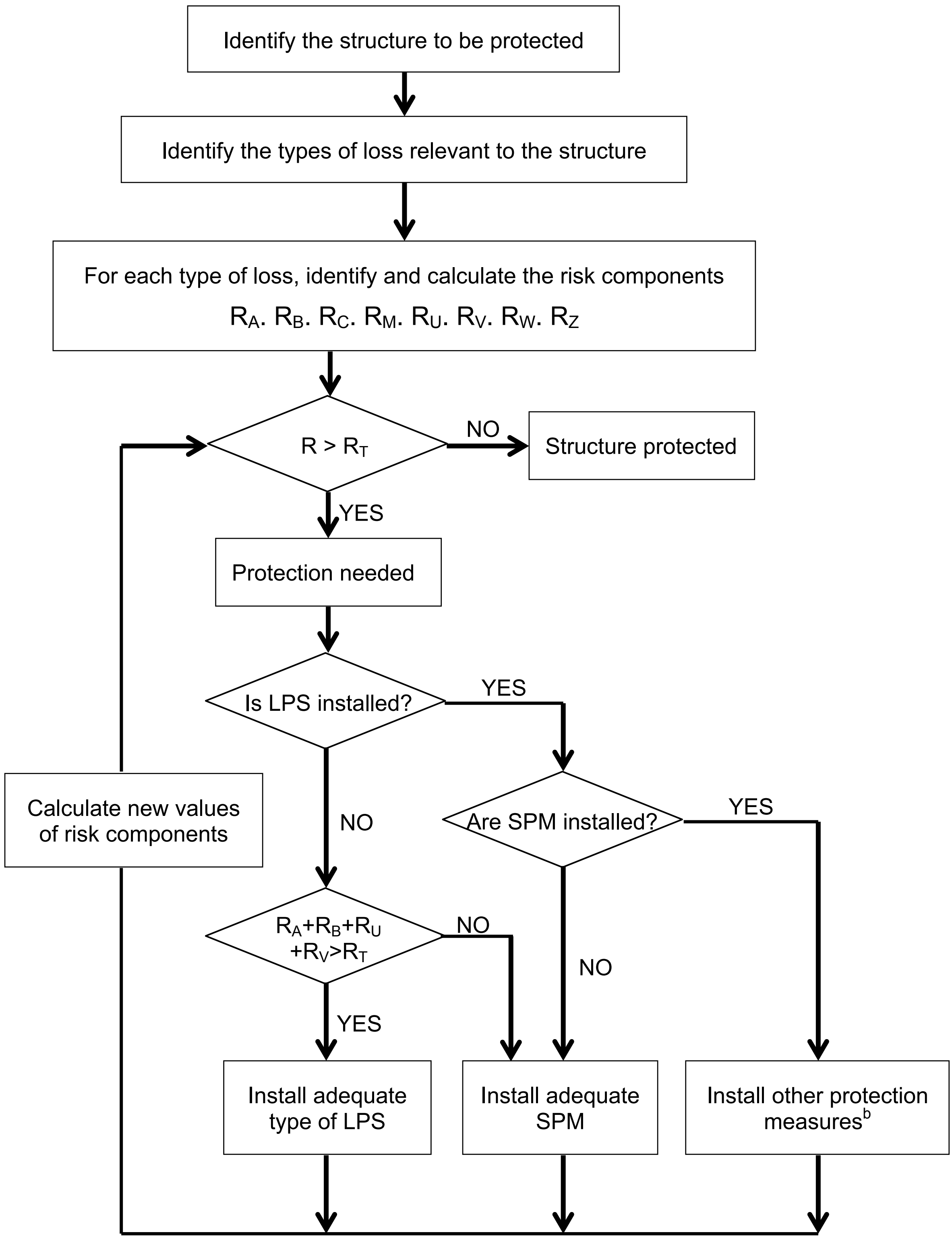


Figure A-1: Procedure for deciding the protection requirements and selecting protection measures

2.2. Assessment of Risk Components

Each risk component $R_B, R_{C,} R_M, R_V, R_W$ and R_Z, consists R_2 and R_4 may be expressed by the following general equation:

$$R_X = N_X \times P_X \times L_X$$

where

N_X is the number of dangerous events per annum

P_X is the probability of damage to a structure

L_X is the consequent loss

The number N_X of dangerous events is affected by lightning ground flash density (N_G) and by the physical characteristics of the structure to be protected, its surroundings, connected lines and the soil.

The probability of damage P_X is affected by characteristics of the structure to be protected, the connected lines and the protection measures provided.

The consequent loss L_X is affected by the use to which the structure is assigned, the attendance of persons, the type of service provided to public, the value of goods affected by the damage and the measures provided to limit the amount of loss.

2.2.1. Composition of risk components

Composition of each risk components are as follows:

R_2: Risk of loss of service to the public: $R_2 = R_{B2} + R_{C2} + R_{M2} + R_{V2} + R_{W2} + R_{Z2}$

R_4: Risk of loss of economic values: $R_4 = R_{B4} + R_{C4} + R_{M4} + R_{V4} + R_{W4} + R_{Z4}$

2.2.1.1. Risk components for a structure due to flashes to the structure

R_B: Component related to physical damage caused by dangerous sparking inside the structure triggering fire or explosion which will also endanger the environment. All types of loss (L1, L2, L3 and L4) will arise.

R_C: Component related to failure of internal systems caused by lightning electromagnetic impulse (LEMP). Loss of type L2 and L4 could occur in all cases along with type L1 in the case of structures with risk of explosion, and hospitals or other structures where failure of internal

R_M: Component related to failure of internal systems caused by LEMP. Loss of type L2 and L4 could occur in all cases, along with type L1 in the case of structures with risk of explosion, and hospitals or other structures where failure of internal systems immediately endangers human life.

2.2.1.2. Risk components for a structure due to flashes to a line connected to the structure

R_U: Component related to injury to living beings caused by electric shock due to touch voltage inside the structure. Loss of type L1 and, in the case of agricultural properties, loss of type L4 with possible loss of animals could also occur.

R_V: Component related to physical damage (fire or explosion triggered by dangerous sparking between external installation and metallic parts generally at the entrance point of the line into the structure) due to lightning current transmitted through or along incoming lines. All types of loss (L1, L2, L3 and L4) will occur.

R_W: Component related to failure of internal systems caused by overvoltages induced on incoming lines and transmitted to the structure. Loss of type L2 and L4 could occur in all cases, along with type L1 in the case of structures with risk of explosion, and hospitals or other structures where failure of internal systems immediately endangers human life.

2.2.1.3. Risk components for a structure due to flashes near a line connected to the structure

R_Z: Component related to failure of internal systems caused by overvoltage induced on incoming lines and transmitted to the structure. Loss of type L2 and L4 could occur in all cases, along with type L1 in the case of structures with risk of explosion, and hospitals or other structures where failure of internal systems immediately endanger human life.

2.2.2. Assessment of annual number N_X of dangerous events

According to the statistic information provided by the National Environment Agency of Singapore, average thunderstorm days per year (T_D) at Changi is 168. The lightning ground flash density N_G will be leaded as follows:

$$N_G \nsim E.1\, T_D = 16.8 \ \ [flashes/km^2/year]$$

2.2.2.1. Number of dangerous events N_D for the structure

N_D may be evaluated as the product:

$$N_D = N_G \times A_D \times C_D \times 10^{-6}$$

where

N_G is the lightning ground flash density $[flashes/km^2/year]$

A_D is the collection area of the structure $[m^2]$

C_D is the location factor of the structure, 0.5 for CWRP

1) Determination of the collection area A_D

For isolated structures on flat ground, the collection area A_D is the area defined by the intersection between the ground surface and a straight line with 1/3 slope which passes from the upper parts of the structure (touching it there) and rotating around it. Determination of the value of A_D will be performed graphically or mathematically.

For an isolated rectangular structure with length L, width W, and height H on flat ground, the collection area is then equal to:

$$A_D = L \times W + 2 \times (3 \times H) \times (L + W) + \pi \times (3 \times H)^2$$

where L, W and H are expressed in meters.

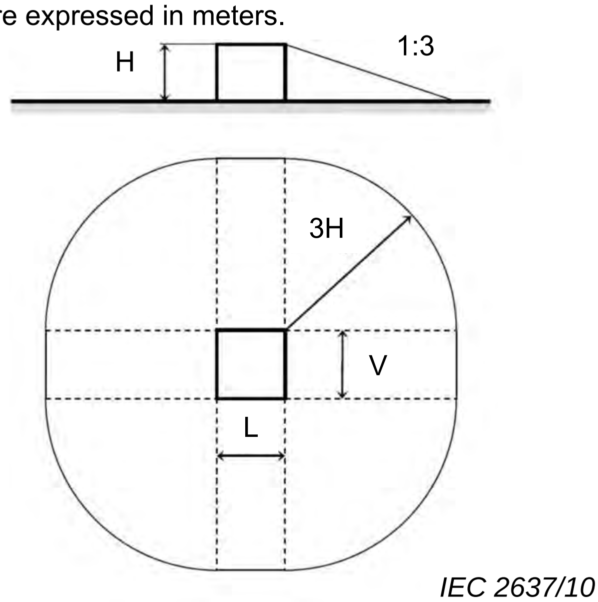


Figure A-2: Collection area $\boldsymbol{A_D}$ of an isolated structure (IEC 62305-2)

2) Relative location of the structure

The relative location of the structure, compensating for surrounding structures or an exposed location, will be taken into account by a location factor C_D. For the weather radar at CWRP, $C_D = 0.5$ (Structure surrounded by objects of the same height or smaller).

2.2.2.2. Assessment of the average annual number of dangerous events N_M due to flashes near a structure

N_M may be evaluated as the product:

$$N_M = N_G \times A_M \times 10^{-6}$$

where

$[flashes/km^2/year] N_G$ is the lightning ground flash density

A_M is the collection area of flashes striking near the structure $[m^2]$

The collection A_M extends to a line located at a distance of 500 m from the perimeter of the structure:

$$A_M = 2 \times 500 \times (L + W) + \pi \times 500^2$$

where length L and width W of the structure are expressed in meter. Therefore the A_M and N_M will be leaded as follows:

$$A_M = 2 \times 500 \times (0.95 + 0.95) + \pi \times 500^2 = 787298.16$$
$$N_M = 16.8 \times 787298.16 \times 10^{-6} = 13.227$$

2.2.2.3. Assessment of the average annual number of dangerous events N_L due to flashes to a line

$$N_L = N_G \times A_L \times C_I \times C_E \times C_T \times 10^{-6}$$

Therefor $C_I = 1,\ C_T = 1,\ C_E = 0.01,\ A_L = 2000$ for CWRP condition, $N_L = 3.36 \times 10^{-4}$

2.2.2.4. Assessment of the average annual number of dangerous events N_I due to flashes near a line

$$N_I = N_G \times A_I \times C_I \times C_E \times C_T \times 10^{-6}$$

Therefor $C_I = 1,\ C_T = 1,\ C_E = 0.01,\ A_I = 200000$ for CWRP condition, $N_L = 3.36 \times 10^{-2}$

2.2.3. Assessment of probability P_X of damage

The probabilities are given in the Annex B of IEC 62305-2. Based on practical condition, the values are shown in the Table A-2.

Table A-2: Values of probability $\boldsymbol{P_X}$ depending on the protection measures to reduce physical damage

Characteristics of structure	LPL	$\boldsymbol{P_B}$	$\boldsymbol{P_C}$	$\boldsymbol{P_M}$	$\boldsymbol{P_V}$	$\boldsymbol{P_W}$	$\boldsymbol{P_Z}$
No protection device	—	1	1	1	1	1	1
Protected by required components	IV	0.2	0.05	1.04×10^{-5}	0.05	0.05	0.05
	III	0.1	0.05	1.04×10^{-5}	0.05	0.05	0.05
	II	0.05	0.02	4.15×10^{-6}	0.02	0.02	0.02
	I	0.02	0.01	2.07×10^{-6}	0.01	0.01	0.01

2.2.4. Assessment of amount of loss L_X

The values of amount of loss L_X should be evaluated and fixed by the lightning protection designer (or the owner of the structure). The typical mean values of loss L_X in a structure given in the Annex C of IEC 62305-2 are merely values proposed by the IEC.

The loss L_X refers to the mean relative amount of a particular type of damage for one dangerous event caused by a lightning flash, considering both its extent and effects. The loss value L_X varies the type of loss considered the weather radar will be classified to L2 and L4.

Table A-3: Type of loss L2 and L4: Loss values for each type of damage

	Type of damage	
Loss	D2	D3
L2	$L_B = L_V = r_p \times r_f \times L_F \times n_z / n_t$	$L_C = L_M = L_W = L_Z = L_O \times n_z / n_t$
L4	$L_B = L_V = r_p \times r_f \times L_F \times (c_a + c_b + c_c + c_s) \times c_t$	$L_C = L_M = L_W = L_Z = L_O \times c_s / c_t$

where

L_O is the typical mean relative value of all goods damaged by failure of internal systems (D3) due to one dangerous event. It will be 10^{-2} for structures of hospital, industrial, office, hotel and commercial.

L_F is the typical mean relative value of all goods damaged by physical damage (D2) due to one dangerous event. It will be 0.5 for structures of hospital, industrial, museum and agricultural.

r_f is the factor reducing the loss due to physical damage depending on the risk of fire. It will be 0 for the weather radar.

Finally, we can get the values as follows:

$$L_B = L_V = 0$$
$$L_C = L_M = L_W = L_Z = 10^{-2}$$

2.3. Risk Assessment Conclusion

Values of the risk components for the unprotected structure are reported in the regulation.

The public service loss (L2) and the economic loss (L4) are relevant for this type of structure. It is required to evaluate the need for protection. This implies the determination of the risk R_2 for L2 and risk R_4 for L4 with the risk components R_B , R_C , R_M, R_V, R_W and R_Z and to compare it with the tolerable risk $R_T = 10^{-3}$. Suitable protection measures will be selected to reduce the risk to or below the tolerable risk.

According to the IEC 62305-2, calculation of the risk parameters is shown as follows:

Table A-4: Risk components for different types of damage and source of damage (IEC 62305-2)

Damage	Source of damage			
	S1	S2	S3	S4
D2	$R_B = N_D \times P_B \times L_B$		$R_V = (N_L + N_{DJ}) \times P_V \times L_V$	
D3	$R_C = N_D \times P_C \times L_C$	$R_M = N_M \times P_M \times L_M$	$R_W = (N_L + N_{DJ}) \times P_W \times L_W$	$R_Z = N_I \times P_Z \times L_Z$

Calculation of the risk components requirement is as shown in the Table A-5.

Table A-5: Weather radar at CWRP: Environment and structure characteristics

Input parameter	Symbol	Value
Ground flash density $[1/\mathrm{km}^2/\mathrm{year}]$	N_G	16.8
Number of over voltages [1/year]	N_D	2.709×10^{-3}
	N_{DJ}	0
	N_M	13.227
	N_L	3.36×10^{-4}
	N_I	3.36×10^{-2}
Structure dimensions [m]	L, W, H	0.95, 0.95, 3.177
Location factor of structure	C_D	0.5

Use the エラー! 参照元が見つかりません。A-4 and the Table A-5, risk assessment result will be calculated. The result is shown in the Table A-6. Therefore considering current condition, the weather radar is not protected by existing lightning rods. Total risk value is exceeded of the tolerable risk value.

We'll propose solution for this later, protecting the radar by additional lightning rod and adapt LPL Class IV. Assessment for this solution is also shown in the Table A-6. According to the result is almost half of the tolerable risk value, so the condition of the radar turned into safe.

Table A-6: Risk assessment result at CWRP

Type of damage	Symbol	Current Condition	Protected by LPL IV
D2: Physical Damage	R_B	0	0
	R_V	0	0
D3 failure of internal systems	R_C	0.01	0.0005
	R_M	0.1323	1.37×10^{-6}
	R_W	3.36×10^{-6}	1.68×10^{-7}
	R_Z	3.36×10^{-4}	1.68×10^{-5}
Total		0.134	0.00052
Tolerable $R_T = 0.001$		NG	Safety

3. Solution: Ways to make a current installation safer

Lightning protection level definition

Lightning protection level (LPL) is defined in the regulation based on peak current. LPL will be selected for installation situations where LPL IV is generally used. Protection area will be made using rolling sphere, its radius is determined in the Table A-7. Example of an actual condition is shown in the Figure A-3.

Table A-7: Probability and rolling sphere radius for LPL (IEC 62305-1)

LPL	Probability for min value	Minimum peak current [kA]	Probability for max value	Minimum peak current [kA]	Rolling sphere radius [m]
I	0.99	3	0.99	200	20
II	0.97	5	0.98	150	30
III	0.91	10	0.95	100	45
IV	0.84	16	0.95	100	60

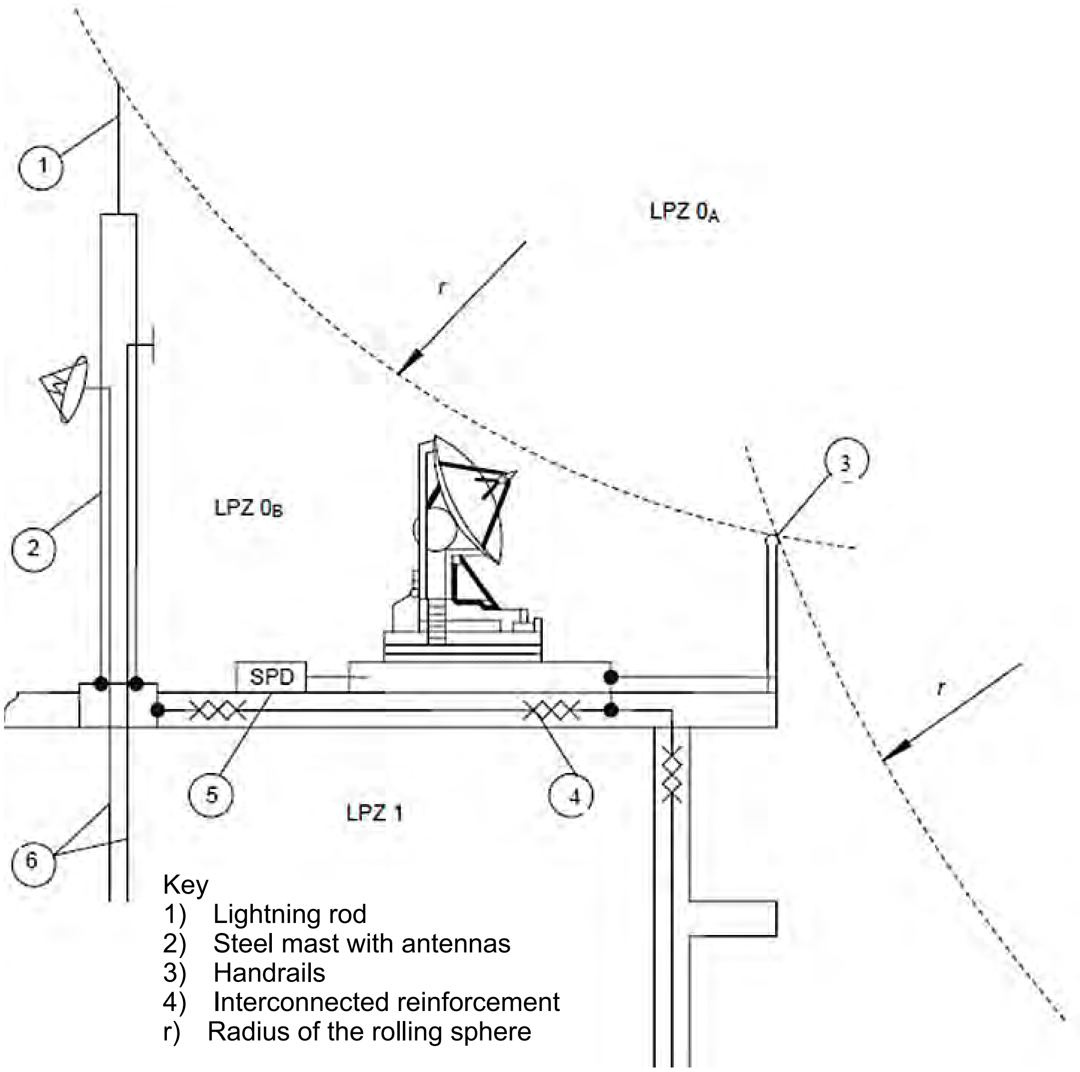


Figure A-3: Protection of aerials and other external equipment (IEC 62305-4)

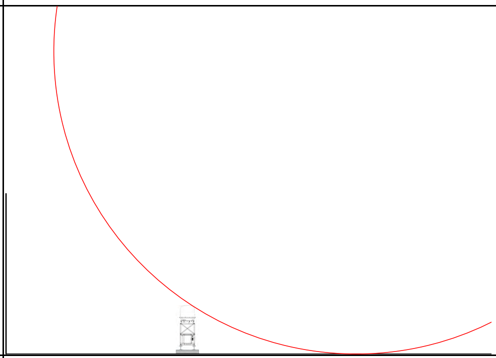
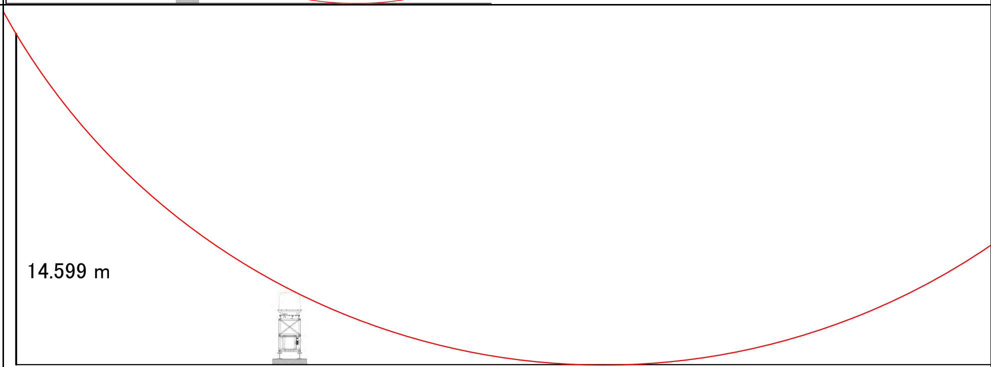
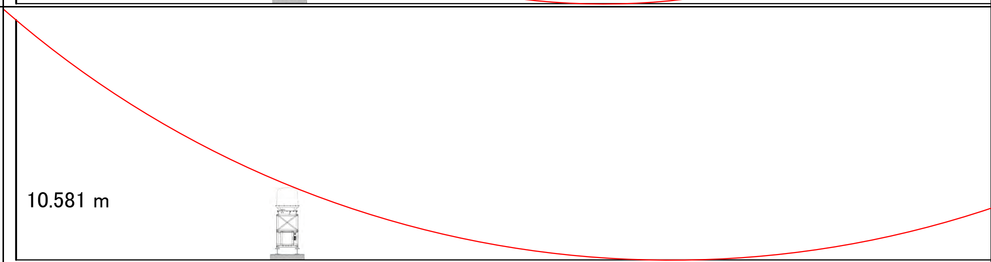
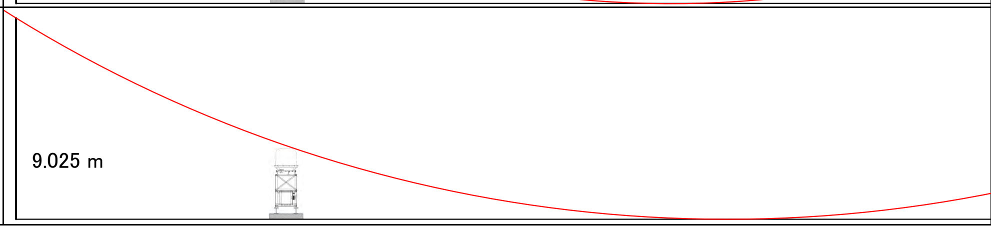
3.2. Modification Plan

As shown in Table A-6 the current condition is not enough to protect the weather radar. We would propose the following modification plan to protect the weather radar.

3.2.1. Extend existing lightning rod

We installed new lightning rod to protect the radar, but it is insufficient due to some restrictions. Now we are considering how to adapt the LPL by extending the lightning rod.
As shown in Table 8 we need to extend the rod at least 5.1 m from the current length, but it is not allowed due to site height restrictions.

Table A-8: Required extension for the existing lightning rod

LPL	Condition	Height [m]
I		Too far from the rod
II		14.6
III		10.6
IV		9.1

3.2.2. Add extra lightning rod

This is an example of adding a lightning rod to compensate for existing lightning rod limitations:

It is installed next to a chimney, 8 meters away from the radar. In this case the chimney is fixed, therefore it is better to install a new lightning rod as shown in Figure A-4.

The weather radar will be properly covered by the combination of new and existing lightning rods.

The height requirement for the new lightning rod for each LPL is shown in Table A-9. The length will be selected depending on the height limitation, therefore it is better to use a longer one.

Unfortunately in this case it is not enough for protecting the weather radar from lightning.

In order to provide a solution for this situation we suggest adding a new lightning rod installed nearby.

Basically a newly prepared rod should be designed as long as possible, but it needs to be within the height limitation.

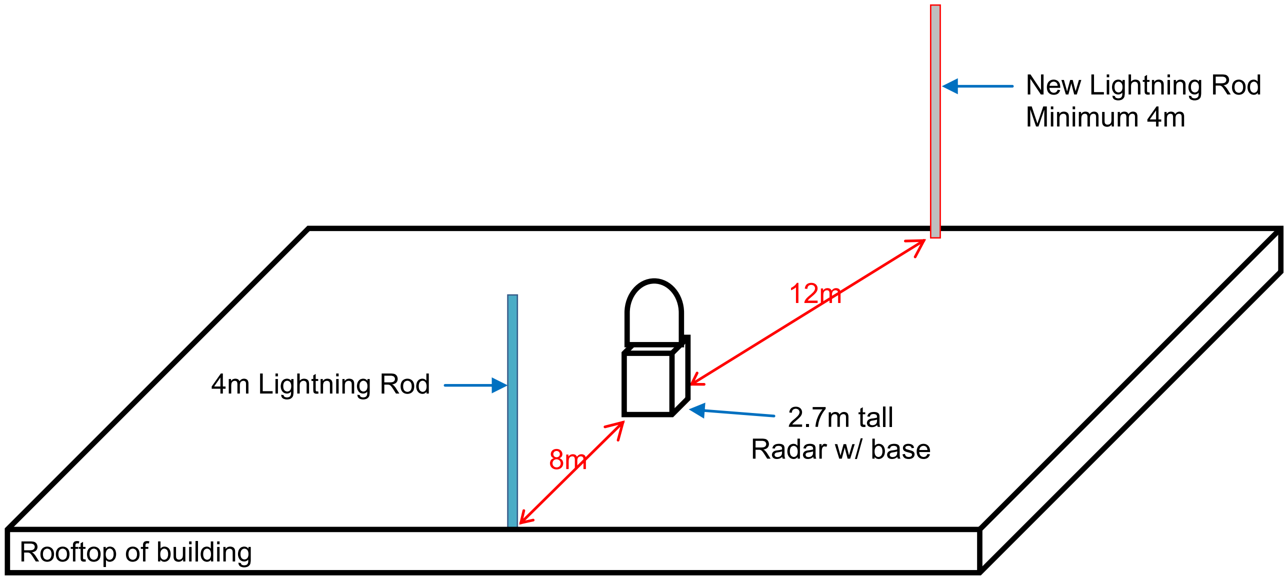
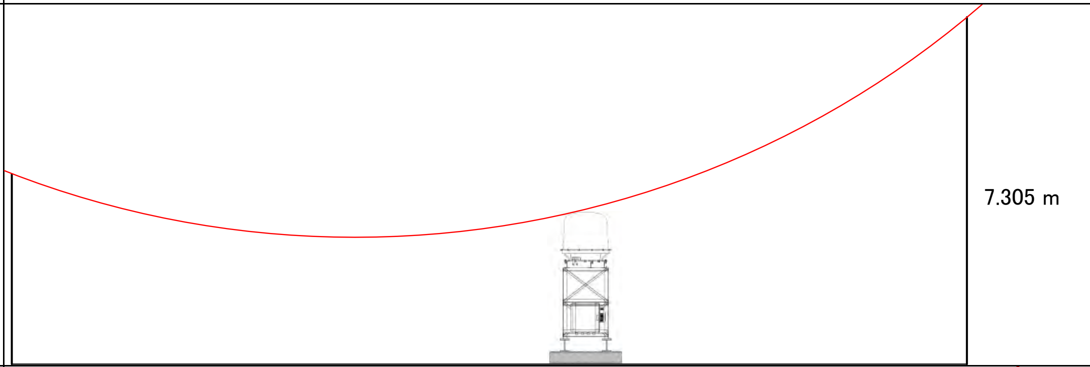
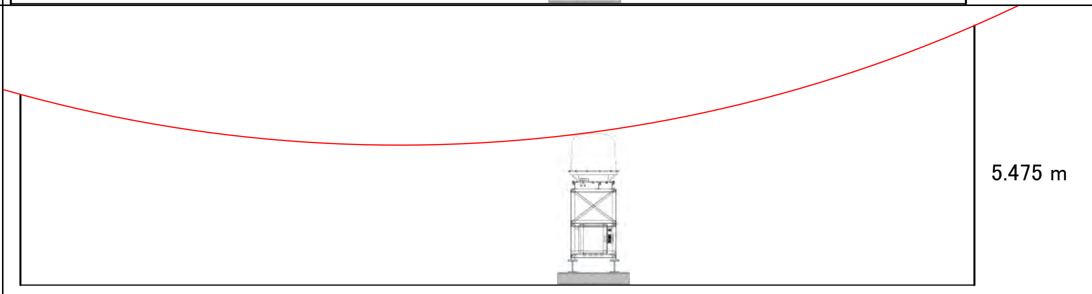
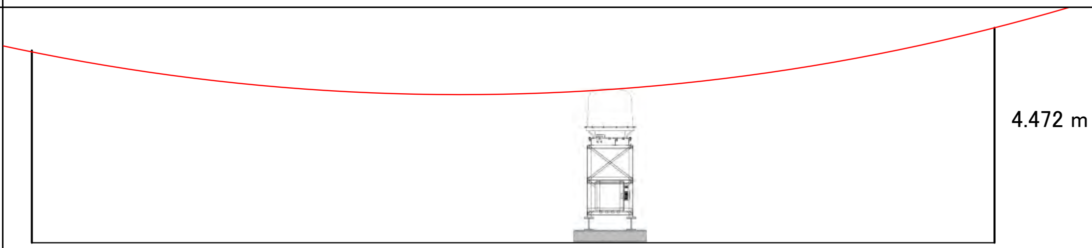
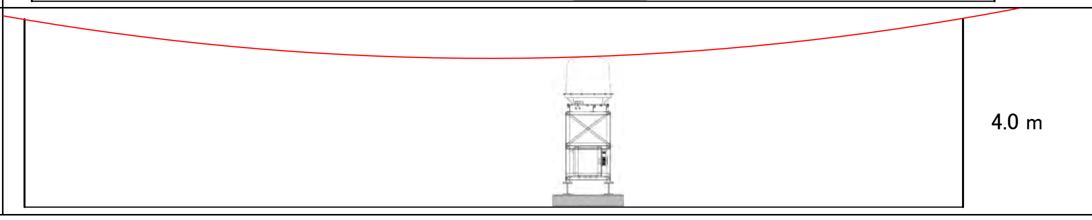


Figure A-4: Drawing at rooftop and candidate place to install the new lightning rod

Table A-9: Height requirement for the new lightning rod

LPL	Condition	Height [m]
I		7.4
II		5.5
III		4.5
IV		4.0

4. Protection of Structures Against Lightning

4.1. Old lightning and angle of protection standard

Old standard stated the protection angle of lightning rods for protecting of people from lightning, electrical facilities, petroleum complexes, gas tanks, plant, and equipment was 60º or less for general buildings. Factory handling hazardous materials such as explosives, flammable gas, liquids, and etc., would be slightly narrower as 45º. Because these specifications were old they did not take height in consideration. Also the protection area was too large and therefore not safe enough even within the protection angle.

The basic data of this standard was created using results of an experiment that tested using an artificial lightning generation apparatus. Since the electrical discharge size generated was too small when compared to actual lightning, it was found that the experiment data results varied from actual lightning observation.

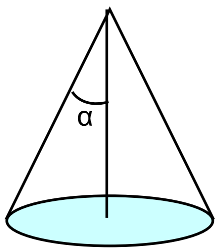


Figure A-5:
Protection range
α: Protected angle

4.2. New standard lightning and angle of protection

Lightning rod height and protection efficiencies were revised when IEC standards were renewed in 2003, replacing the older 1990 standard. The angle of protection decreases as the height of protected structure gets higher. Any protection level of structure over 60 meters will not be enacted in the protection angle because a lightning rod is ineffective for buildings over 60 meters when a side-on lighting strike hits side of a building.

Protection level	Protection efficiency	Rolling sphere method Radius(m)	Protection angle method (height: h)	Mesh method (m)
I	0.98	20	See Figure 6 below	5
II	0.95	30		10
III	0.9	45		15
IV	0.8	60		20

*: Applicable only to rolling sphere and mesh methods.

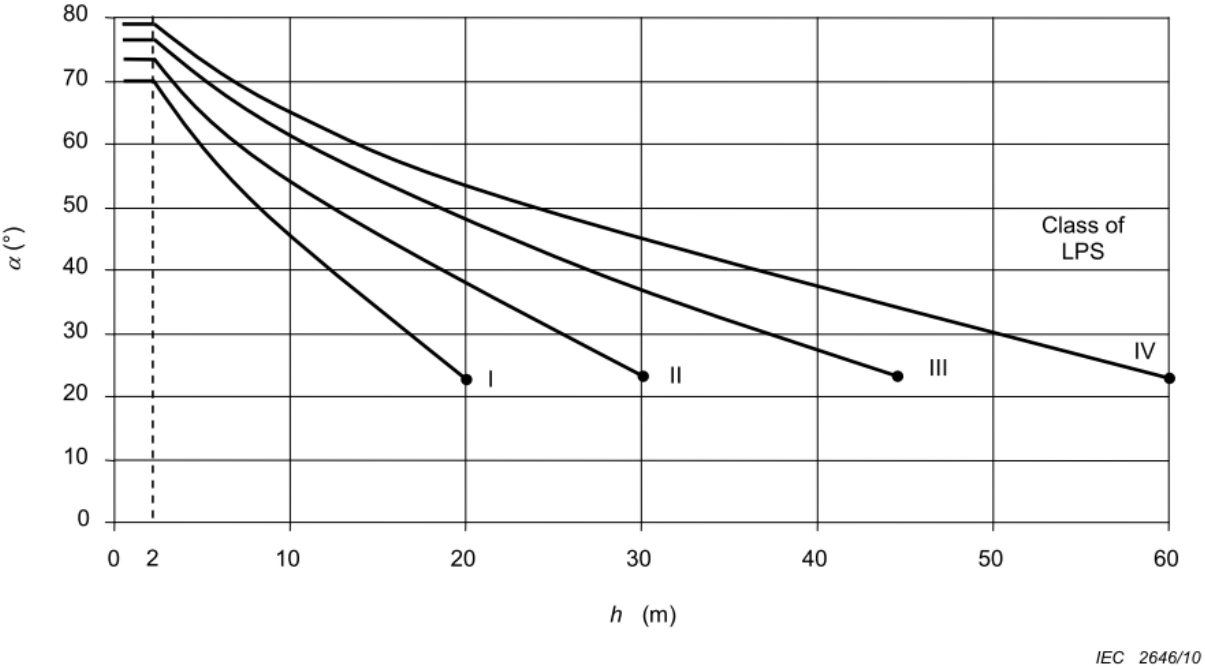


Figure A-6: Protection angle corresponding to the class of LPS (IEC62305-3)

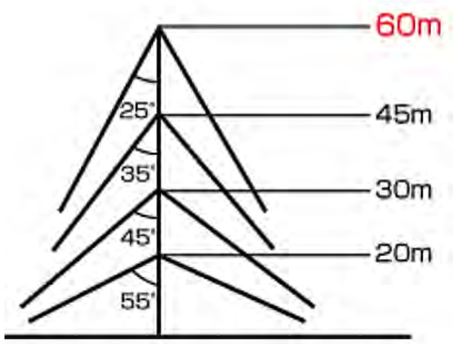


Figure A-7:
Lightning rod angle of protection at protection level IV (Protection efficiency 0.80)

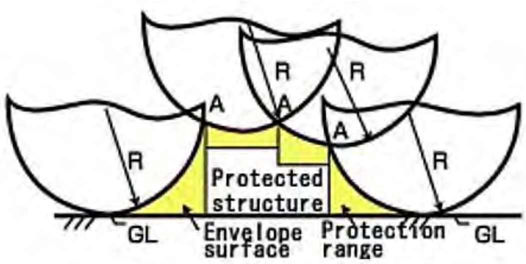


Figure A-8:
Protective range of rolling sphere method

5. Conclusion

For some installations it is difficult to add a tall lightning rod because of area height regulations and restrictions. It may be necessary to carefully consider all potential lightning protection solutions.

B. COMMUNICATION NETWORK

Radar needs an internet connection to provide remote maintenance service, main operation, and transfer of collected observation data.

There are several types of communication network in the world. Only the following types are fast enough to support proper radar operations.

1) Cable (Broadband Internet Connection): Through the use of a cable modem you can have a broadband Internet connection that is designed to operate over cable TV lines. Cable Internet works by using TV channel space for data transmission, with certain channels used for downstream transmission, and other channels for upstream transmission. Because the coaxial cable used by cable TV provides much greater bandwidth than telephone lines, a cable modem can be used to achieve extremely fast access. Cable providers typically implement a cap to limit capacity and accommodate more customers. Cable speeds range is approx. 512 Kbps to 20 Mbps.

2) Wireless Internet Connections: or wireless broadband is one of the newest Internet connection types. Instead of using telephone or cable networks for your Internet connection, you use radio frequency bands. Wireless Internet provides an always-on connection which can be accessed from anywhere — as long as you geographically within a network coverage area. Wireless access is still considered to be relatively new, and it may be difficult to find a wireless service provider in some areas. It is typically more expensive and mainly available in metropolitan areas.

3) T (Tier / Transmission System) -1 Line (Lease Line): A popular leased line option for businesses connecting to the Internet and for Internet Service Providers (ISPs) connecting to the Internet backbone. It is a dedicated phone connection supporting data rates of 1.544Mbps. A T-1 line actually consists of 24 individual channels, each of which supports 64Kbits per second. Each 64Kbit/second channel can be configured to carry voice or data traffic. Most telephone companies allow you to buy just one or some of these individual channels. This is known as fractional T-1access. T-1 Lines support speeds of 1.544 Mbps. Fractional T-1 speeds are 64 Kbps per channel (up to 1.544 Mbps), depending on number of leased channels. T-1 standards is basically use in ANSI, Northern America. There is a similar type (actually consists of 30 individual channels, each of which supports 64Kbps (up to 2.048Mbps)) in Europe called E-1 Line.

4) Bonded T-1: Two or more T-1 lines that have been joined (bonded) together to increase bandwidth. Where a single T-1 provides approximately 1.5Mbps, two bonded T1s provide 3Mbps or 46 channels for voice or data. Two bonded T-1s allow you to use the full bandwidth of 3Mbps where two individual T-1s can still only use a maximum of 1.5Mbps at one time. To be bonded the T-1 must run into the same router at the end, meaning they must run to the same ISP. Typical Bonded T-1 (two bonded T-1 lines) speed is around 3 Mbps.

5) T-3 Lines (Dedicated Lease Line): Dedicated phone connections supporting data rates of about 43 to 45 Mbps. It too is a popular leased line option. A T-3 line actually consists of 672 individual channels, each of which supports 64 Kbps. T-3 lines are used mainly by Internet Service Providers (ISPs) connecting to the Internet backbone and for the backbone itself. A typical T-3 support speeds ranging is approx. 43 to 45 Mbps. T-3 is a bigger, faster, more expensive version of T1. It can get up to 44Mbitps upload and download speeds. It is great for medium/large businesses, as it provides a good deal of bandwidth. T2, T4, T5 all exist as well, with the higher numbers being faster, however T1 and T3 are the more common ones. T-3 standards is basically use in ANSI, Northern America. There is a similar type (16 individual channels (34.368Mbps/480 channel)) in Europe called E-3 Line.

6) OC3 (Optical Carrier): Short for Optical Carrier, level 3 it is used to specify the speed of fiber optic networks conforming to the SONET standard. OC3 is typically used as a fiber optic backbone for large networks with large voice, data, video, and traffic needs. Speeds are 155.52 Mbps, or roughly the speed of 100 T1 lines.

7) IoS (Internet over Satellite): It allows a user to access the Internet via a satellite that orbits the earth. A satellite is placed at a static point above the earth's surface, in a fixed position. Because of the enormous distances signals must travel from the earth up to the satellite and back again, IoS is slightly slower than high-speed terrestrial connections over copper or fiber optic cables. Typical Internet over satellite connection speeds (standard IP services) average around 492 up to 512 Kbps.

8) Fiber Optic Network: The fastest way to access the Internet, but it's also the most expensive. Fiber converts electrical signals to light which travels through tiny glass filaments. Transmission speeds vary greatly depending on several factors, including the distance between the transmitting location and the receiving location, the amount of bandwidth allotted by the Internet service provider, and use of the fiber-optic lines for other services. The FCC says that most modern fiber connections transmit at speeds of tens to hundreds of Mbps faster than other broadband options

Summary:

We recommend you to use the fiber optical network or any faster network for transferring the weather observation data to the data center server or office. If the radar location does not have access to any fast network (up/download minimum 8 Mbps constantly) but can connect to a wireless network then use the internet just for remote operation and save the data to an external HDD. A 6TB HDD can save up to 6 months of data depending on observation settings without requiring network transfer.

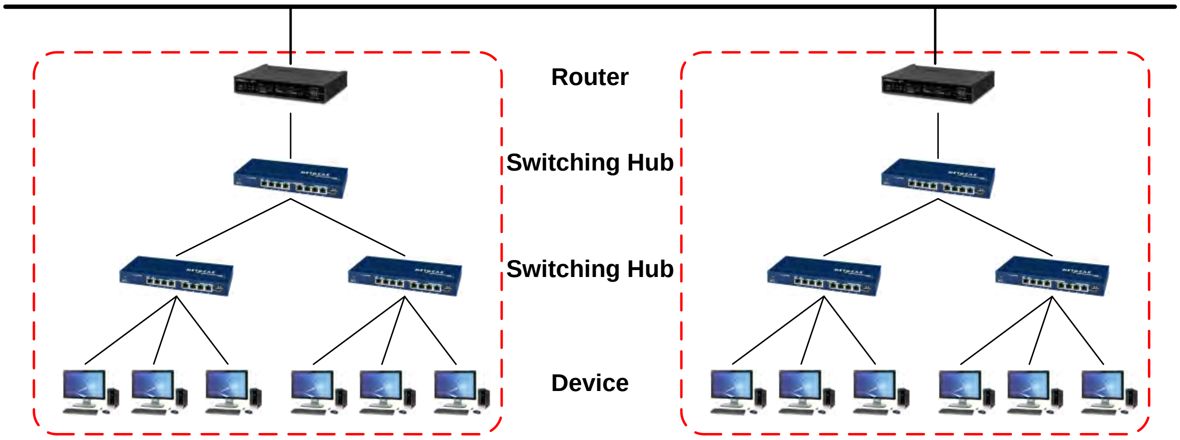
In addition there are ISP’s (Internet Service Provider) that may make a separate contract to provide internet access with a suitable communication network (DSL, wireless, fiber optic network, etc.).

A LAN (Local Area Network) setting must be made for using internet access on DPU. First it requires an IP (Internet Protocol) address setup in DPU. An IP address is basically a numerical form address that identifies the location of DPU device. This is similar to a home address. It is 4 sets of numbers between 0 and 255 (these represent 8 bits or 8 ones and zeros).
In order for a device to send information on a local area network when connected to the same switch it needs a "private" IP address. These usually fall within the 192.168.X.X or 10.X.X.X realm. X represents a number between 0 and 255.
Once it reaches the Internet via a router it needs to have a "unique" IP address called a "public" IP. This is given by an Internet Service Provider. Every computer has its own unique number which cannot be duplicated on the Internet. Any traffic for this IP address will be routed to it.
Computers need their own numbers. However there is no way to remember the IP of all websites. To help DNS was created. DNS is the Domain Name System and it translates the web address into an actual "public" IP. It can be displayed by using the command prompt (start > run > type cmd.exe) and type “ping” for the web address. At first there is a pause while DNS translates the IP and then it will display the ping as the unique IP address number formatted as xxx.xxx.xxx.xxx which is specific to the web address’s web server.

The SPU system is using IPv4: 192.168.1.55 and it is using the private address inside LAN.

Class	Start	End	Subnet mask	No. of addresses
A	10.0.0.0	10.255.255.255	255.0.0.0	16,777,216
B	172.16.0.0	172.1.255.255	255.240.0.0	1,048,576
C	192.168.0.0	192.168.255.255	255.255.0.0	65,536

It also must setup the Subnetwork and Subnet mask. Address space of subnetwork is indicated by subnet mask. Ex. Subnet mask is 255.255.255.0, which supports 254 addresses.
Regarding IP address, 0 indicates the network itself, 255 is a broadcast address. In this case it can use xxx.xxx.xxx.1 to xxx.xxx.xxx.254



Address space: 192.168.1.0 / 24
Subnet mask: 255.255.255.0

Address space: 192.168.2.0 / 24
Subnet mask: 255.255.255.0

When choosing LAN cable it is important to note use of Category of Ethernet cables, Cat. 5e (enhanced category 5) or better quality is required. Larger category numbers have better shielding.
General uses and easy to purchase cables are unshielded and called UTP (unshielded twist pair)
Note: STP (shielded twist pair) is required which is same as marine products. Maximum length of about 50 meters between switch and device is best to keep consistent data transfer. For LAN cable lengths longer than 50 meters, fiber optic cable with media converters should be used.

Check the marking on cables to ensure compatibility

C. STORAGE MEDIA

Hard Disk Drive (HDD) uses several types of connecting interfaces. If using an external HDD for saving observed data it should use USB 3.0 or faster interface because of large data files.
Transfer speed of USB2.0 is 480Mbps, and USB3.0 is 4Gbps.

Standard USB have 2 types:

USB2.0 (High Speed)	HI-SPEED CERTIFIED USB
USB3.0 (SuperSpeed) **USB3.1 (SuperSpeed)**	SUPERSPEED CERTIFIED USB

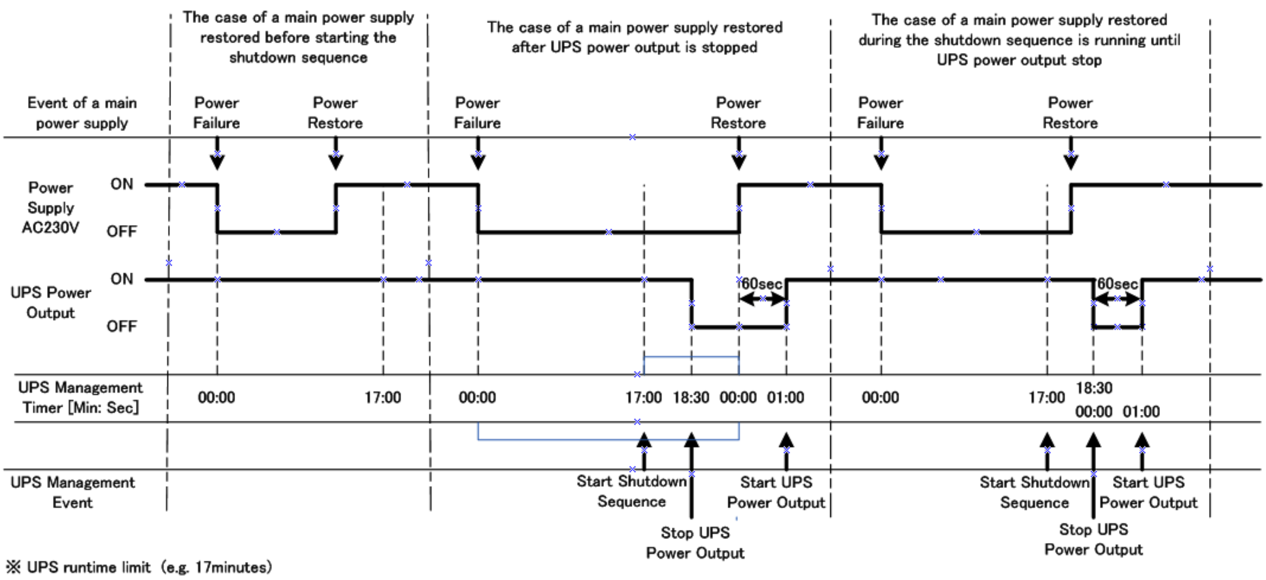
Although not standardized generally insulator color of USB 3.0 is blue, and USB 3.1 is teal blue.

D. UPS SETTING

Try to prepare a high function UPS to avoid PC data loss during power outages and immediate shutdown that damage the internal circuitry of the PC mainly hard disk. There is a function to send a command to shut down the PC before run out of UPS battery. Reference information of setting UPS is shown below. (It describes from APC Smart-UPS 1500RM model)

General	Power Parameters	High Transfer [V]	265	
		Low Transfer [V]	196	
		Sensitivity	High	
		Nominal Output [V]	220	
		Audible Warning	On Battery	
Server Shutdown	Shutdown Sequence	Command File	Not Enabled	
		Operating System	Delay [mins]	00:00
			Duration [mins]	01:30
	Power Failure	When power fails, begin a shutdown procedure	At runtime limit	
		When power returns, reboot UPS	After the following occurs	Battery charges to 0% And the elapsed time is: 60sec
		Shutdown Type	Shutdown	

Note: Rest of the above settings would be default settings.



E. TEAMVIEWER (Remote control management tool)

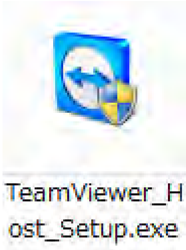
NOTE: This software is the place allows using remote control via internet. If your facility is prohibited of using it, please uninstall this software. Furthermore, TeamViewer may behave as unauthorized access.

1. Installation

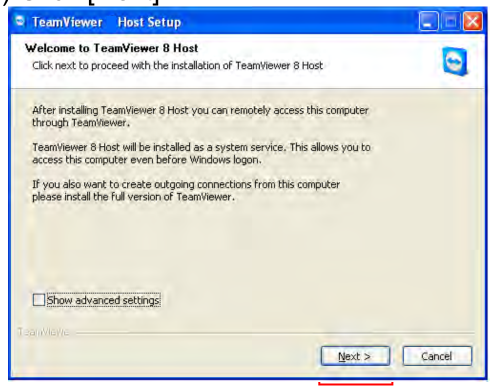
1. Download the software of TeamViewer “**Host**” (For remote server) from the following web site:
   https://www.teamviewer.com/ja/download/
2. Double click “TeamViewer_Host_Setup.exe” to install the software.

Note: Operator who wants to access by remote to the host TeamViewer must need the local TeamViewer with the same or newer version. Moreover, the host software must be installed version 12 or newer.

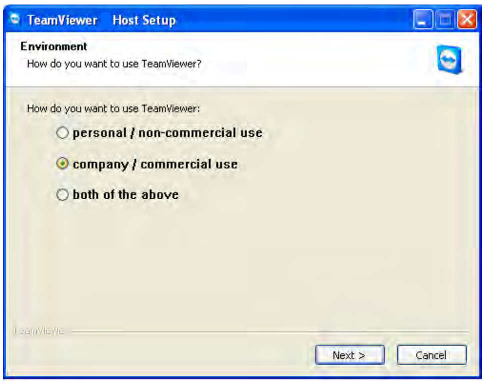
(1) Double click the icon



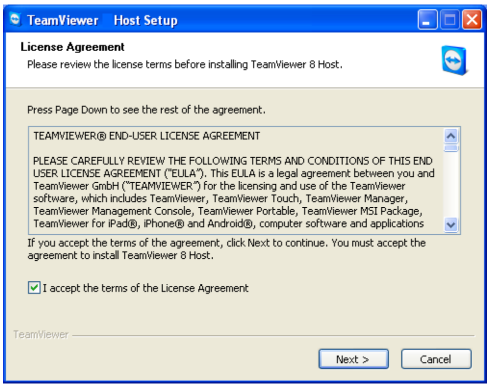
(2) Click [Next]



(3) Select “company / commercial use”, and then click [Next]

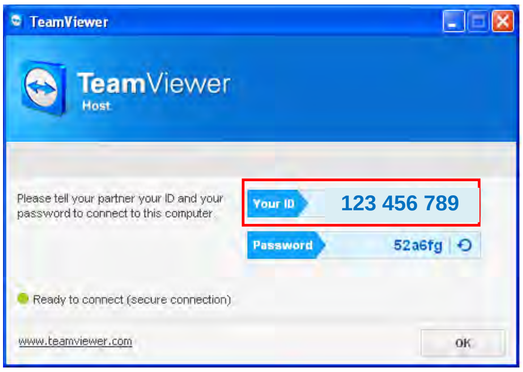


(4) Check on “License Agreement”, and then click [Next]



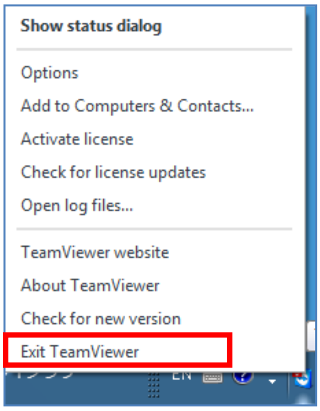
(5) Make password and computer name
Password: rmsrms (enter this password)
Computer name: Enter location’s name
and then click [Exit]

(6) “Your ID” will be issued automatically.
(* Remember this ID)
And then click [OK]



3. After installed software, please inform “Your ID” to the headquarter of Furuno who is in charge.
4. Use other DPU to confirm remote access by TeamViewer.

2. Uninstallation



1) Change the login user to the “Control” account. (See the password from APPENDIX A.2. in the operator’s manual)

2) If TeamViewer icon is in the task bar, click “Exit Teamviewer” to close the software.

3) From the Start Menu, select Control Panel.

4) Under Programs click the Uninstall a Program link.

5) Select the program (TeamViewer) to remove and right click then select Uninstall/Change.

6) Follow the prompts to finish the uninstallation of the software.

ECF
(Elemental Chlorine Free)
The paper used in this manual
is elemental chlorine free.

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