Discussion on regional radar network and radar exchange
(Weather Radar Maintenance)

6th February 2018

Shuichi Inoue

General Manager
Business Development Department
Japan Radio Co., Ltd.

Operation and Maintenance of the Meteorological Radar

1. Relation of maintenance and radar equation

- Radar equation considering Z-R relation
- Reflection intensity(dBZ) → Precipitation intensity (mm/h) Conversion

2. Various maintenance items for the radar equipment

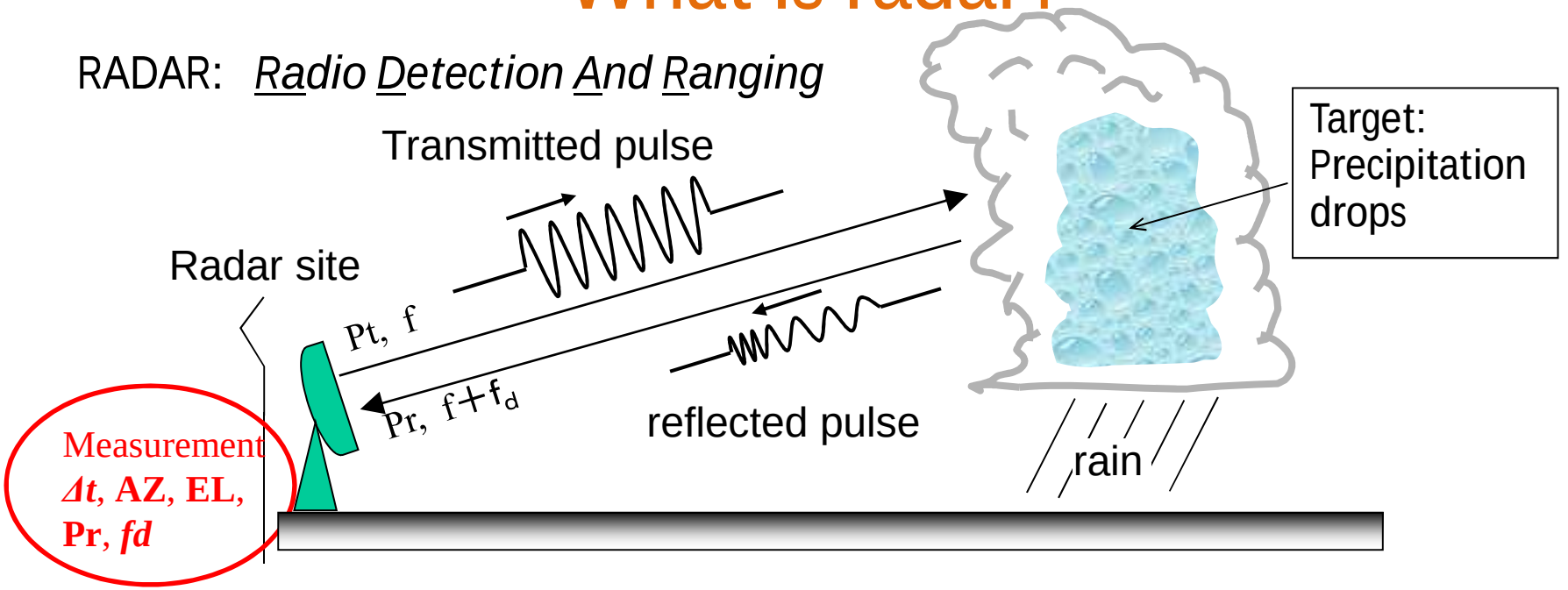
- The Purpose of Periodic Maintenance and Calibration
- Periodic Maintenance for Each Equipment (Daily, Weekly, Monthly, 6 Monthly)

3. Caution point

- Basic precautions
- Caution for using the test instruments
- Precautions for handling special tubes
- Cleaning and Check

What is radar?

RADAR: *Radio Detection And Ranging*



- ***Δt*** : time of each pulse propagation → ***Δt=2r / c*** → ***r = cΔt / 2*** distance between radar and target
  c: light velocity
- **AZ, EL, *r*** → Direction and height of the target

} distribution of the precipitation

- **Pr** : received power → Radar equation
  Pr $= (Rc \cdot Z / r^2) \cdot 10^{-0.2 \cdot kg \cdot r}$
  Z : radar reflectivity factor
  Rc : radar constant
  → ***Z-R*** relation $Z = B \cdot R^{\beta}$

} rain rate

- f_d : doppler frequency → $V = f_d \cdot \lambda / 2$
  V : Doppler velocity
  λ : wave length

} air flow within precipitation area

Periodic Maintenance Items

- Antenna and Antenna Controller Specifications

(1) Type 4 m in Diameter Parabolic Dish Antenna
(2) Gain More than 42 dB
(3) Beam Width less than 1.2 degrees
(4) Polarization Horizontal
(5) Rotation Speed 4 rpm +/- 5 %
(6) EL Angle Range -2 to +45 degrees
Lower 1st limit: -3 degrees
Lower 2nd limit: -5 degrees
Upper 1st limit: +46 degrees
Upper 2nd limit: +48 degrees

$$Rc = \frac{\pi^3}{2^{10}\log_e 2} \cdot \frac{P_t \cdot h}{\lambda^2} \cdot G_0^2 \cdot \theta_1 \cdot \phi_1 \cdot \left| \frac{\varepsilon - 1}{\varepsilon + 2} \right|^2$$

dBZ・mm/h

$$Z = B \cdot R^{\beta} \qquad \text{(Z: mm6/m3, R: mm/h)}$$

In Japan, B = 200 and β = 1.6 are adopted.

- Precipitation intensity(mm/h) → Reflection intensity (dBZ) Conversion

$$\text{Reflection intensity (dBz)} = 10\log_{10} Z = 10\log_{10}(B \cdot R^{\beta})$$
$$= 10\log_{10}\left(200 \times \text{Precipitation intensity(mm/h)}^{1.6}\right)$$
$$= 10\log_{10}(200) + 16\log_{10}\left(\text{Precipitation intensity(mm/h)}\right)$$
$$= 23 + 16\log_{10}\left(\text{Precipitation intensity(mm/h)}\right)$$

- Reflection intensity(dBZ) → Precipitation intensity (mm/h) Conversion

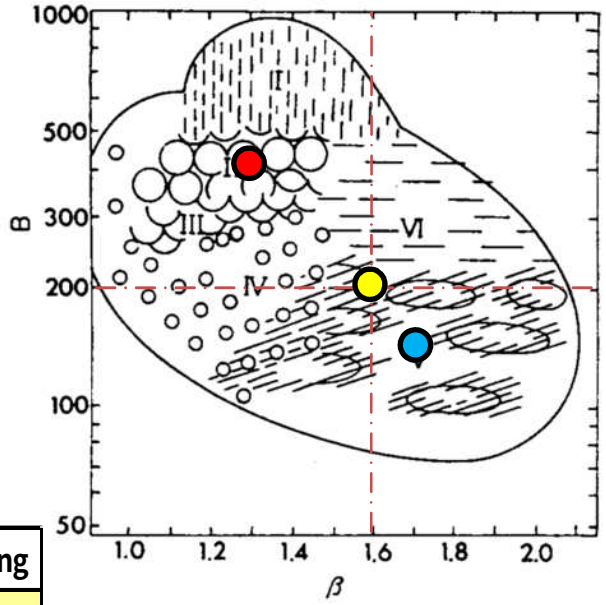
$$\text{Precipitation intensity(mm/h)} = 10^{\left[\frac{\text{Reflection intensity (dBz)} - 23}{16}\right]}$$

Z – R Relation

The relation between radar reflectivity factor Z and rain rate R [mm/h] is expressed statistically as follows :

$$Z = BR^{\beta}$$

(rain) B：80～1000 (snow) B：500～2000
β：1.0～2.0 β：2.0



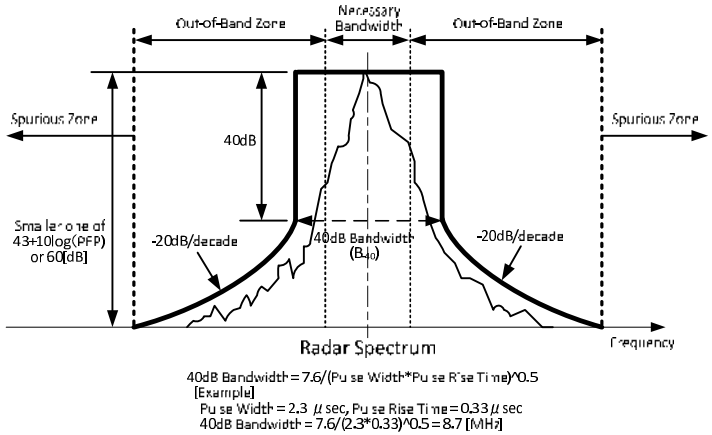
Type of rain	B	β	Weak ← The strength of the rain [mm/h] → Strong					
JMA	200	1.6	0.50	1.0	4	16	64	256
II	400	1.3	0.25	0.6	3.2	18	98	540
(Convective)			50%	59%	81%	111%	153%	211%
V	130	1.7	0.67	1.3	4.8	18	65	238
(Stratiform)			134%	129%	119%	109%	101%	93%

Comparison of rainfall when using B and β of JMA standard, **II**, **V** in the figure on the right.
Showing percentages are comparison with JMA standard.

I：Scattered but somewhat heavy portion of thunderstorm echo, or high, isolated, convective echo in dry atmospheric air (water drops evaporate considerably).
II：Center portion where thunderstorm echo is dominant, or strong, massive echo with slightly scattered shape.
III：Breaking out or growing stage of the convective cells.
IV：Small, solid-like, convective echoes scattered or aligned.
V：Stratiform echoes uniformly spread, or scattered weak echoes.
VI：Final stage of thunderstorm completely scattered, or scattered portions.

The Purpose of Periodic Maintenance and Calibration

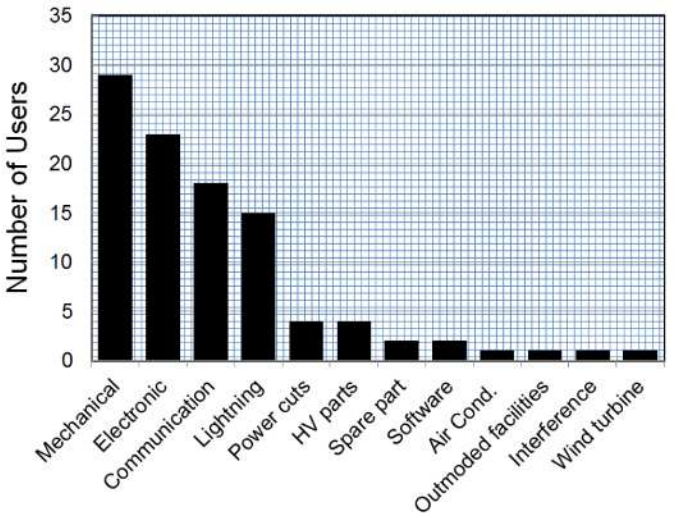
- To achieve a certain level of data quality
- To keep to the regulations
  - Quality of radio wave from radar is regulated by the Radio Law and related regulations.



Spurious Zone and Out-of-band Zone for the Radar

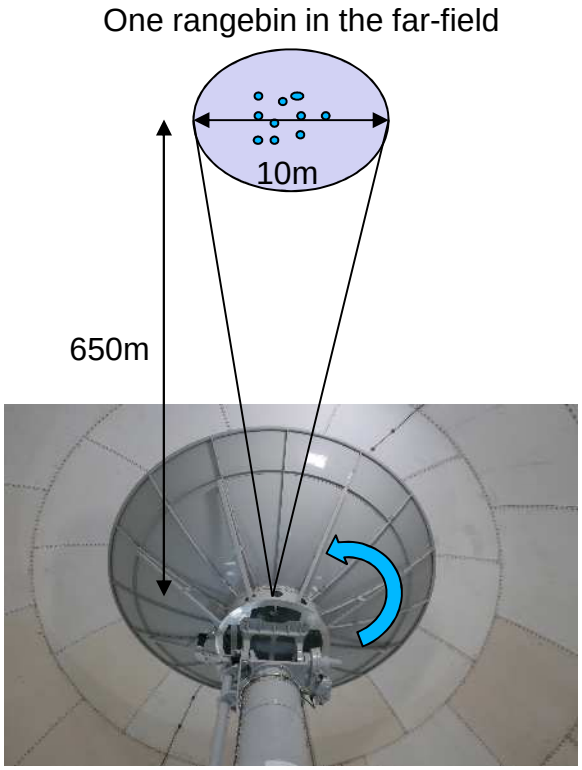
- In order to prevent critical failure in radar system and equipment

Parameter	Definition	Acceptable accuracy [a]
ϕ	Azimuth angle	0.1°
γ	Elevation angle	0.1°
V_r	Mean Doppler velocity	1.0 m s^{-1}
Z	Reflectivity factor	1 dBZ
σ_v	Doppler spectrum width	1 m s^{-1}
Zdr	differential reflectivity	*0.2 dB*
K_{DP}	specific differential phase	*< 0.5 degree km^{-1}*
ρ_{HV}	cross-polar correlation	*0.001*

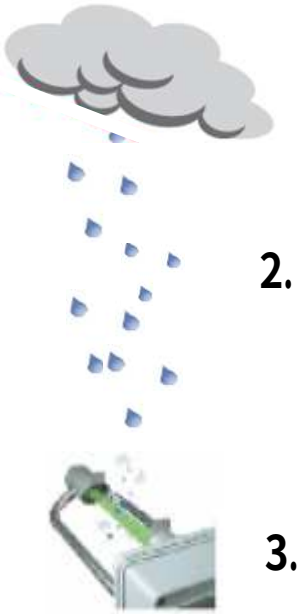


Radar Failure Modes: Results from the WMO Weather Radar Survey showing the main failure modes of a radar (2010)

Radar Calibration



AZ Scan at 90 ° EL



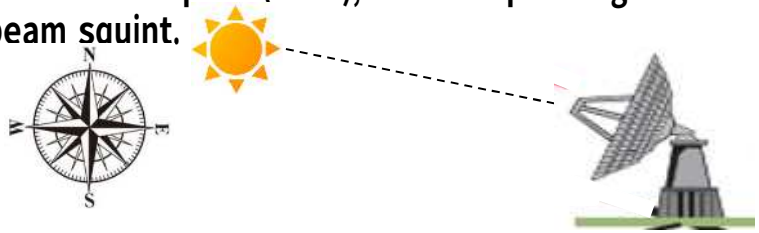
Disdrometer

The key assumption of the method is that ZDR is zero when looking at falling raindrops from below.

The difference is that only range bins are considered where we have Zh > 20 dBZ and ρ_{hv} > 0.98.

1. Solar flux measurement:

Monitoring the receiver sensitivity, differential offset of the receive path (ZDR), antenna pointing accuracy, beam squint.



2. Absolute calibration:

Using measurements of AZ scan at 90 ° EL and disdrometer measurements at the radar sites.

3. System differential offsets of ZDR and Φ_{DP}:

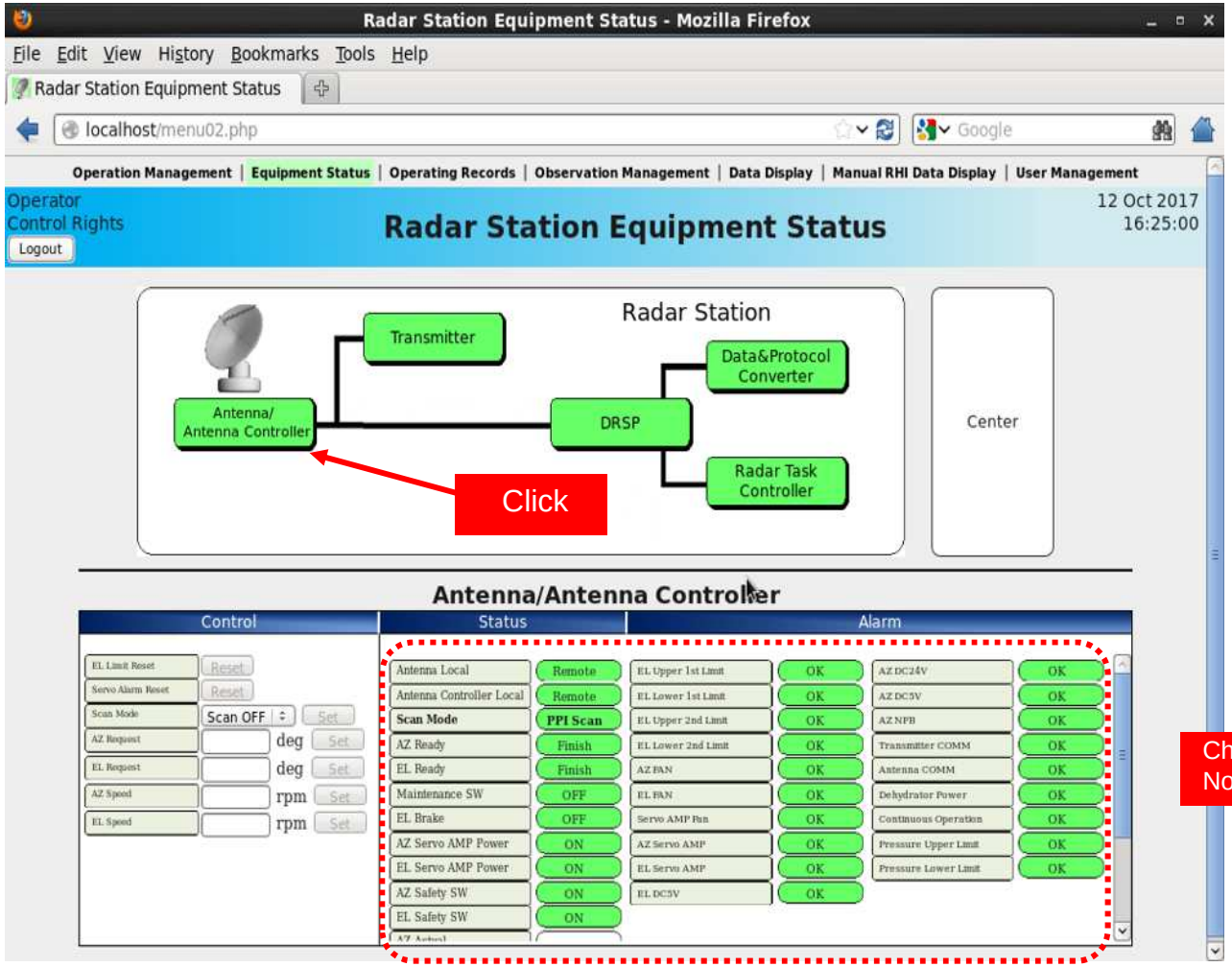
Using measurements of an operational AZ scan at 90 ° EL.

The ZDR offset is currently a static offset which has to be set manually. It is part of a list of processing parameters needed by the signal processor to compute ZDR.

Periodic Maintenance of the Radar Equipment

1. Periodic maintenance is really important not only keeping a good condition of the radar system but also keeping a good quality of the radar data.
2. Carrying out a periodic maintenance is very useful to understand the current condition of the radar system.
3. The radar system should be checked and maintained periodically as daily, weekly, monthly and 6 monthly.
4. For daily inspection, it is carried out through remote control from the central monitoring station.
5. For 6 monthly inspection, it is carried out in cooperation with a person in the radar management office and necessary to stop the regular observation for the monthly and 6 monthly check and maintenance
6. Results of the periodical maintenance must be recorded in the log book.

Daily Maintenance Items



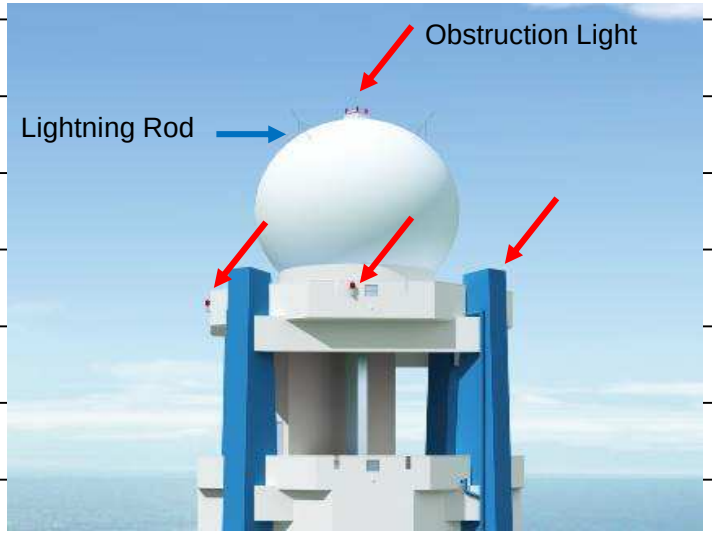
Check
No RED Color Indicator

Periodic Maintenance Items for Radome

(1) Radome

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items	Interval
Water Leaking (trace) in the radome	3
Panel surface	
scratch, cracking, peeling, dirt	6
Panel joint caulking	
peeling, cracking, dirt	6
Lightning rod and grounding cable	6
Aviation obstruction lights	D
Panel surface cleaning	5 years



Periodic Maintenance Items for Antenna

(2) Antenna (1/2)

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items		Interval
Azimuth and elevation drive section		
	Motor, reducer, gear, brake	6
	Motor brush, coupling or drive belt	6
	Lubricant (grease, oil), leakage	6
Slip-ring and brush		
	Contact surface of slip-ring and brush	1
	Brush powder, brush remaining	1
Rotary-joint and waveguide		
	Rotation sound, squeaking noise, rotation smoothness	6
	Deformation, asperity, joint cracks, air leakage	6
Angle detector, Limit switch		6

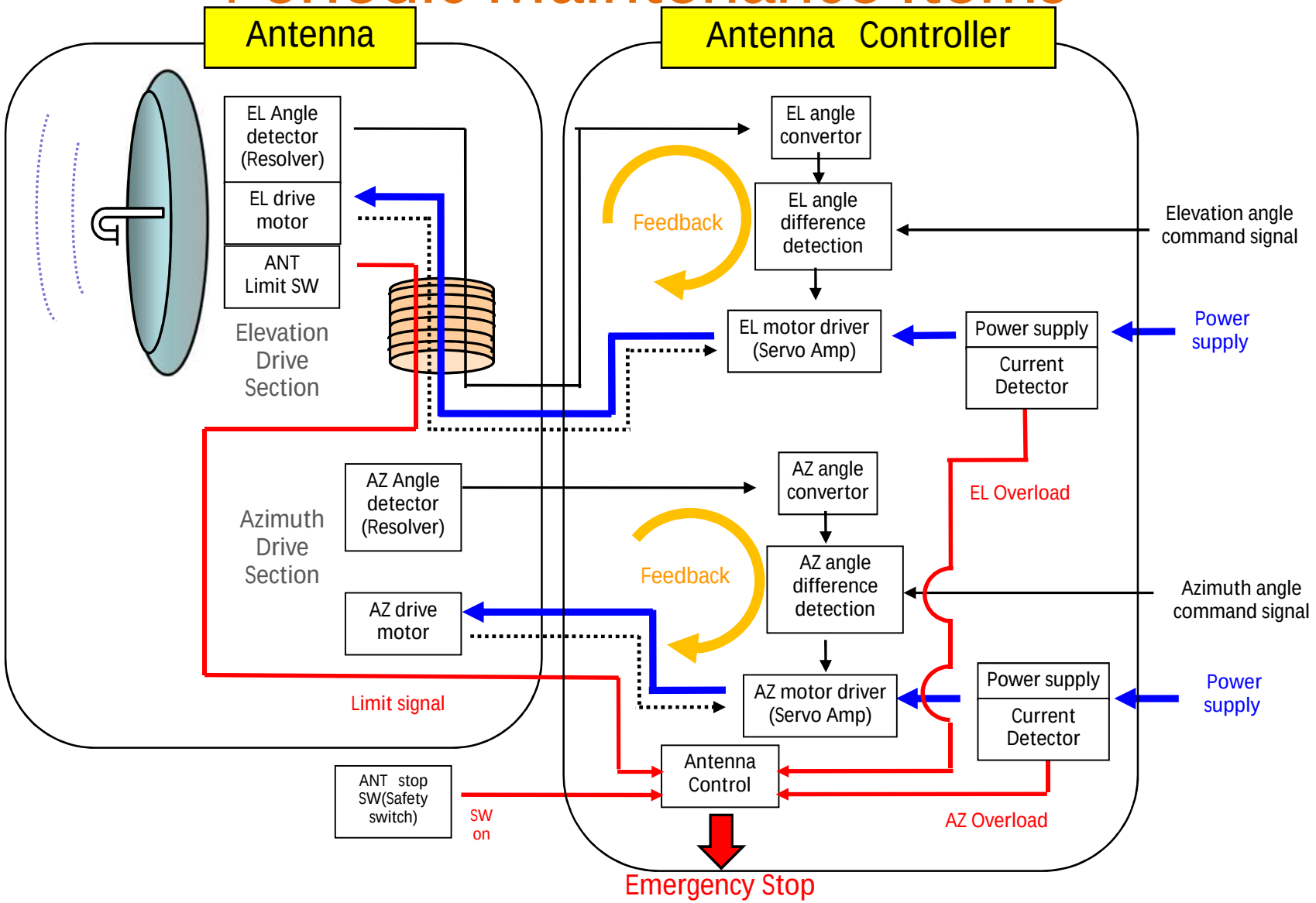
Periodic Maintenance Items for Antenna

(2) Antenna (2/2)

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly, A: Annual

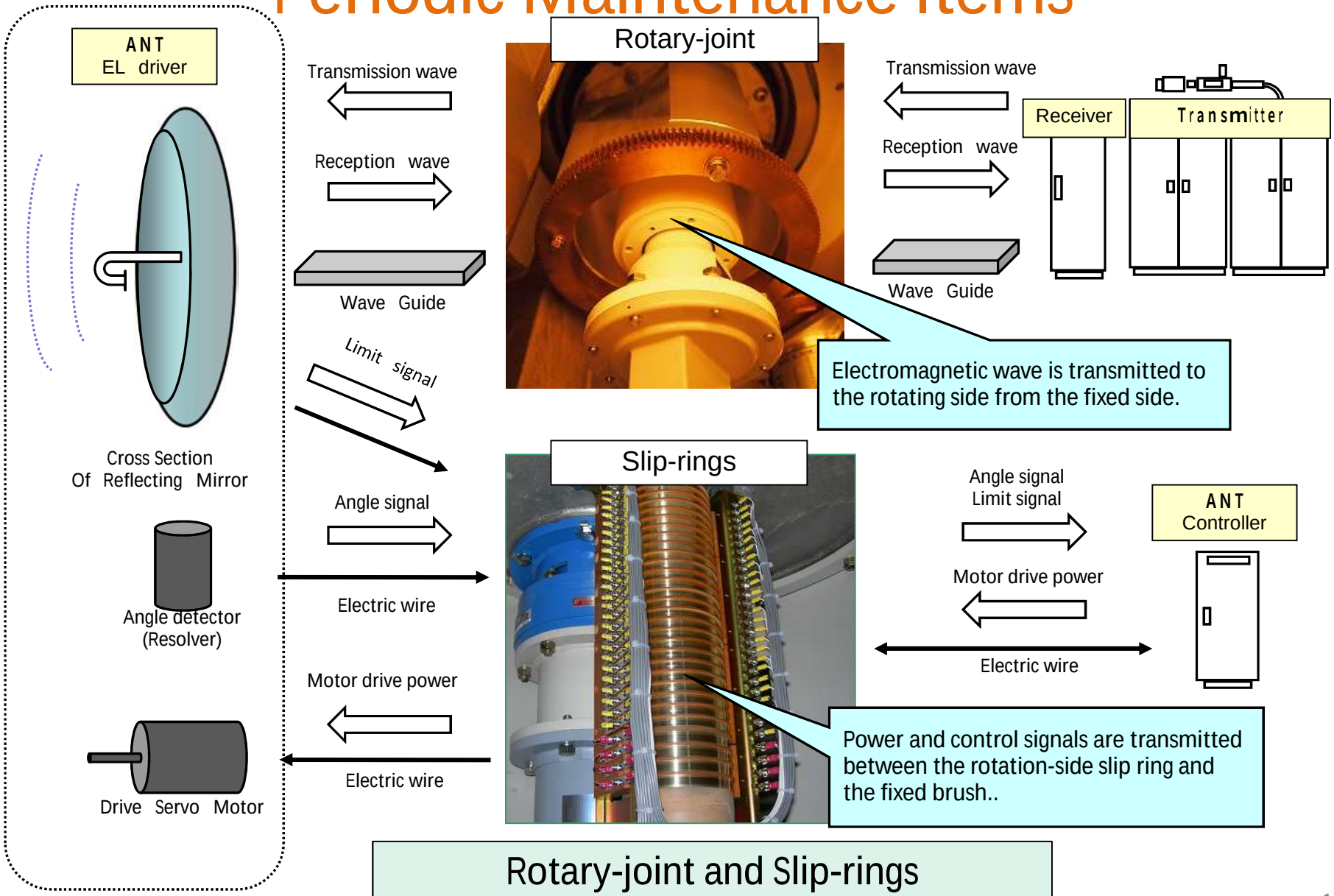
Periodic Inspection and Maintenance Items		Interval
Operational status of azimuth and elevation section		
	Rotation sound, squeaking noise and rotation smoothness	W
	Rotation speed	6
	Positioning accuracy	M
Safety function		
	Elevation limit operation	6
	Safety switch operation	W
Calibration		
	Antenna level	A
	Antenna orientation	A

Periodic Maintenance Items



Signal Flow between the Antenna and Antenna Control Unit

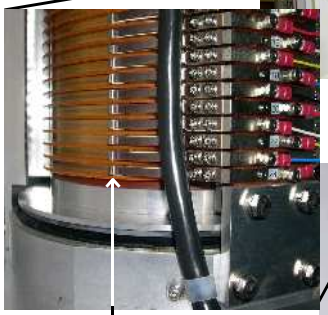
Periodic Maintenance Items



Rotary-joint and Slip-rings

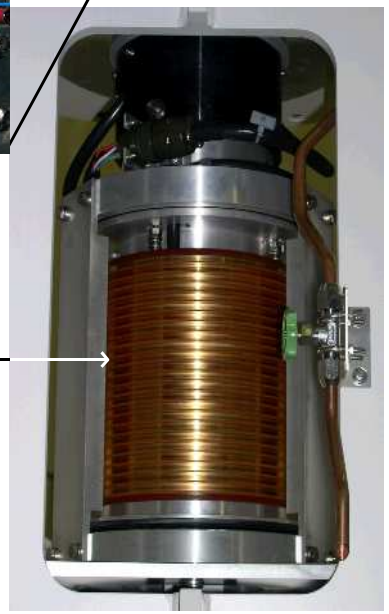
Periodic 1 month Maintenance Items

Open the Cover of the Slip ring & Brush (Front Side)



Brush

Clean the slip ring with dry soft cloth.



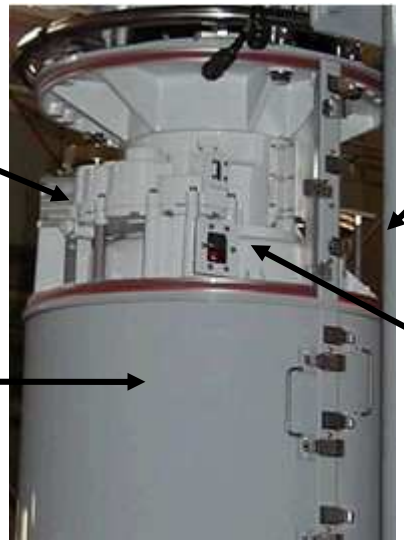
Slip ring

Periodic 6 month Maintenance Items

Grease Replenishment

EL oil outlet

AZ oil outlet



Pedestal AZ body

EL oil gauge

AZ oil gauge

If oil level is low,

Reduction gear oil replacement

Oil gauge and Oil outlet

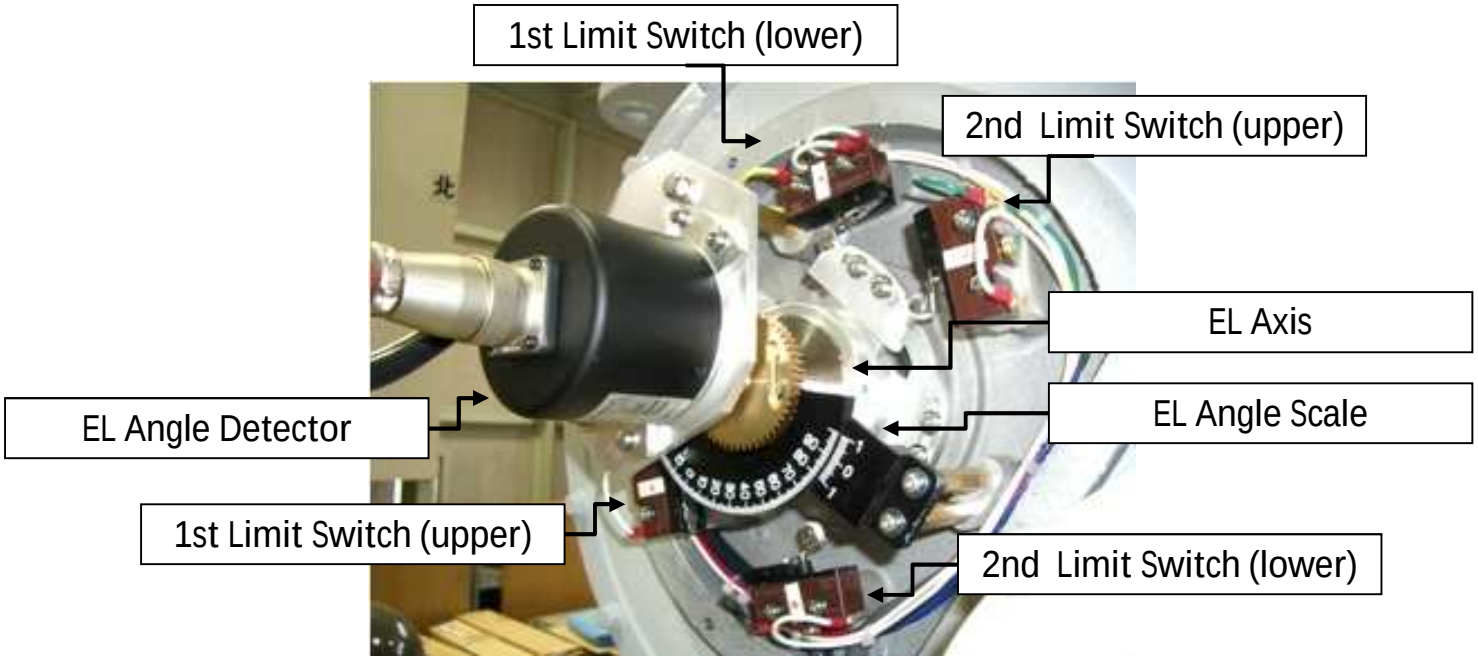
Periodic 6 month Maintenance Items

EL drive belt

AZ drive belt

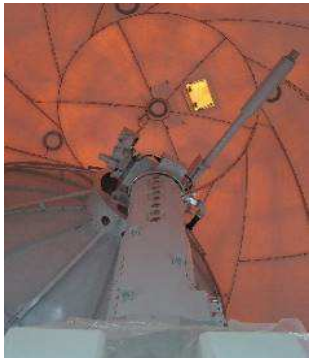
Azimuth and Elevation drive belt

Periodic 6 month Maintenance Items



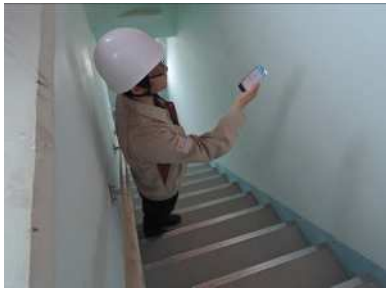
Operation of Limit Switch

Periodic 6 month Maintenance Items

START

Stopwatch
(Smartphone)



STOP

Time measurement of one (1) rotation

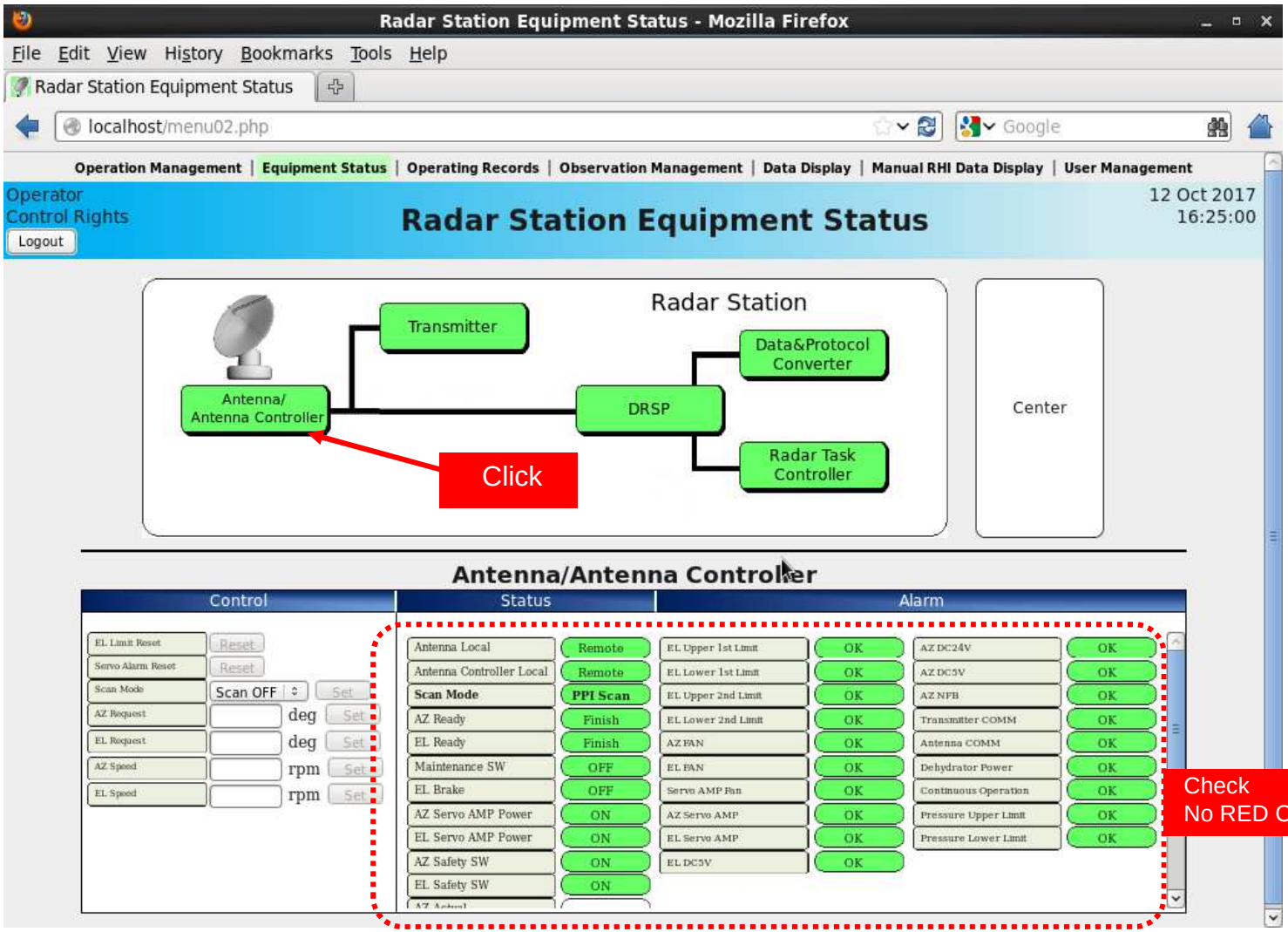
Periodic Maintenance Items for Antenna Controller

(3) Antenna Controller

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items		Interval
Control function		
	Mode control	6
	Position control	3
	Rotation speed control	6
	Safety interlock and protection	6
Monitoring function		
	Antenna operating status, meter indication	1
	Azimuth/elevation angle	1
	Alarm information	D

Daily Maintenance Items



Periodic Maintenance Items for Transmitter

(4) Transmitter (1/2)

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items		Interval
Transmitting operation		
	Peak power, frequency, spectrum, stability	1
	Transmission pulse width, pulse repetition frequency	1
	Transmission tube current, its waveform	W
	Modulator operating sound	D
Monitoring function		
	Operating time indication of the transmission tube	M
	Modulator operating status, meter indication	D
	Alarm information	D

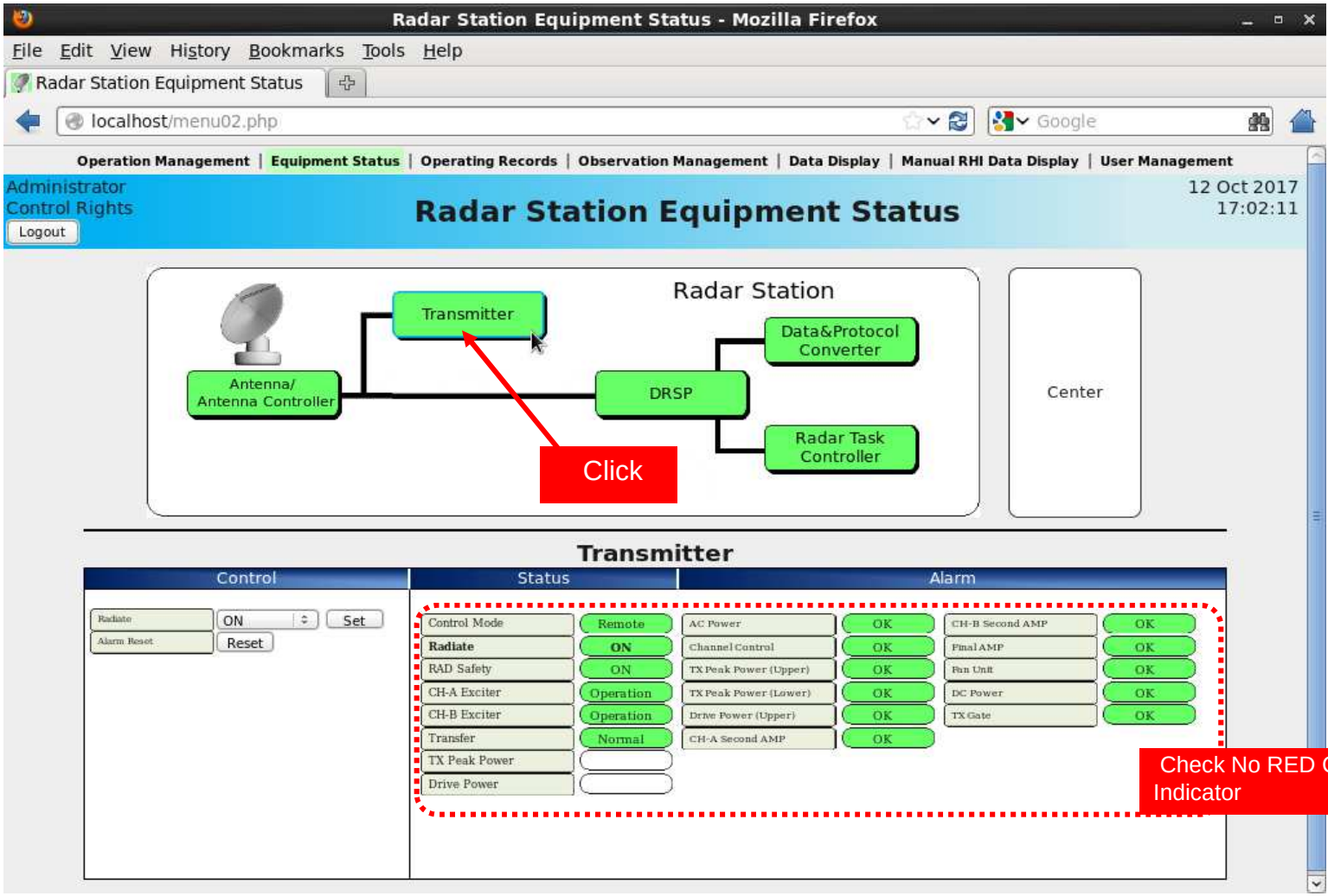
Periodic Maintenance Items for Transmitter

(4) Transmitter (2/2)

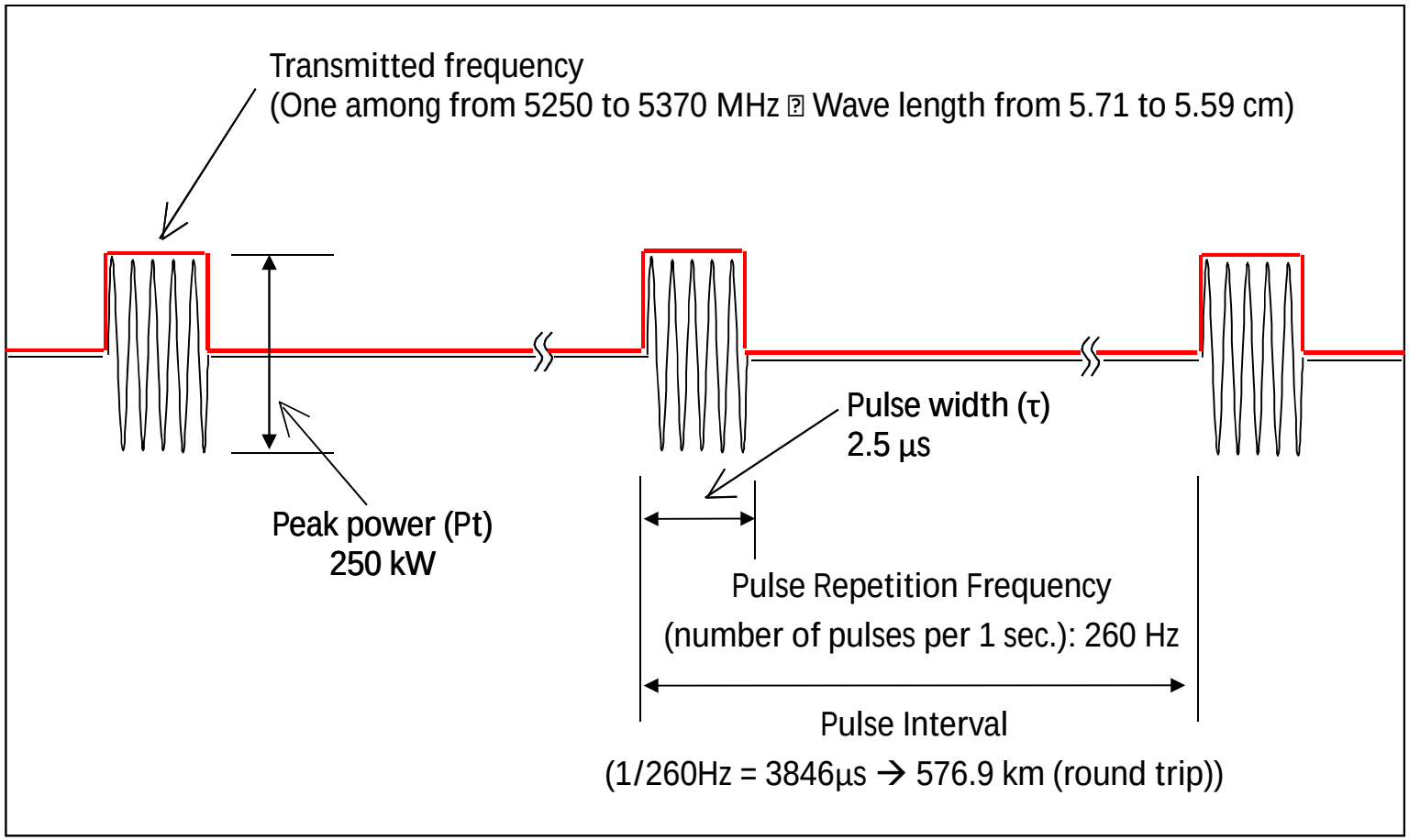
Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items		Interval
Operation		
	Operation mode control	6
	Temperature, cooling	3
	Safety interlock and protection	6
Parts condition		
	High voltage parts such as a coil, wiring inside in the modulator	6
	Insulation oil level, insulation materials, bushes	6
	Air filter	3

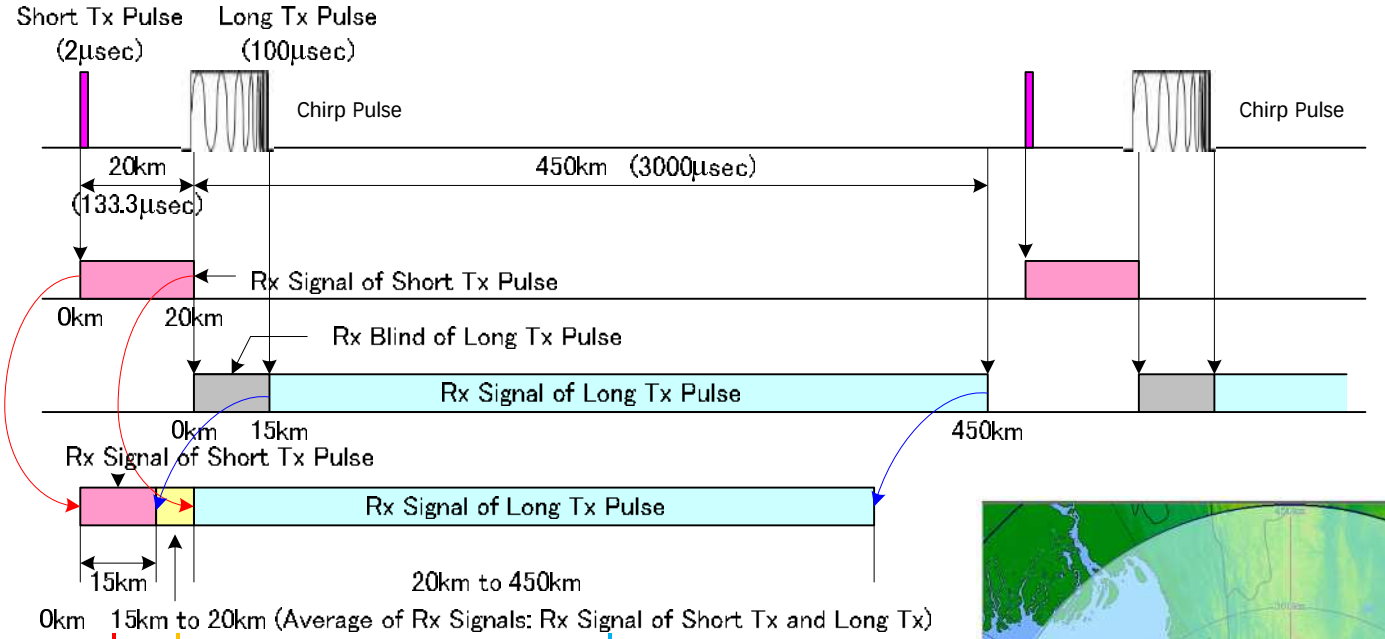
Daily Maintenance Items

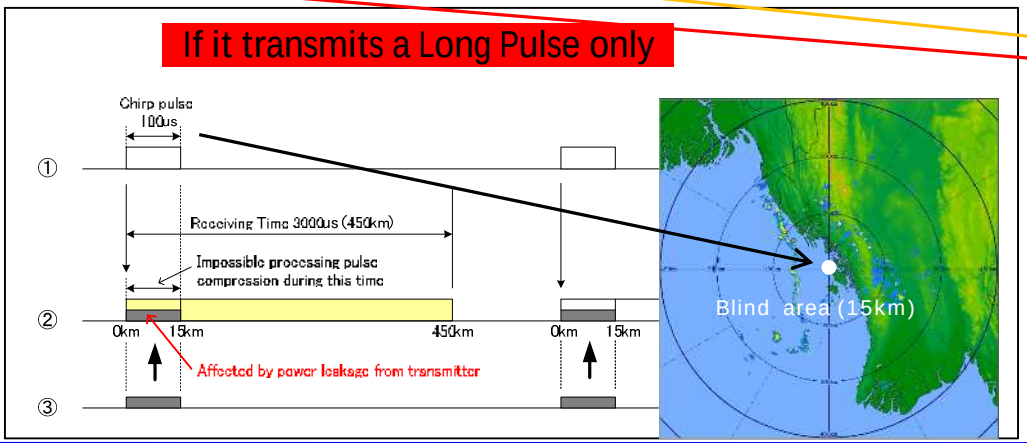


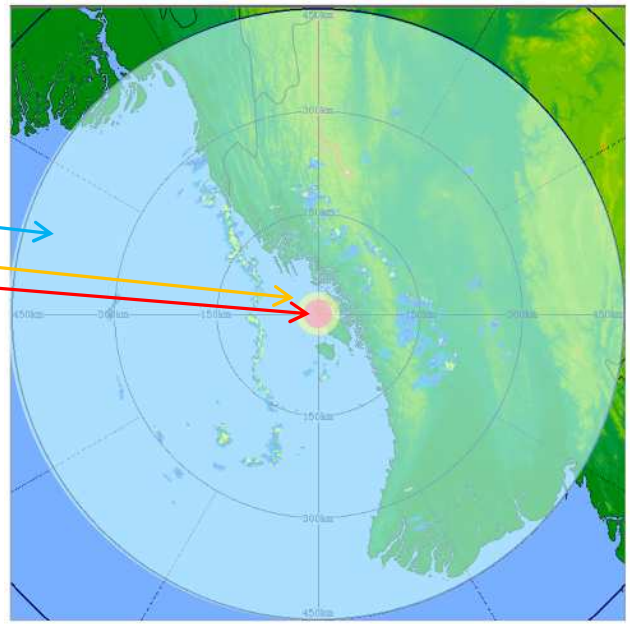
(Review) Transmission Pulse of the Weather Radar (in case of Klystron, Magnetron type)



Transmission Pulse of the Weather Radar (for SSPA type)







Why does the Solid State Transmitter radiate a long pulse?

- Solid State Type Transmitter
  Peak Power : 10kW

-Electronic Tube Type Transmitter
Peak Power : 500kW

-Peak power : 500kw (Pulse width 2us)
Minimum detectable rainfall precipitation : 1 mm/hr (at 450km)

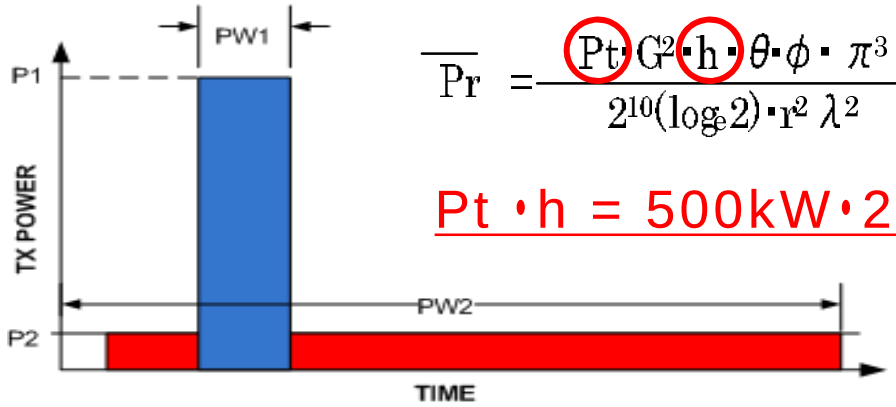
-Peak power : 10kw (Pulse width 2us)
Minimum detectable rainfall precipitation : 12 mm/hr (at 450km)

Problem!

Pulse width 2us → 100us

Solution!

-Peak power : 10kw (Pulse width 100us)
Minimum detectable rainfall precipitation : 1 mm/hr (at 450km)



$$\overline{Pr} = \frac{Pt \cdot G^2 \cdot h \cdot \theta \cdot \phi \cdot \pi^3}{2^{10}(\log_e 2) \cdot r^2 \lambda^2} \left| \frac{\varepsilon - 1}{\varepsilon + 2} \right|^2 BR^{\beta} \cdot 10^{-0.1L} \cdot 10^{-0.2kg \cdot r}$$

Pt・h = 500kW・2us = 10kW・100us

Periodic Maintenance Items

● Transmitter Specifications (C-band, in Japan)

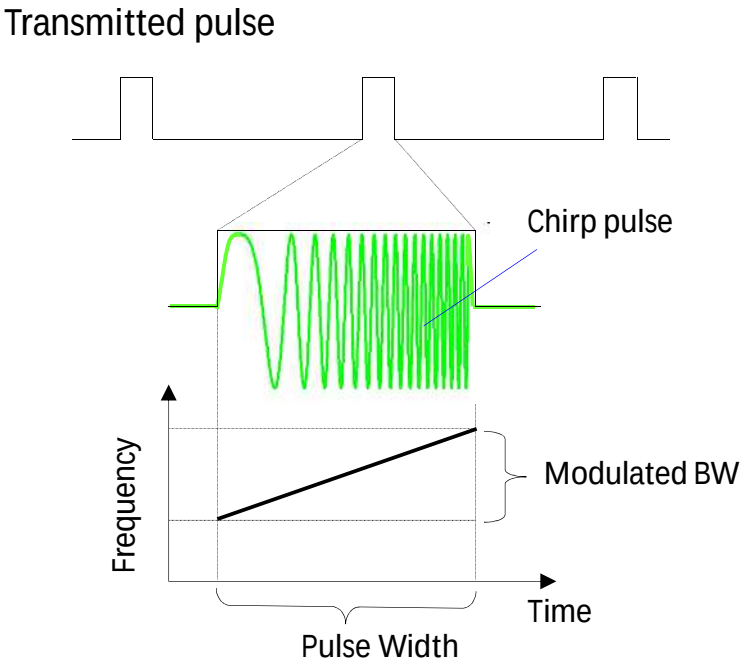
(1) Type Klystron tube (or Magnetron tube)
(2) Transmission Frequency One among from 5250 to 5370 MHz
(3) Transmission Peak Power 250 kW
(4) Transmission Pulse Width
Long Range Mode: 2.5μs +20% -0%
Doppler Mode: 1.0μs +20% -0%
(5) Pulse Repetition Frequency Variable in 1500 Hz or less
Long Range Mode: 260 Hz
Doppler Mode: **330, 480, 600, 752 and 940 Hz**
(6) Modulator Solid-state type
(not use the thyratron)

$$Rc = \frac{\pi^3}{2^{10} \log_e 2} \cdot \frac{P_t \cdot h}{\lambda^2} \cdot G_0{}^2 \cdot \theta_1 \cdot \phi_1 \cdot \left| \frac{\varepsilon - 1}{\varepsilon + 2} \right|^2$$

Solid State Chirp Pulse Radar

■Transmitter

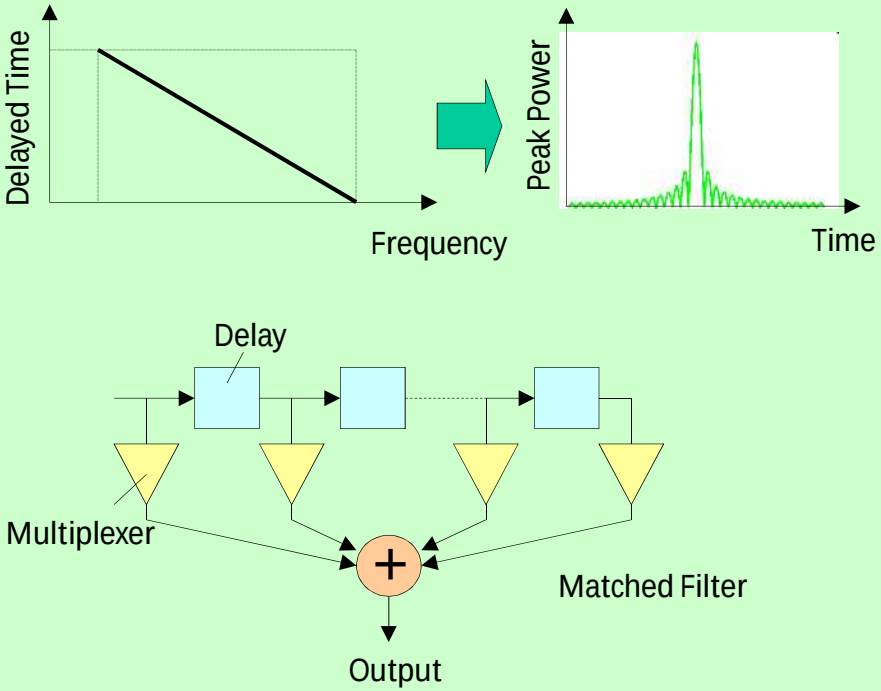
Chirp modulation pulse is transmitted.



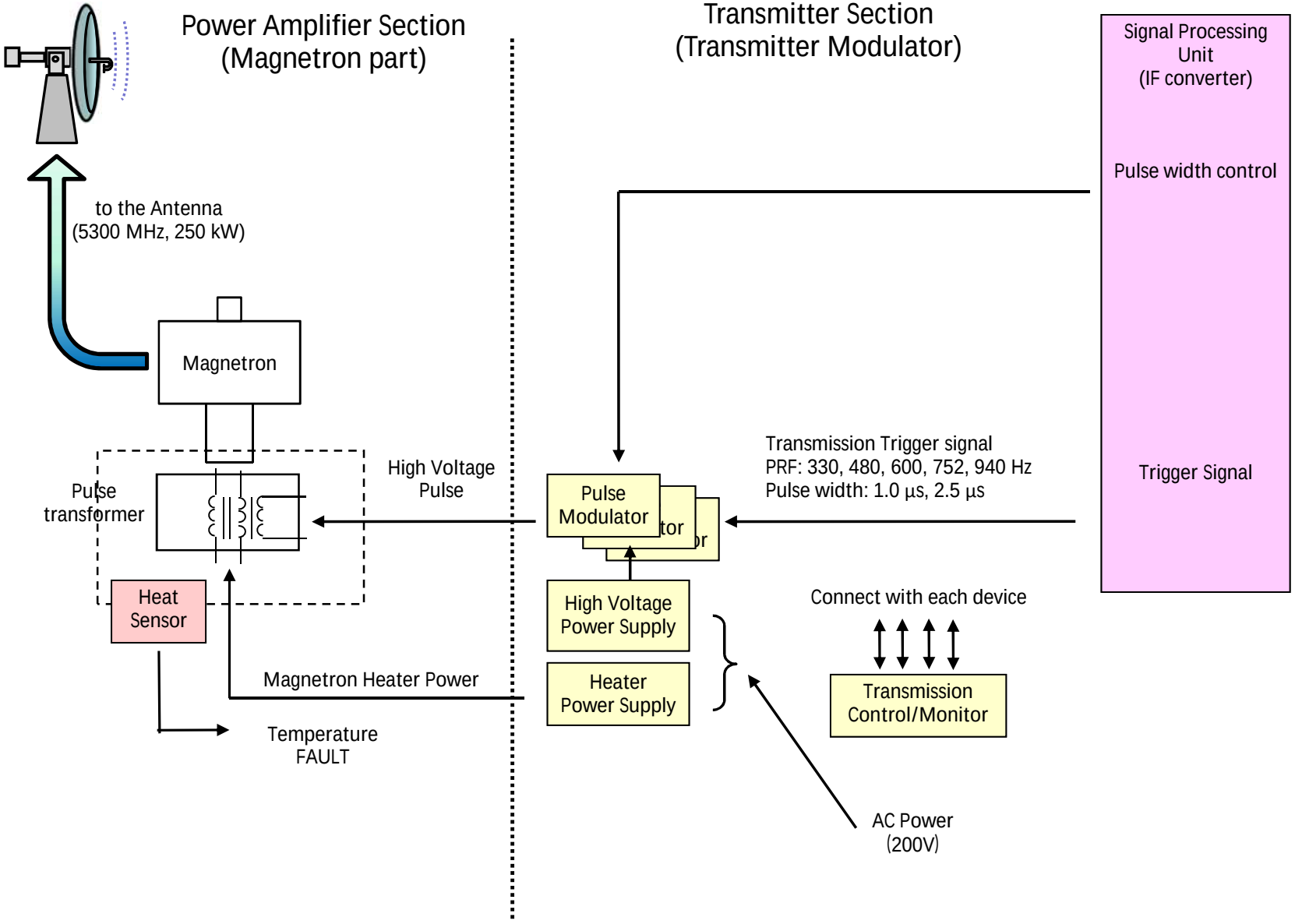
Linear Frequency Modulation(LFM)

■Receiver

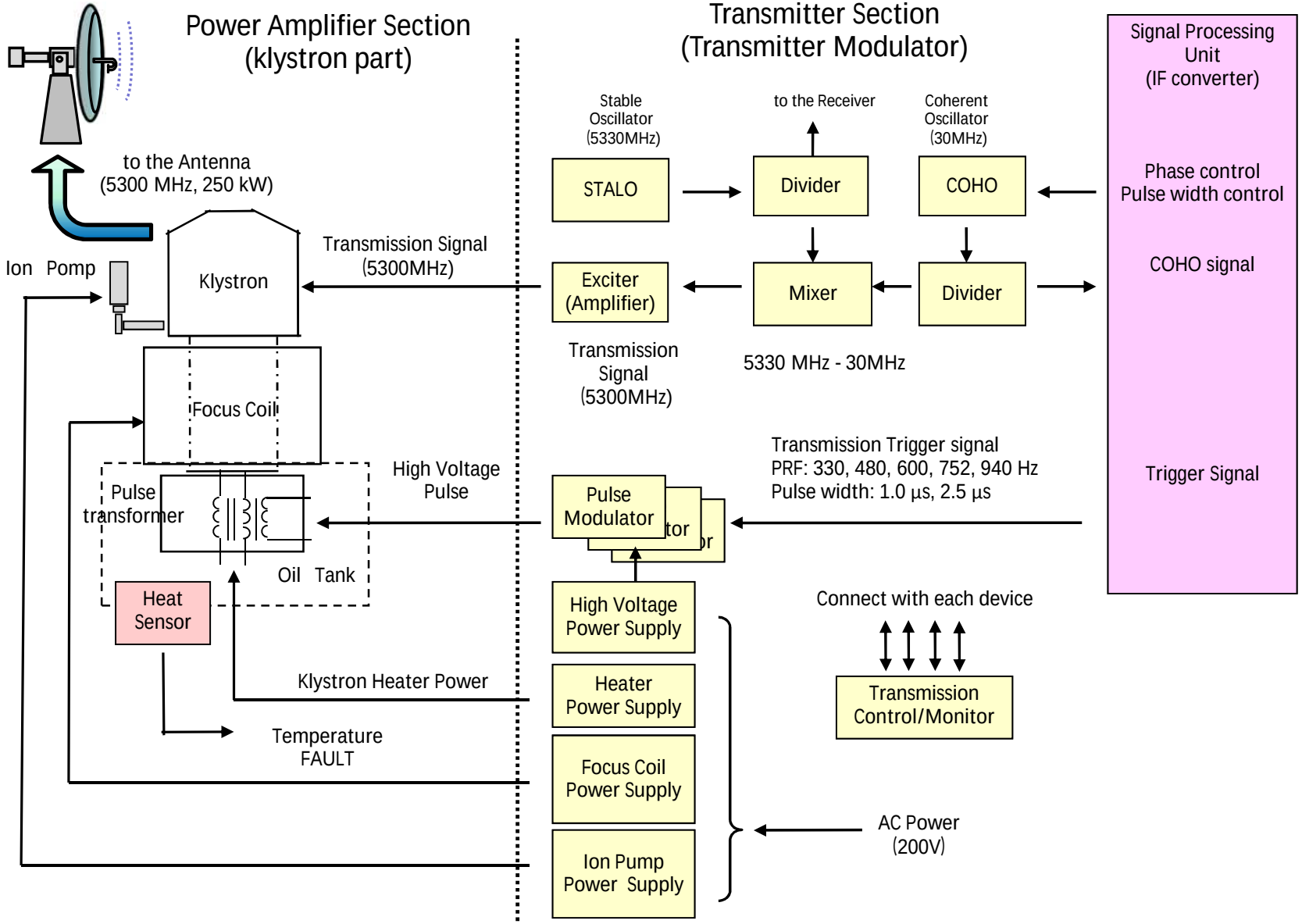
Pulse Compression



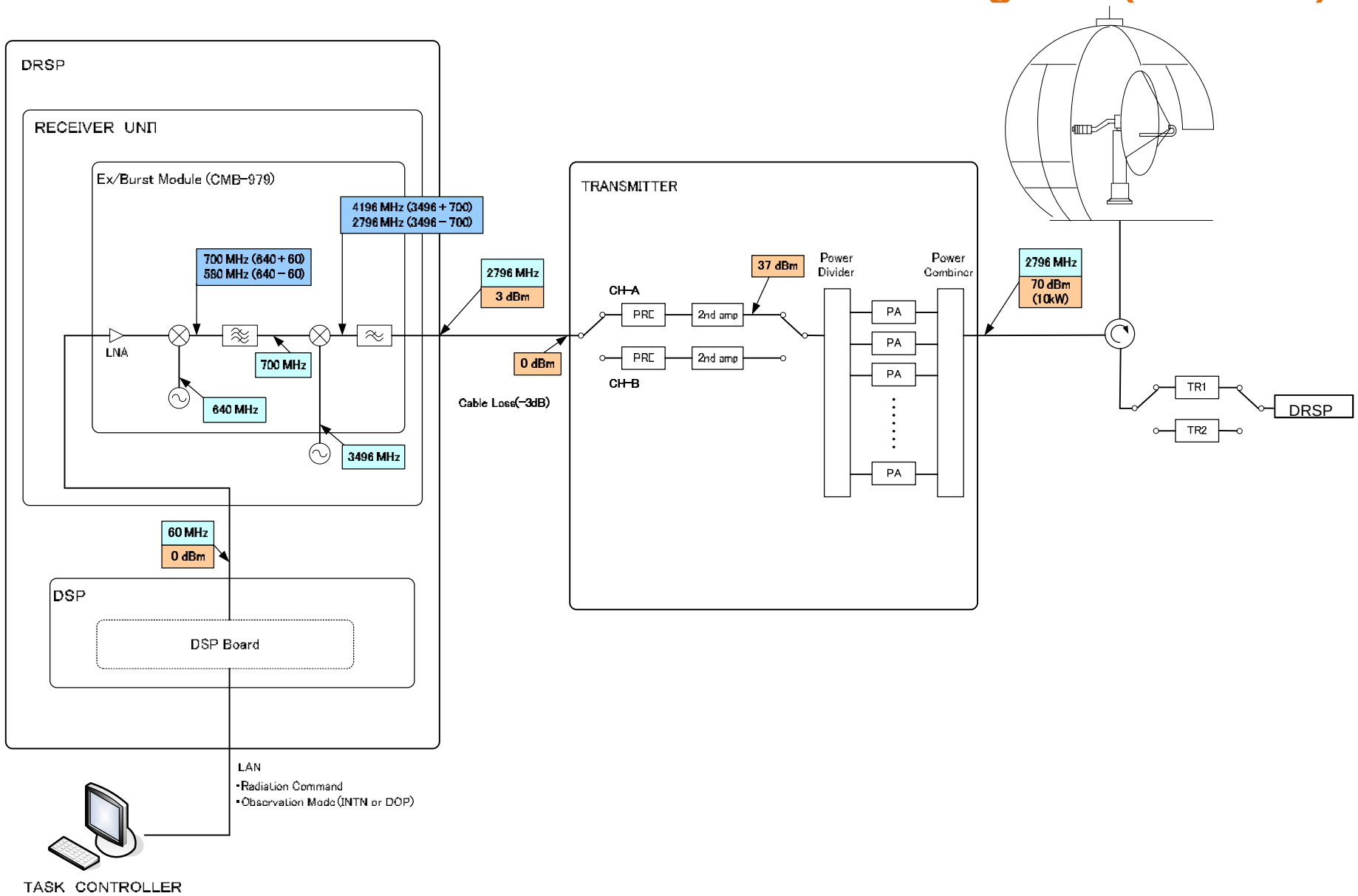
(Review) Magnetron Transmitter Schematic Diagram



(Review) Klystron Transmitter Schematic Diagram

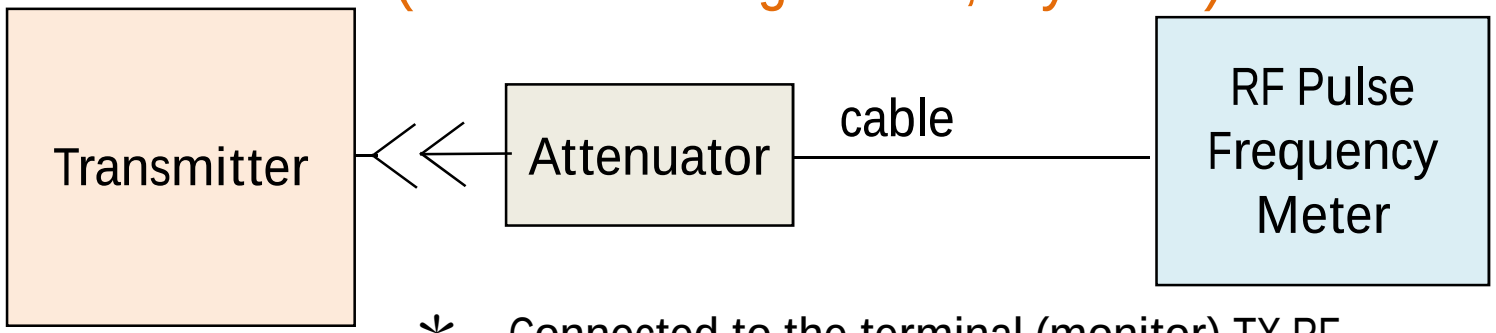


Solid-state Transmitter Schematic Diagram(S-band)

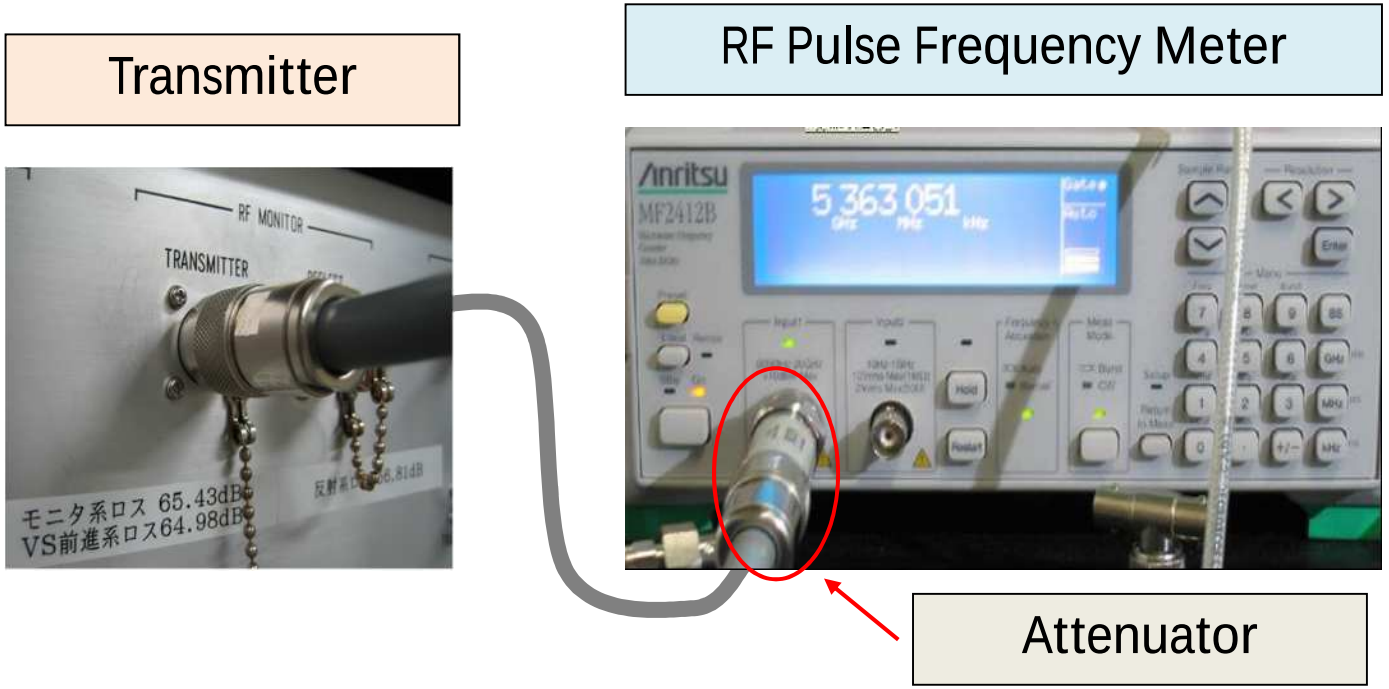


Transmitting Frequency Measurement

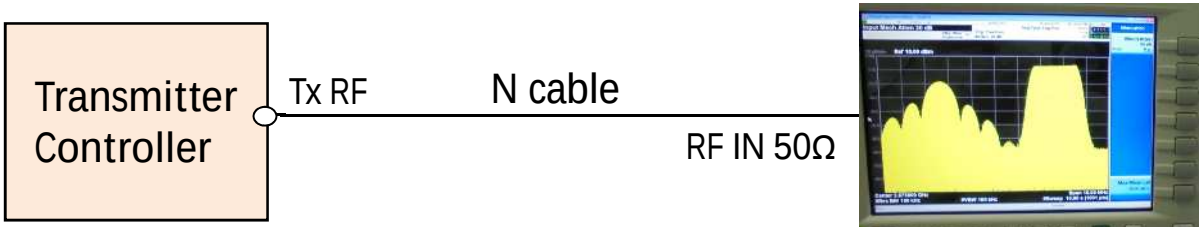
(in case of Magnetron, Klystron)



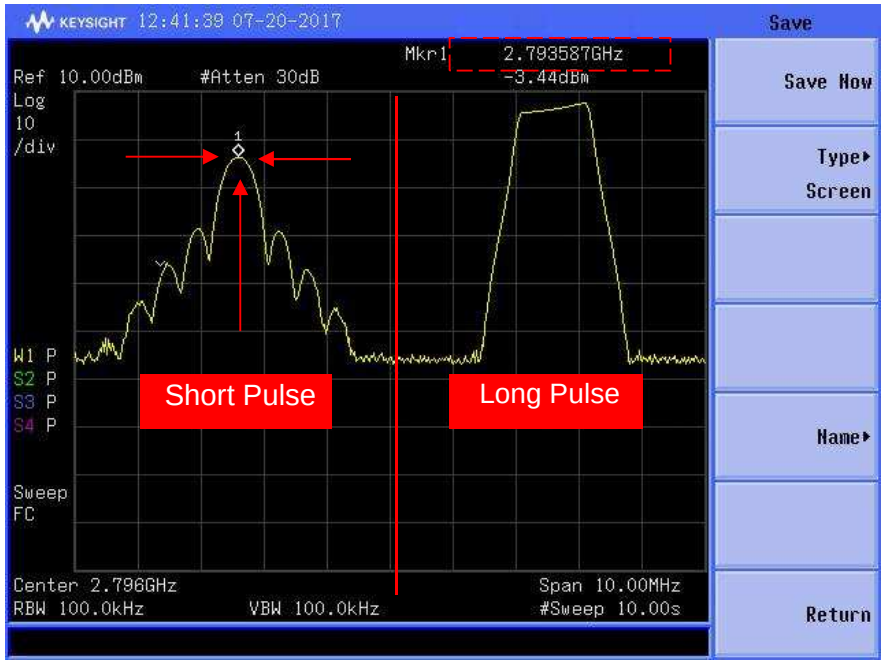
＊ Connected to the terminal (monitor) TX RF MON of the transmission unit.

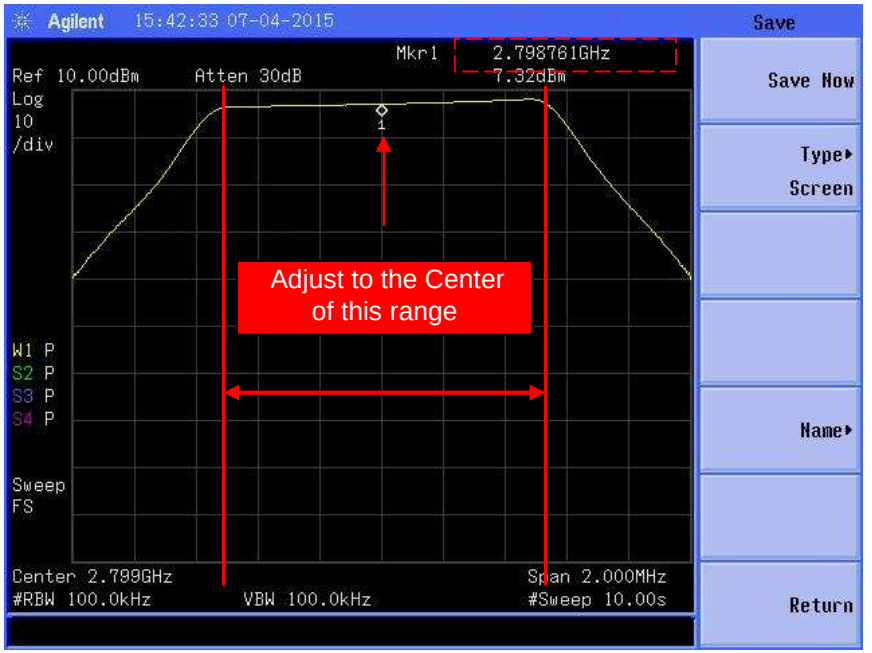


Transmitting Frequency Measurement
(In case of SSPA Type)



Transmitting Frequency Measurement Connection Diagram



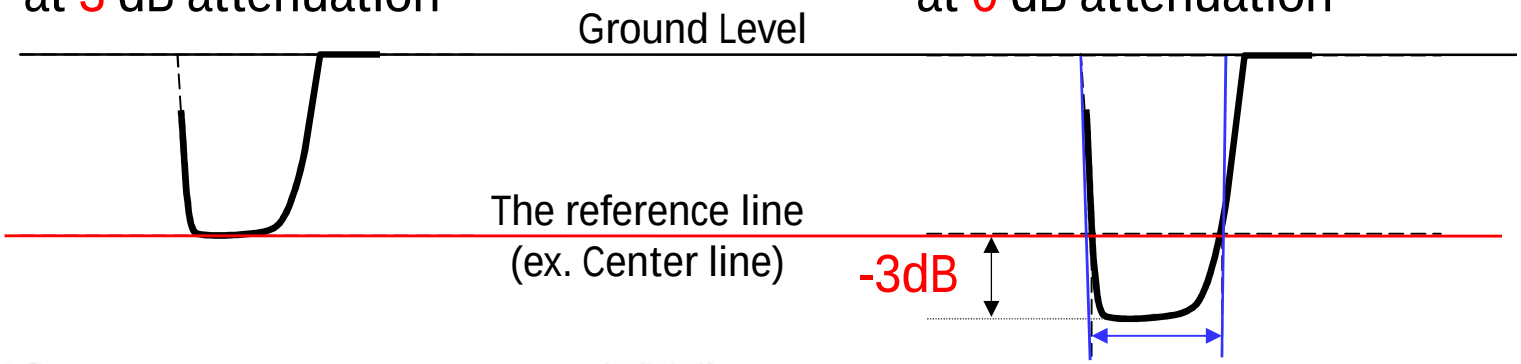


Measurement of short pulse on the spectrum analyzer window

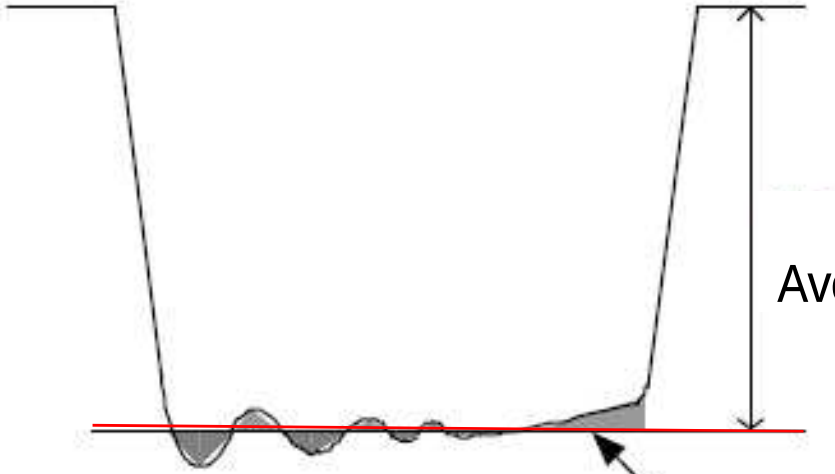
Transmitting Pulse Width (τ) Measurement
(In case of Klystron, Magnetron)

RF detection waveform
at 3 dB attenuation

RF detection waveform
at 0 dB attenuation



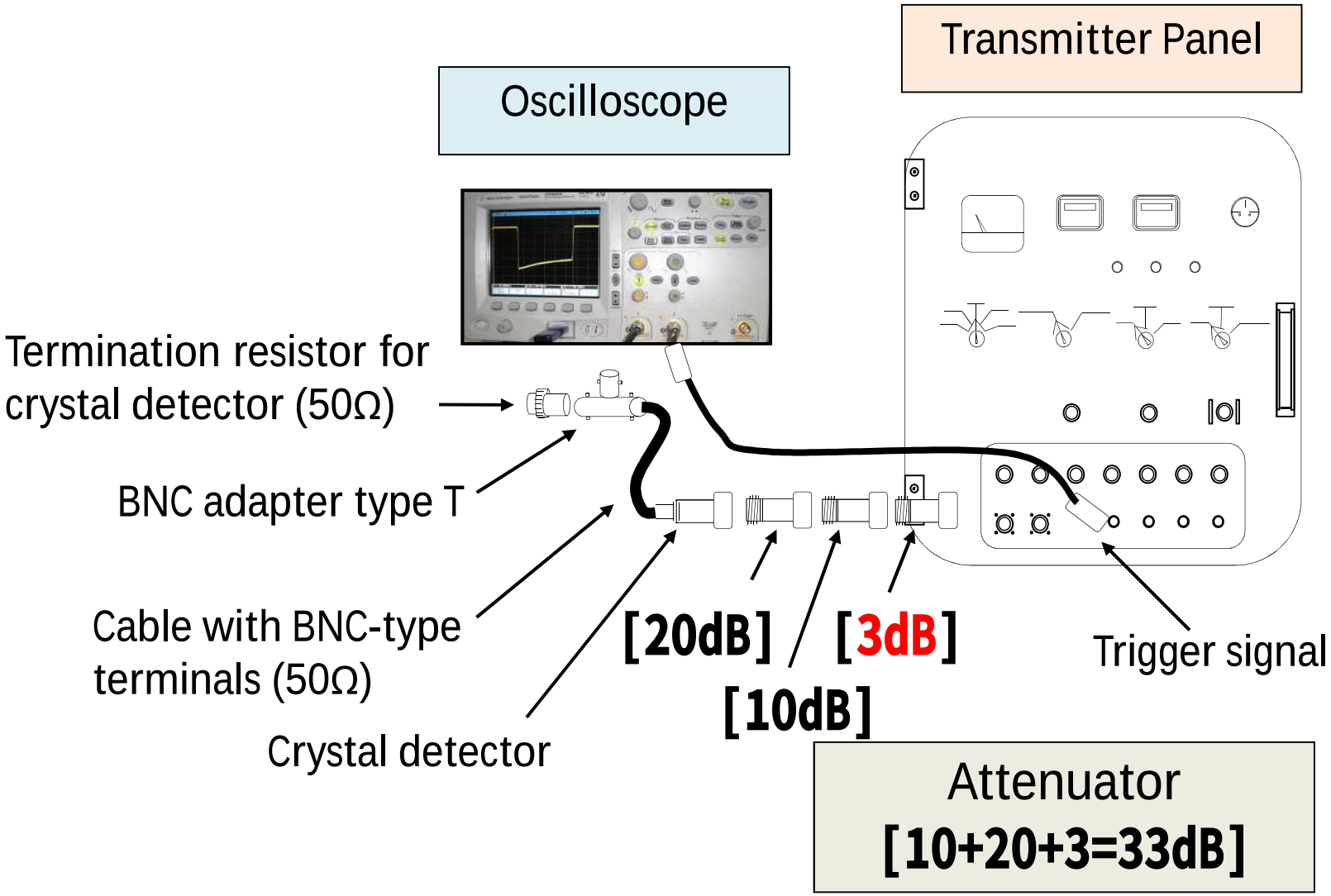
Pulse Width
Defined at 3dB point decrease
from the average wave height



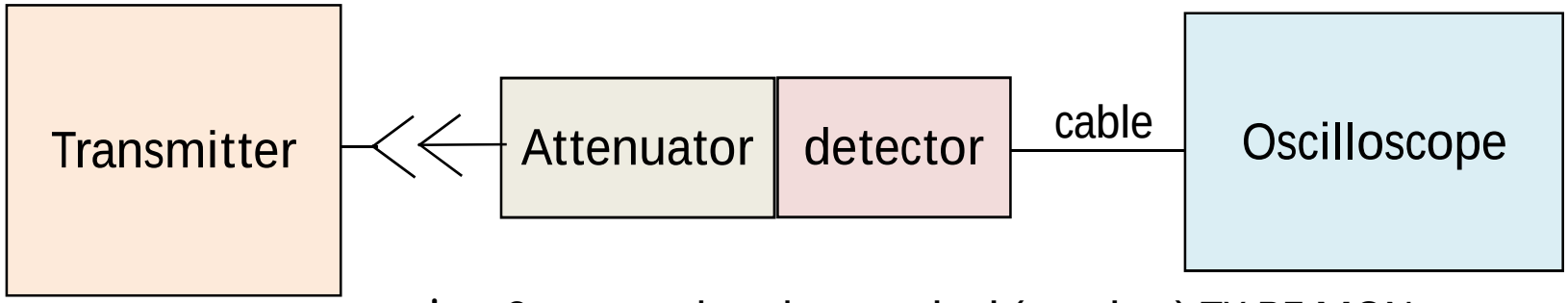
Average wave height

Find out the average wave height
position visually

Transmitting Pulse Width (τ) Measurement
(In case of Klystron, Magnetron)

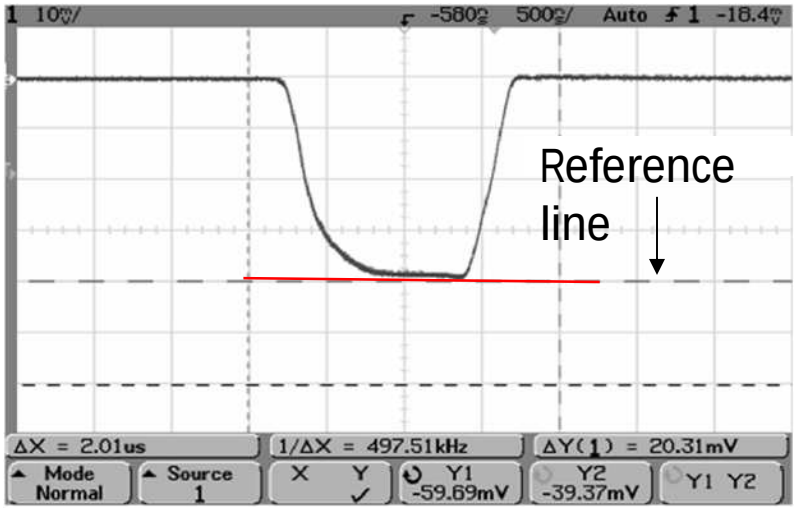


Transmitting Pulse Width (τ) Measurement
(In case of Klystron, Magnetron)

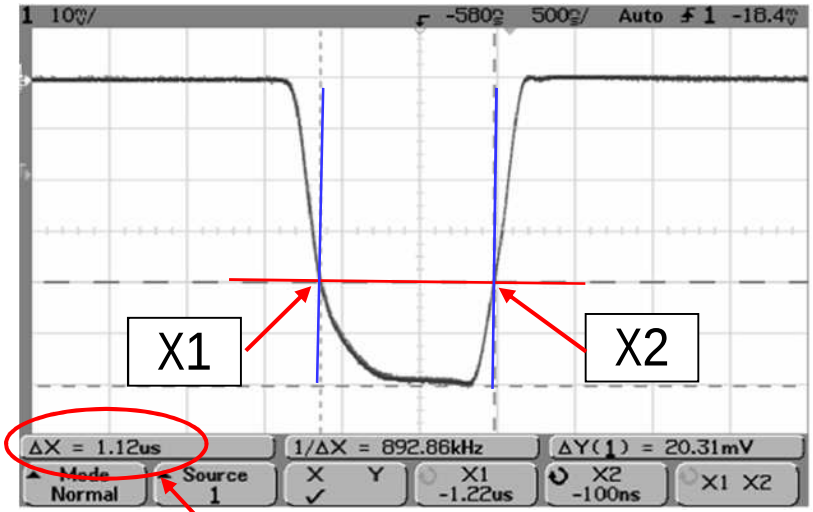


＊ Connected to the terminal (monitor) TX RF MON of the transmitter.

【3 dB Attenuator】: Connect

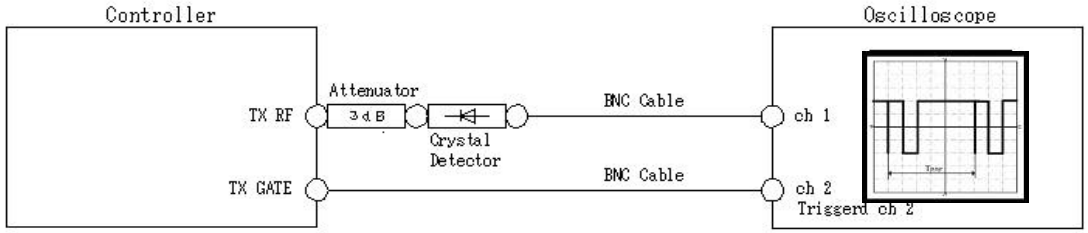


【3 dB Attenuator】: Disconnect



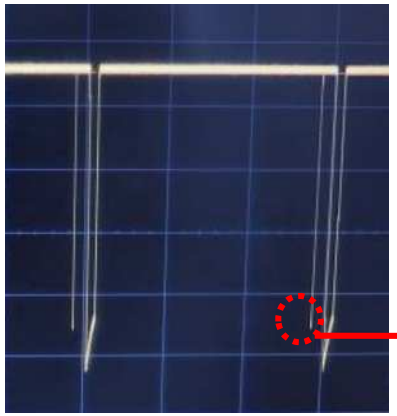
1.12μS measurements

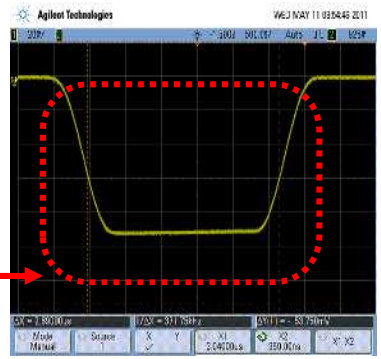
Transmitting Pulse Width (τ) Measurement
(In case of SSPA Type)



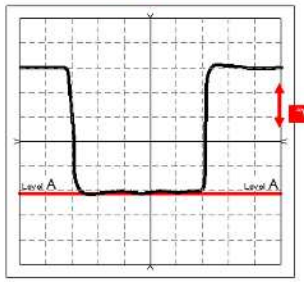
Transmitting Pulse Width Measurement Connection Diagram

- Connect another BNC cable between TX GATE monitor terminal of the controller and channel 2 of the oscilloscope.
- Set the impedance of CH1 to 50Ω and CH2 to 1MΩ

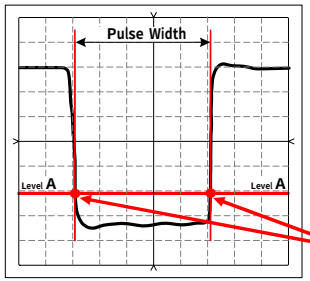




Detector waveform (CH-1) and TX GATE (trigger timing / CH-2) will appear on the oscilloscope (Short Pulse)

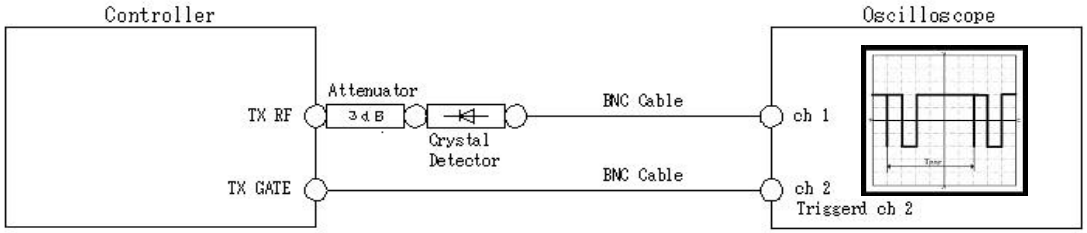


Detector Waveform Shown on Oscilloscope (with 3db Attenuator)

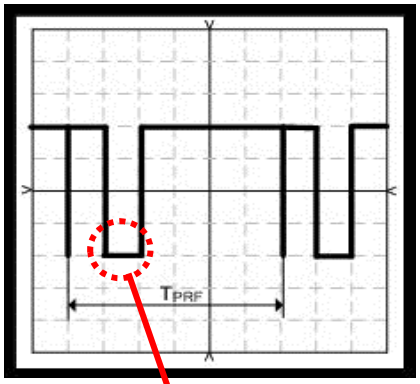


Detector Waveform Shown on Oscilloscope (without 3db Attenuator)

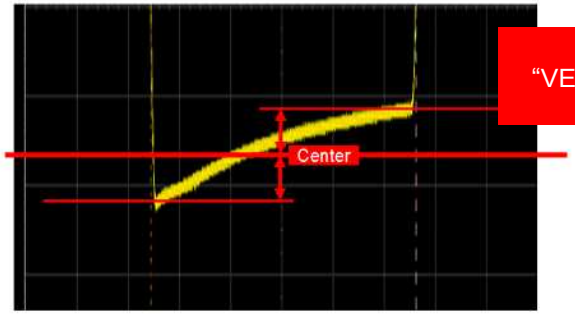
Transmitting Pulse Width (τ) Measurement
(In case of SSPA Type)



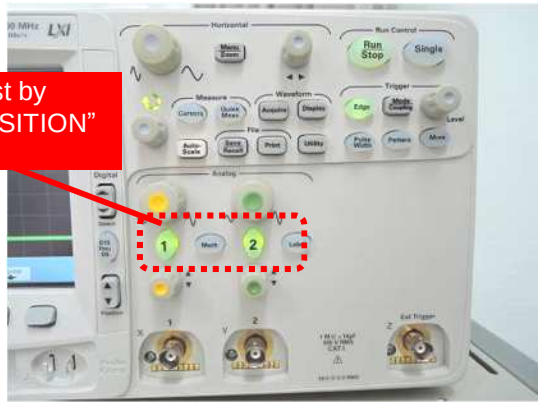
Transmitting Pulse Width Measurement Connection Diagram

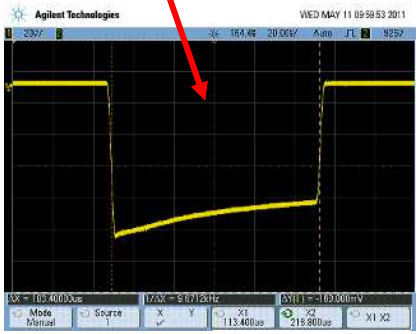


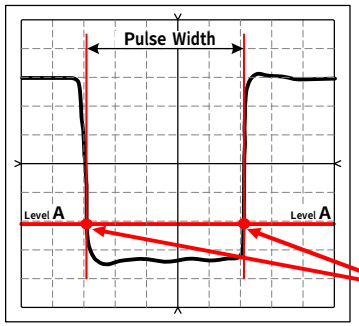
(1)



Adjust by
"VER POSITION"



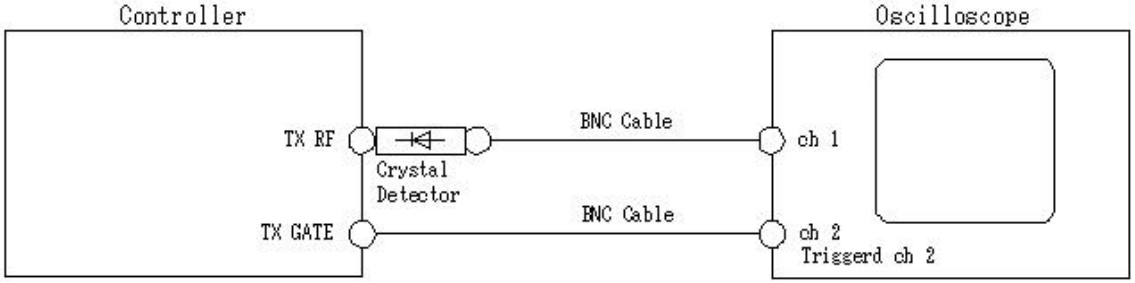




- Remove the attenuator (3dB) and reconnect the crystal detector to TX RF monitor terminal of the controller.
- As a result, the electric power will be increased by 3dB and the oscillation of the detector waveform will be amplified on the oscilloscope.

Detector waveform (CH-1) and TX GATE (trigger timing / CH-2) will appear on the oscilloscope (Long Pulse)

Pulse Repetition Frequency (PRF) Measurement



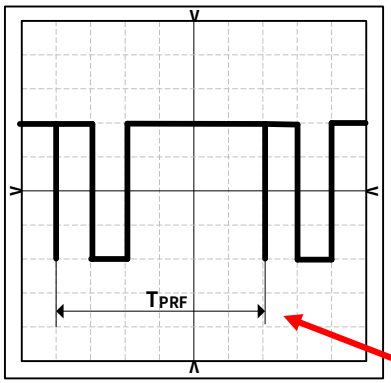
Transmitting Pulse Width Measurement Connection Diagram

< Using a oscilloscope >

Connecting diagram is same as measuring method for the pulse width (mentioned in the previous page).
Measure the cycle time of crystal detecting waveform on the oscilloscope display.
Then, calculate the PRF from cycle time.

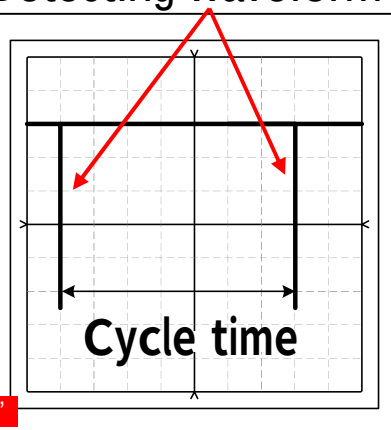
PRF = 1 / cycle time

Detecting waveform



PRF for SSPA

Detecting waveform

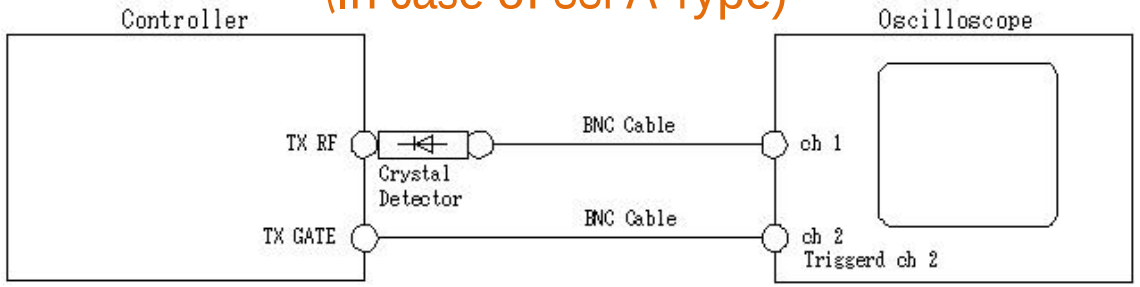


"PRF-1"

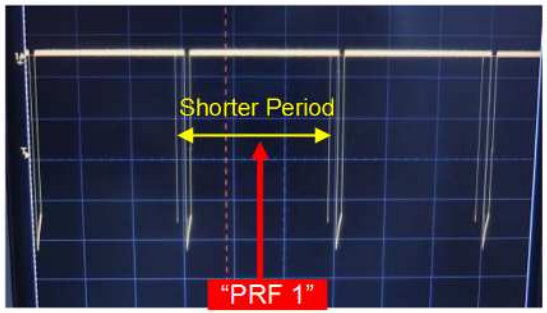
PRF for Klystron, Magnetron

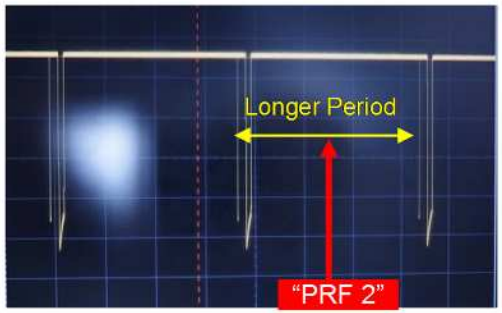
Pulse Repetition Frequency (PRF) Measurement of Doppler Mode

(In case of SSPA Type)



Transmitting Pulse Width Measurement Connection Diagram



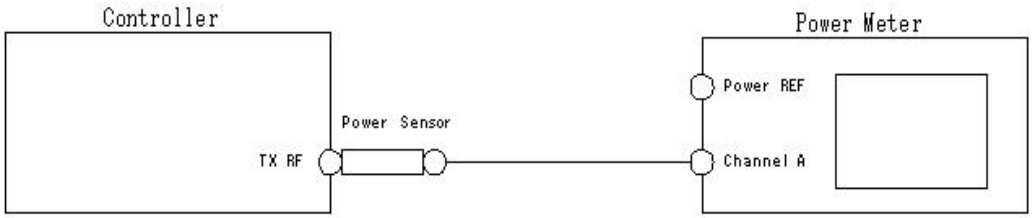


- For staggered mode (Doppler Mode), two (2) periods is displayed on the oscilloscope.
- Measure both of them and then record it.

PRF Rated Value (In case of S-band Doppler Radar)

Schedule Name	Rated Value
Intensity Mode	300Hz ±10% (270Hz – 330Hz)
Doppler Mode	670Hz ±10% (603Hz – 737Hz)
	536Hz ±10% (482.4Hz – 589.6Hz)

Transmission Average Power Measurement



* Connected to the TX RF monitor terminal of the transmitter.

Average power [dBm]

Transmitting Power Measurement Connection Diagram

P_T [dBm] = P_{AVG} + L_{CUP} - $Du_{(dB)}$
P_T [W] = 10^(P_T [dBm]/10) / 1000

P_{AVG} Average Power (Measured Value)
L_{CUP} Overall attenuation of directional coupler, cable and others (TX RF loss)
Du(dB) Duty cycle = 10 × log (PRF × τ(s))
h Pulse width (Short Pulse + Long Pulse)
PRF Pulse Repetition Frequency
Intensity Mode: PRF-1
Doppler Mode: Average of PRF-1 & PRF-2

In case of SSPA

How to Get the Peak Power (C-band)

Peak power Pt [dBm] = Average power P [dBm] + L [dB] - Du [dB]

Measured average power (P) :	-20.20 [dBm]
Measurement loss (included D.C. coupling rate) (L) :	73.66 [dB]
Measured pulse width (h) :	2.62 [μs]
Measured pulse repetition frequency (PRF) :	330.03 [Hz]

Duty cycle Du = h · PRF = 2.62 × 10-6 [s] × 330.03 [Hz] = 0.000864679
Du [dB] = 10log (0.000864679) = -30.63 [dB]
Pt [dBm] = -20.20 [dBm] + 73.66 [dB] - (-30.63 [dB]) = 84.09 [dBm]

Conversion the power [mW] to [dBm] or the power [dBm] to [mW] are;
Pt [dBm] = 10log (Pt [mW]), or Pt [mW] = 10(Pt [dBm] / 10)

Then,
Pt [mW] = 10 ^ (84.09 [dBm] / 10)
= 256,448,404 [mW] = 256,448 [W] = 256 (kW)

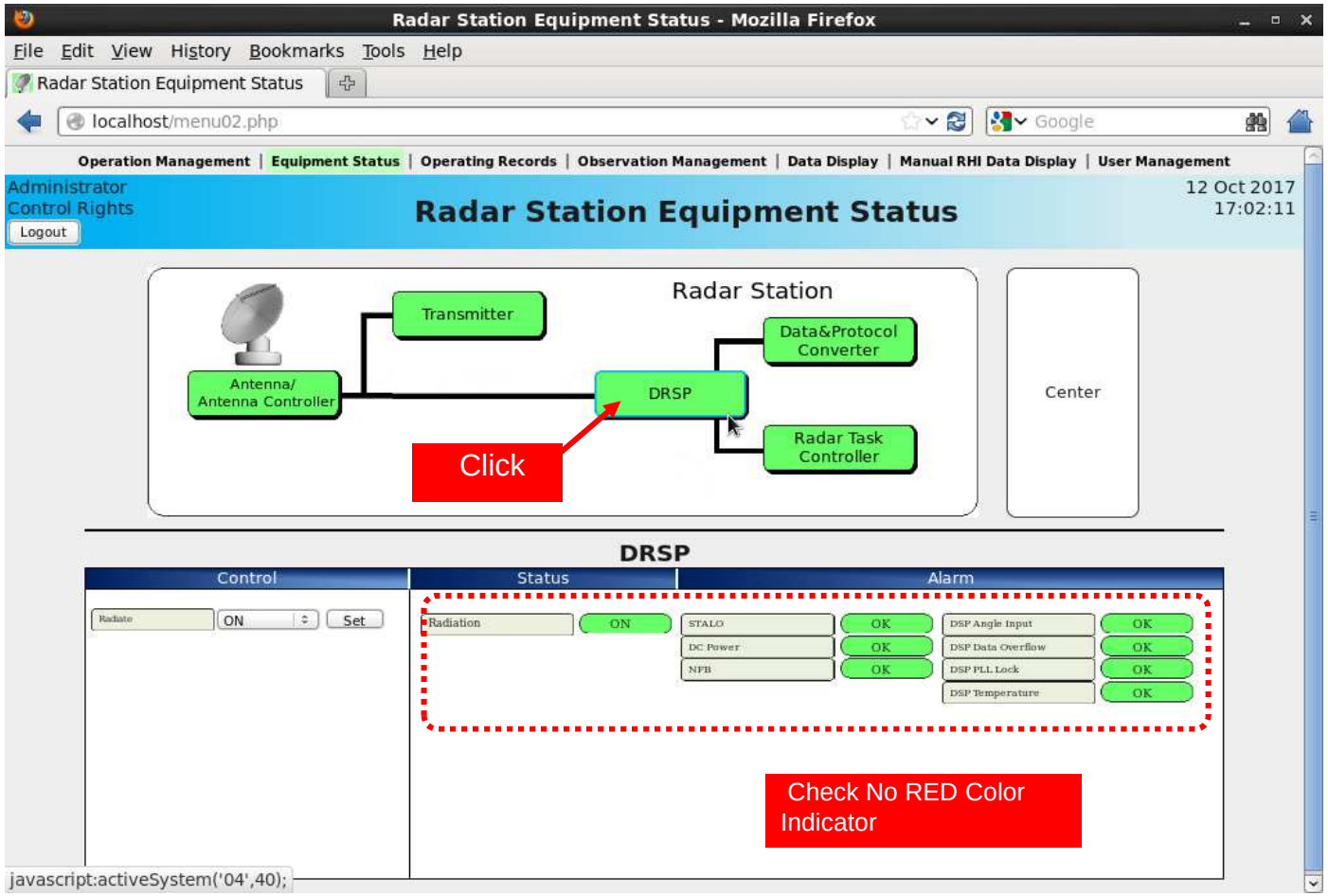
Periodic Maintenance Items for Receiver

(5) Receiver

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items	Interval
Minimum discernible Signal (MDS)	6
Receiver input / output characteristics	
Digital RX: RF input – IF output	6
Analog RX: RF input – logarithmic video amplifier output	1
Receiver dynamic range	
Noise level and maximum output level	6
Output signal level of the STALO unit and COHO unit	6
Operation time of the TR tube, measurement of its insertion loss	M
Automatic / manual frequency control (only for the Magnetron radar)	1

Daily Maintenance Items



Periodic Maintenance Items

● Receiver Specifications (C-band, in Japan)

(1) Type Super-heterodyne
(2) Noise Figure (NF) 3 dB or less
NF= (Signal_out/Noise_out)/(Signal_in/Noise_in)

(3) Minimum Sensitivity -97 dBm or less
(4) Output Signal IF: 30 MHz +/- 0.1 MHz
(5) Dynamic Range more than 80 dB

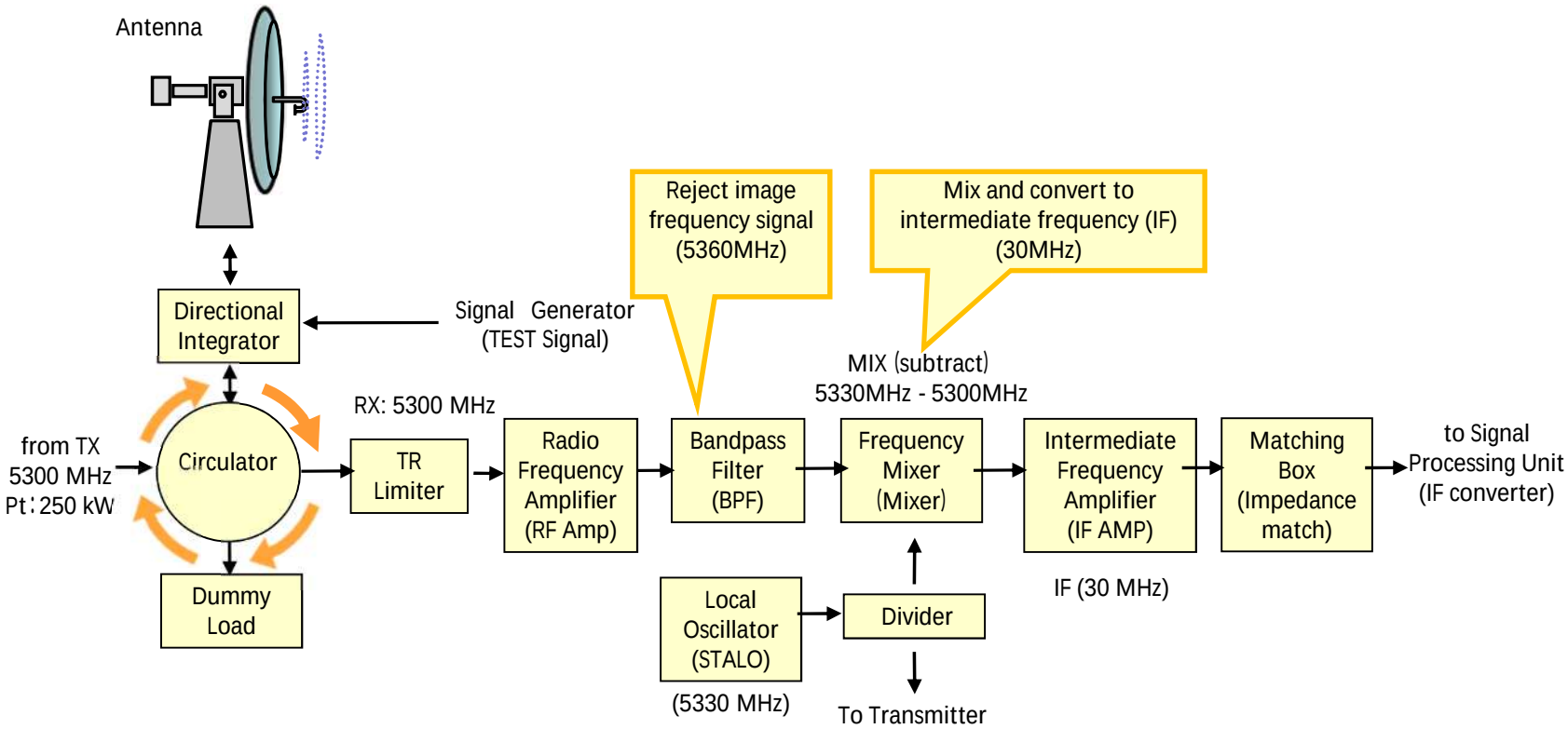
-110dBm: Reception strength of precipitation 1mm/h of 500km ahead
Reception strength of precipitation 0.008mm/h of 100km ahead
-30dBm: Reception strength of precipitation 1300mm/h of 5km ahead

Radar equation

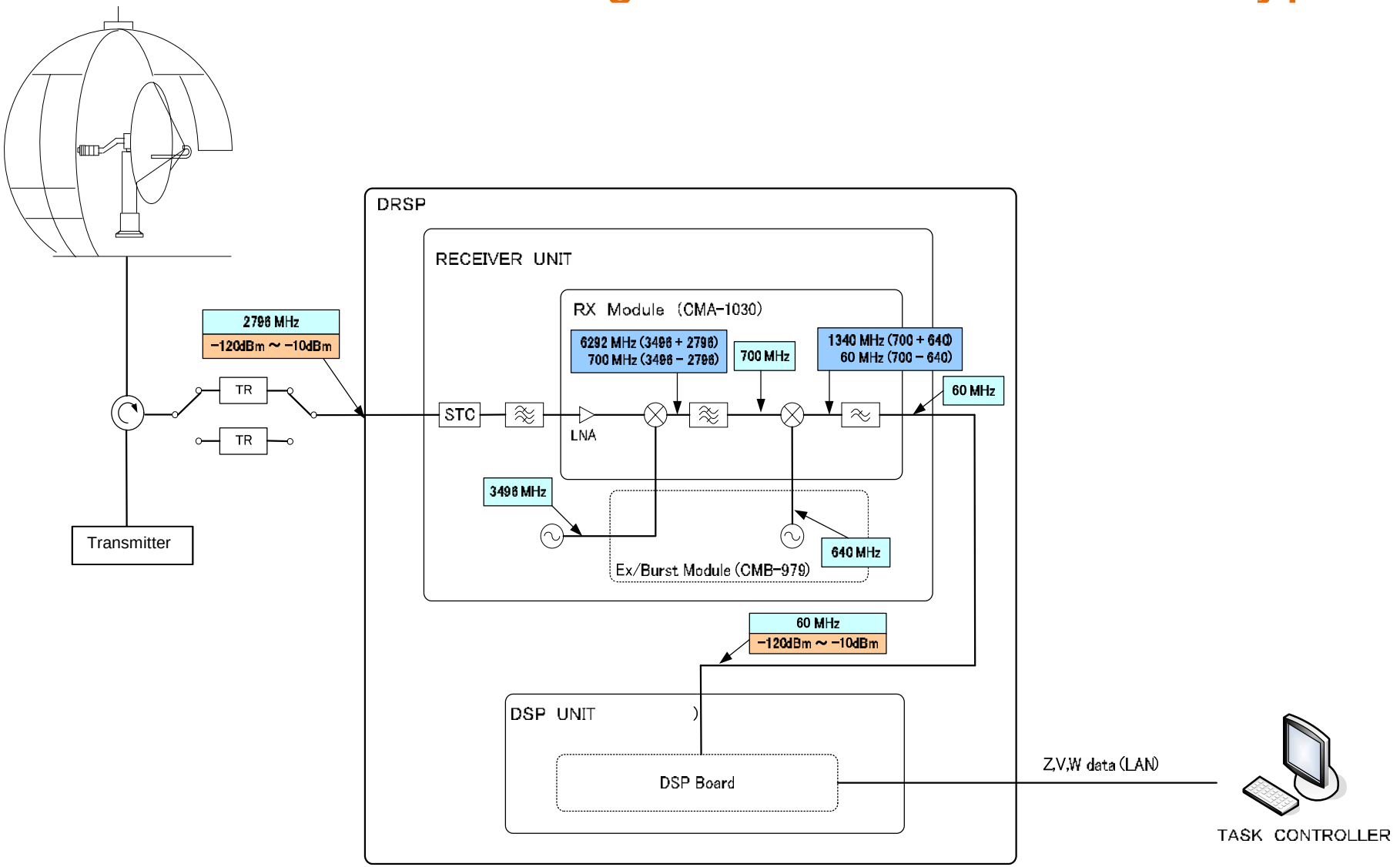
$$Pr = (Rc \cdot Z / r^2) \cdot 10^{-0.2 \cdot kg \cdot r}$$

Z : radar reflectivity factor
Rc : radar constant

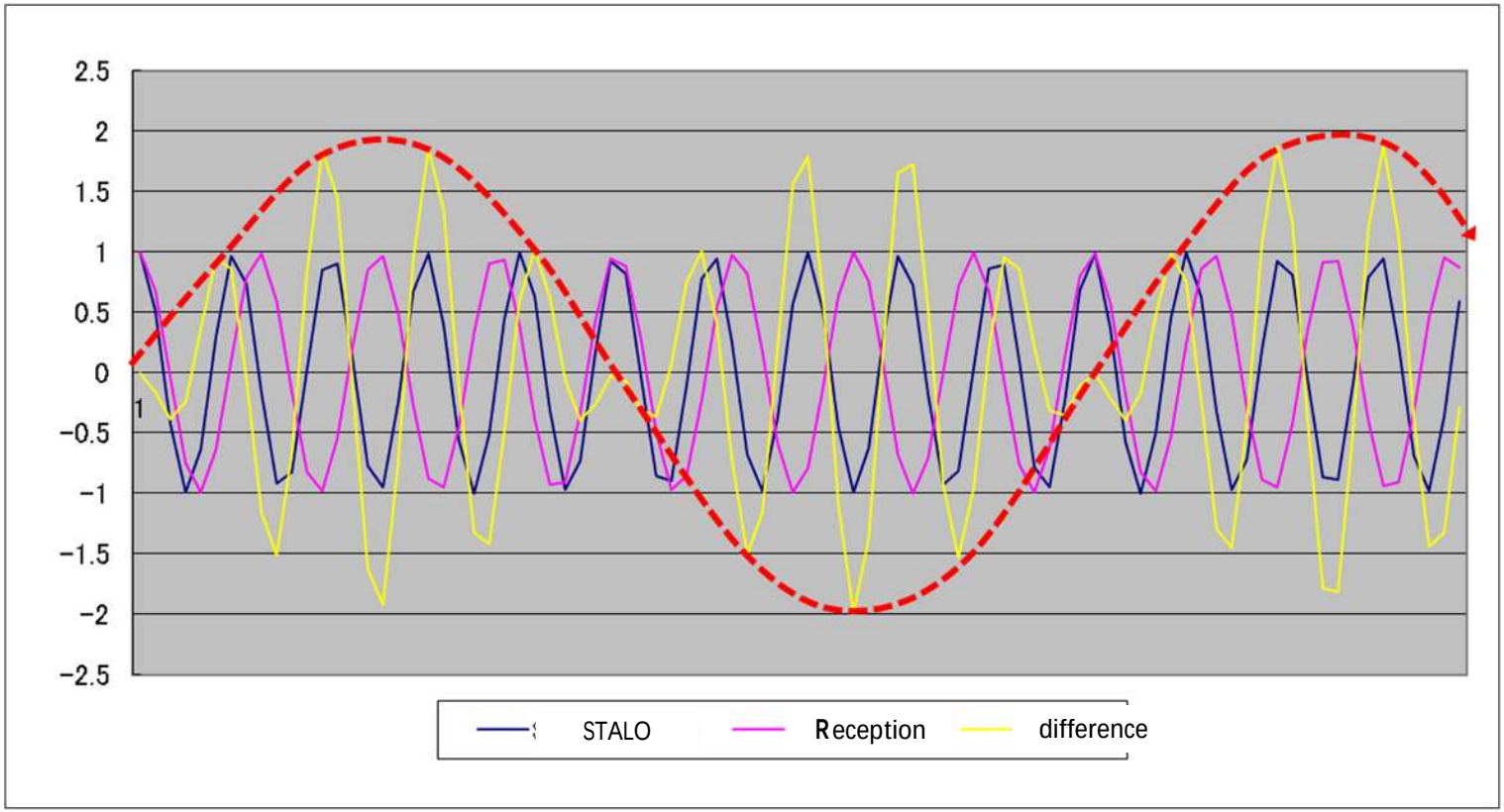
(Review) Receiver Schematic Diagram for Magnetron, Klystron



Receiver Schematic Diagram of the Solid-state Type



(Review) Principle of the Mixer Operation



When two frequency signals are combined, they create a frequency of difference.

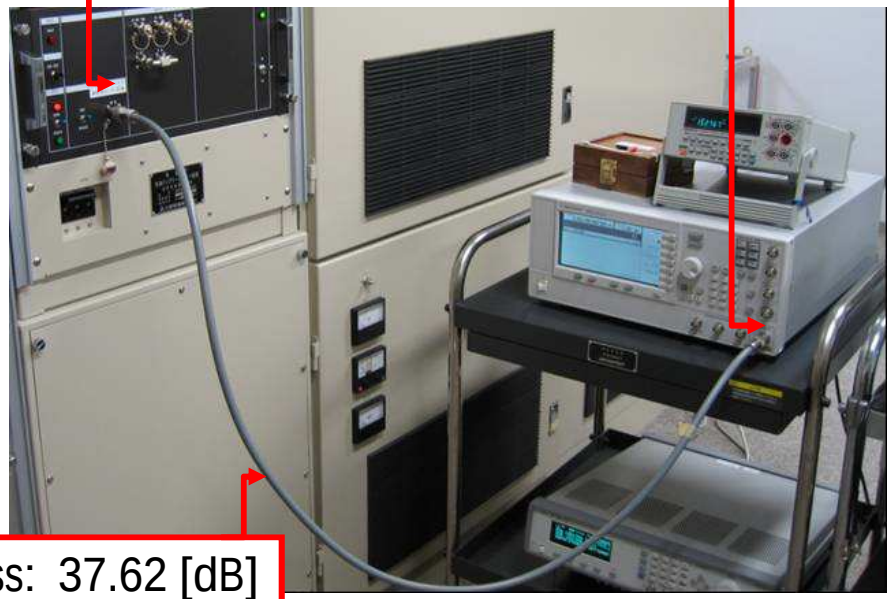
(STALO：5330MHz、Reception：5300MHz、difference：30MHz)

Receiver In/Out Characteristic Measurement

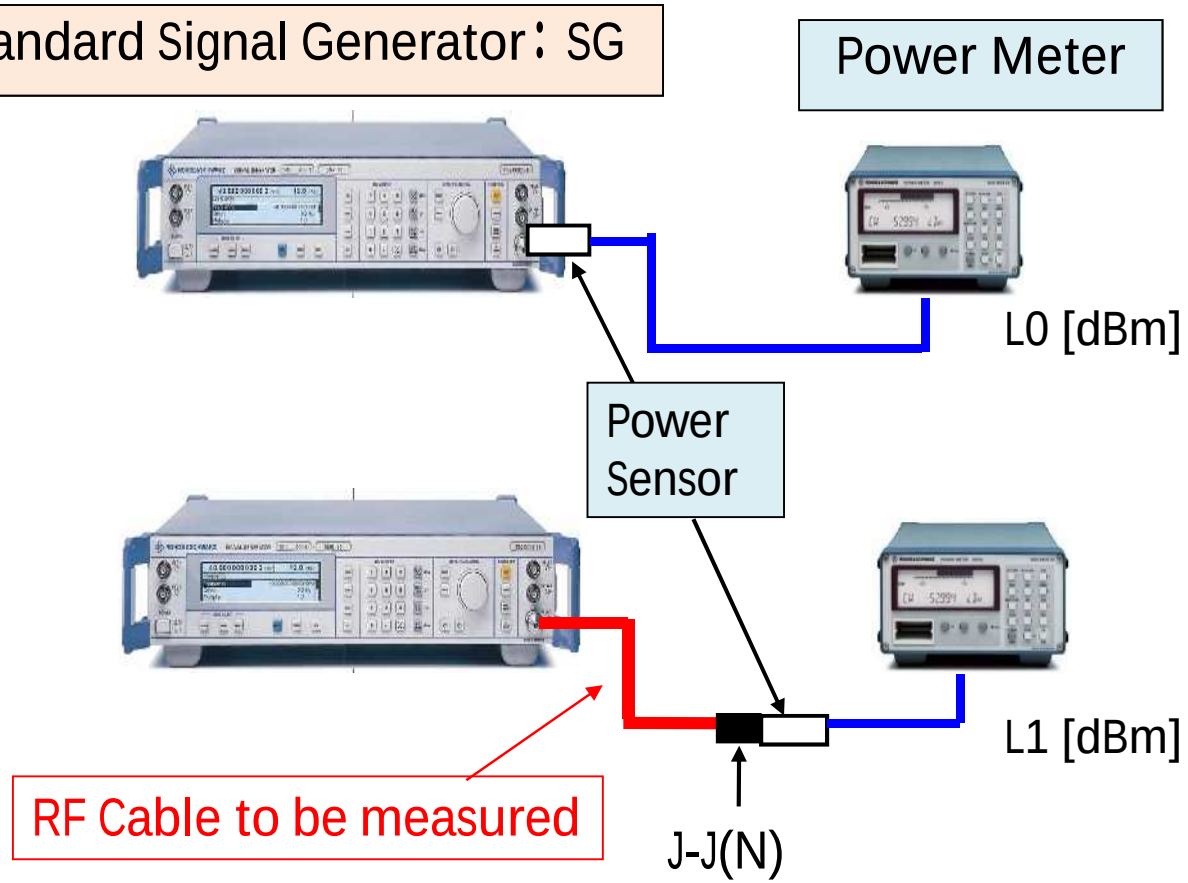
- Connect the SG to radar receiver test input terminal, the equivalent output -40 dB (Consider the coupling loss).
- Setting value of SG output level will be;

  -2.38 [dBm] = -40.00 [dBm] - (Measurement system loss: -37.62dB)

Expansion

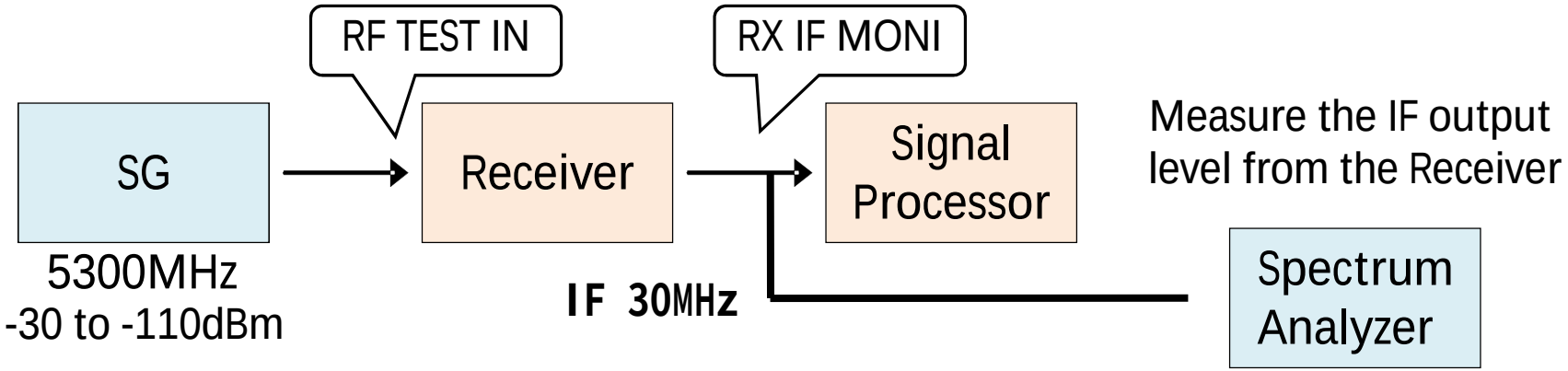


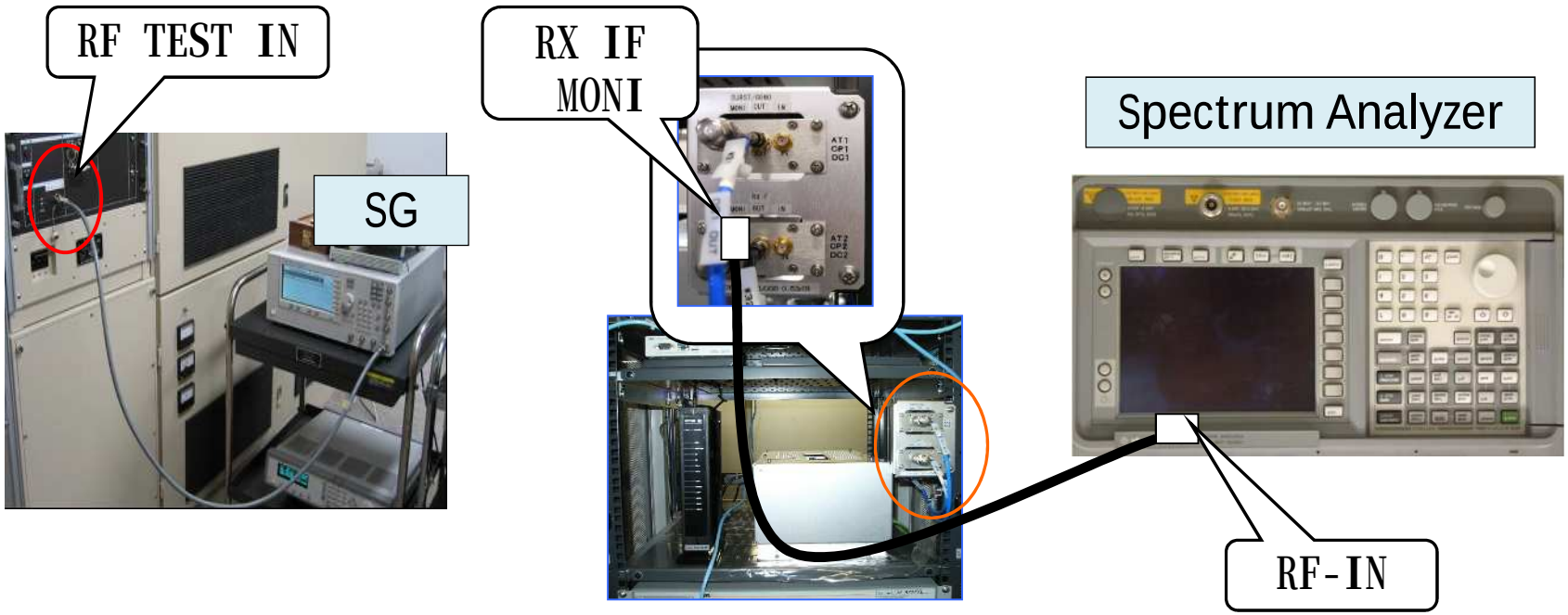
RF Cable Loss Measurement



RF cable Loss [dB] = L0 [dBm] – L1 [dBm]

Receiver In/Out Characteristic Measurement

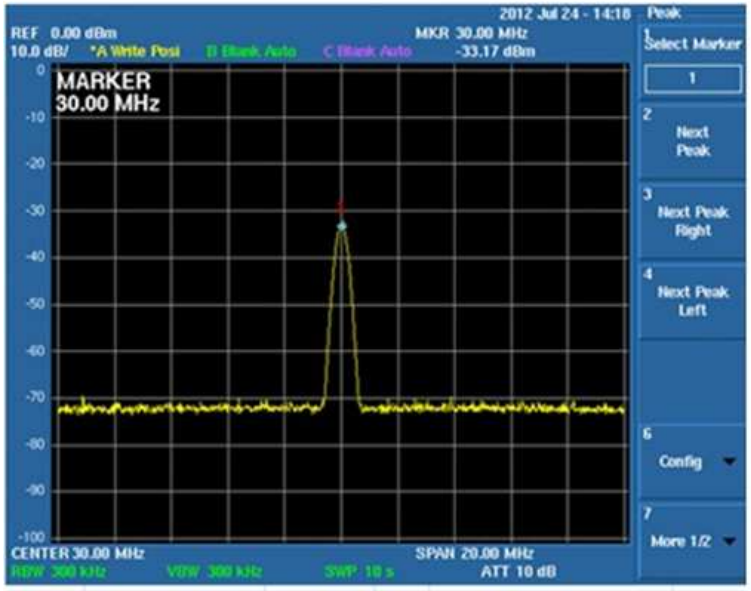




Receiver In/Out Characteristic Measurement

Receiver IF Frequency and Output Level

Measured by the Spectrum Analyzer, Receiver Input: -60 dBm

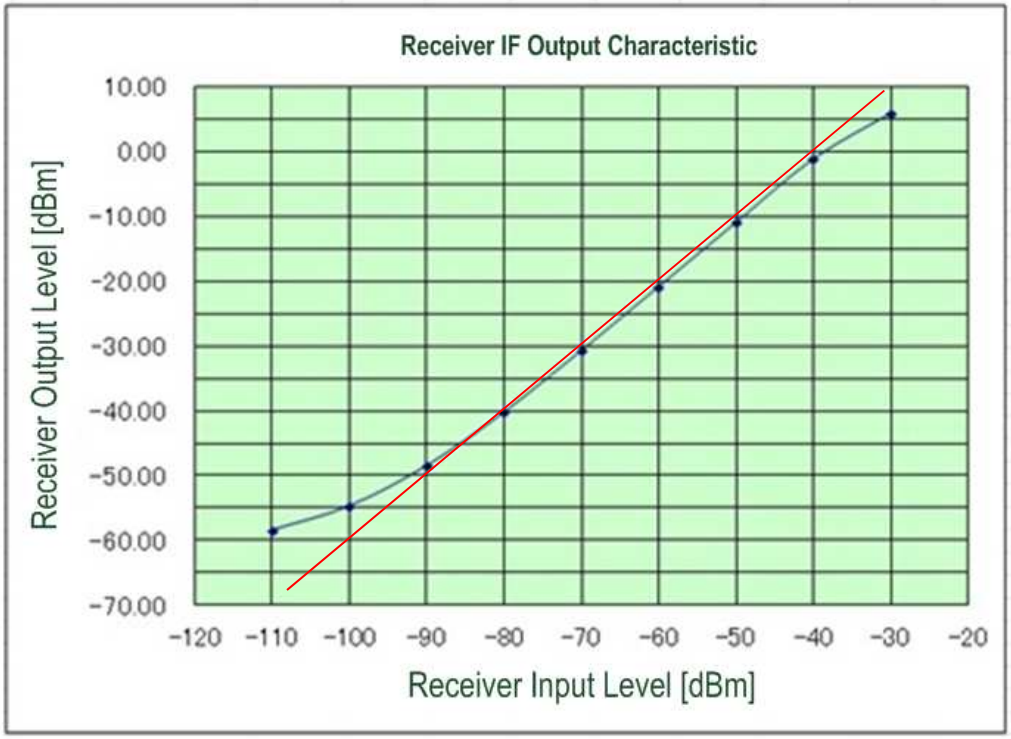


Receiver IF Frequency	30.00 MHz	Reference: 30 +/- 0.1 MHz
Receiver Output Level (included coupling ratio)	-33.17 dBm	Reading = Actual Level - Coupling Ratio
Receiver Output Actual Level	-20.81 dBm	Reference: -20 dBm +/- 3 dB
Coupling Ratio	12.36 dB	

Receiver IF Output Characteristic

Input: RX SG pair Output: RX Output

Receiver Input Level [dBm]	-110	-100	-90	-80	-70	-60	-50	-40	-30
Receiver Output Level [dBm] (included coupling of 12.36 [dB])	-70.74	-67.02	60.81	-52.53	-43.04	-33.17	-23.24	-13.41	-6.38
Receiver Output actual Level [dBm]	-58.38	-54.66	-48.45	-40.17	-30.68	-20.81	-10.88	-1.05	5.98



Periodic Maintenance Items for Waveguide and Dehydrator

(6) Waveguide and Dehydrator Check

Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

	Periodic Inspection and Maintenance Items	Interval
Waveguide		
	Deformation, asperity, joint cracks, air leakage	6
Dehydrator		
	Indication of pressure gauge, operation counter	1
	Alarm indication	D
	Silica gel condition	1
	Operation sound of the compressor	1

(Review) Wave-guide

Rectangular waveguide (WRJ-5)

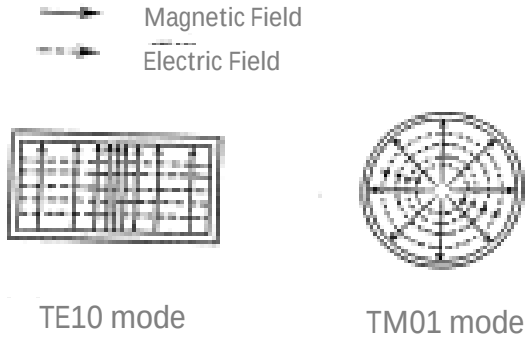
- Cheaper than the circular type
- Thickness is 5cm x 2.5cm

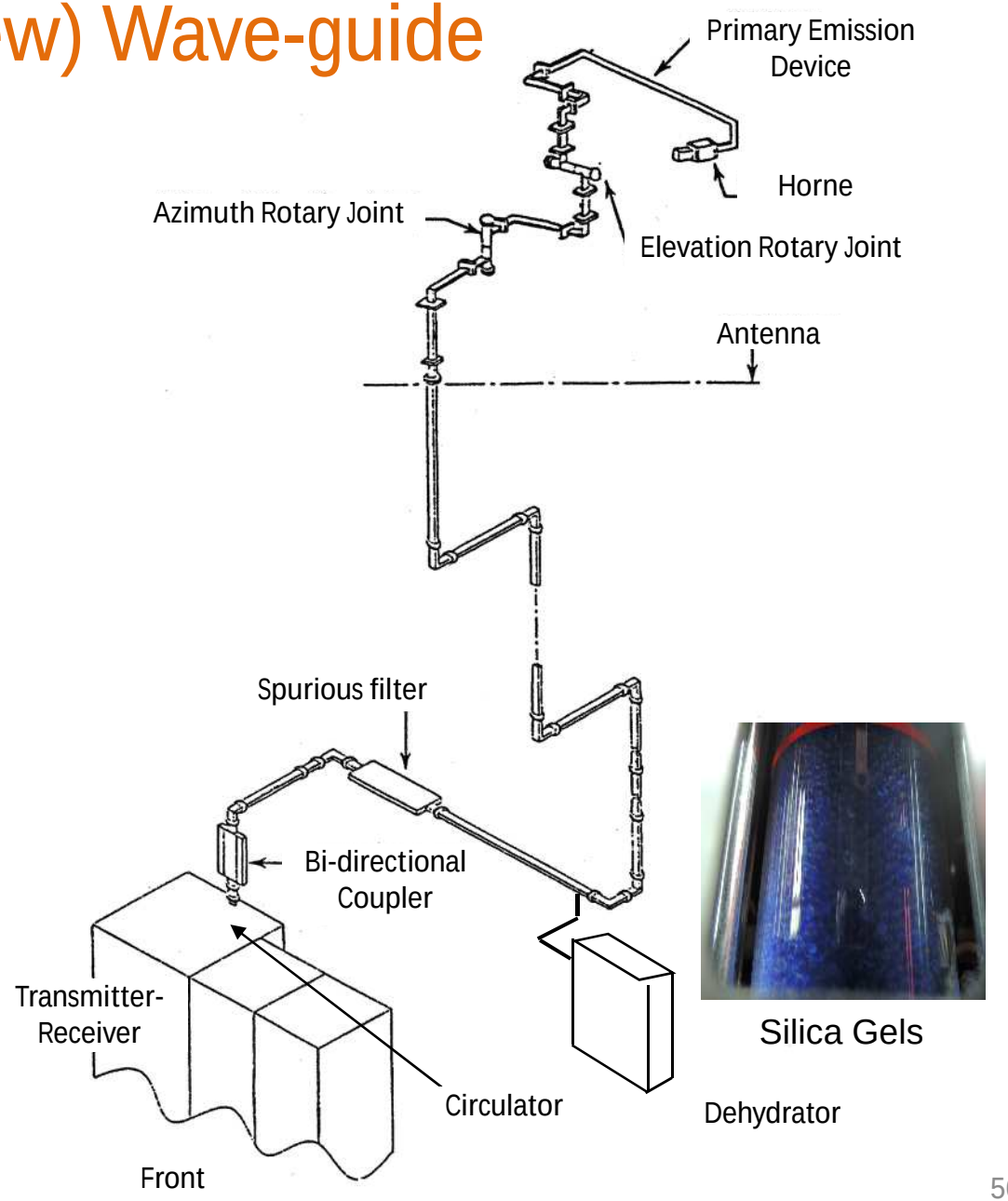
Circular waveguide (WC-5)

- More expensive than the quadrel type
- For Rotary Joints
- Less decay than quadrel

Corrugated waveguide

- Flexible
- Can be curved without joint attachments and shows little decay





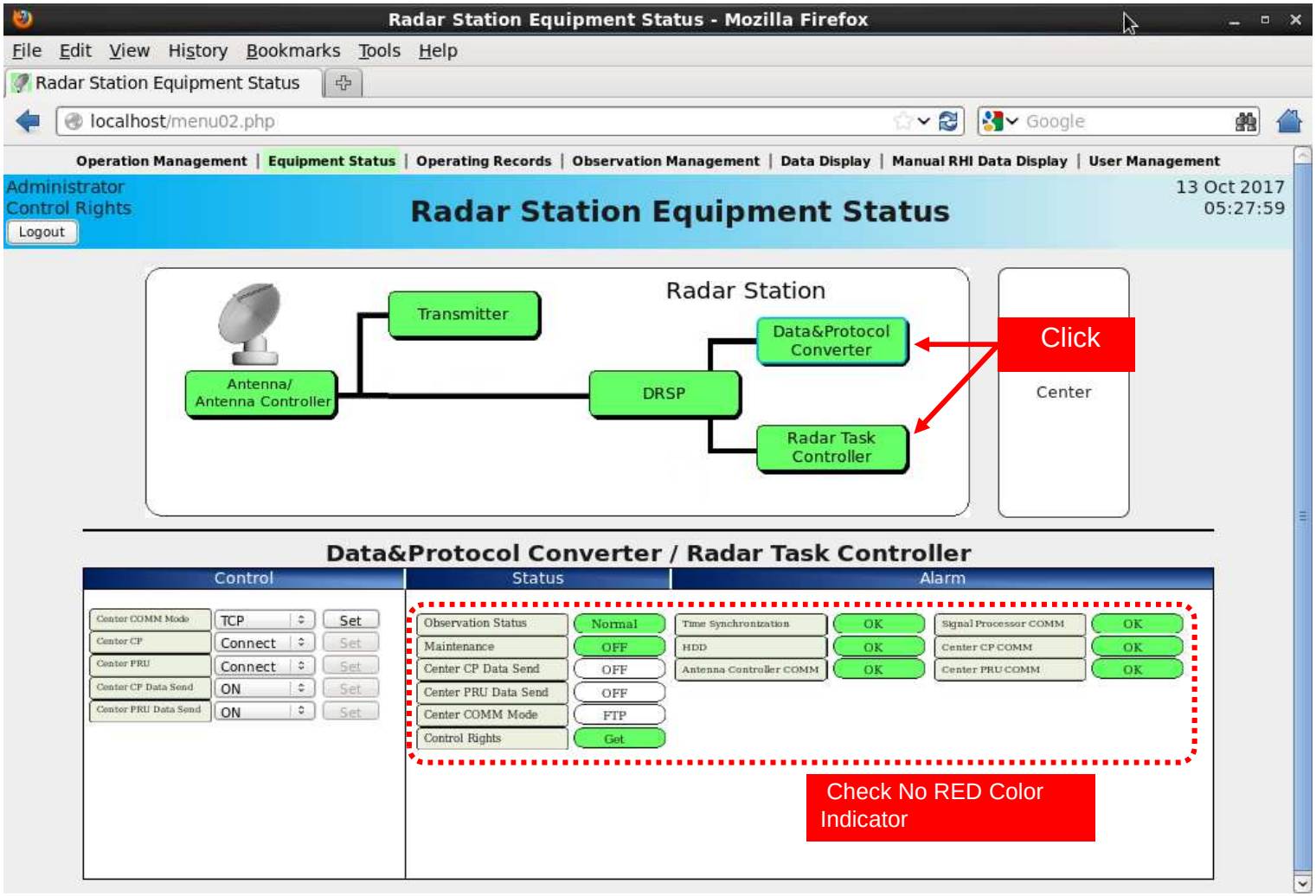
Periodic Maintenance Items for Signal Processor

(7) Signal Processor Check

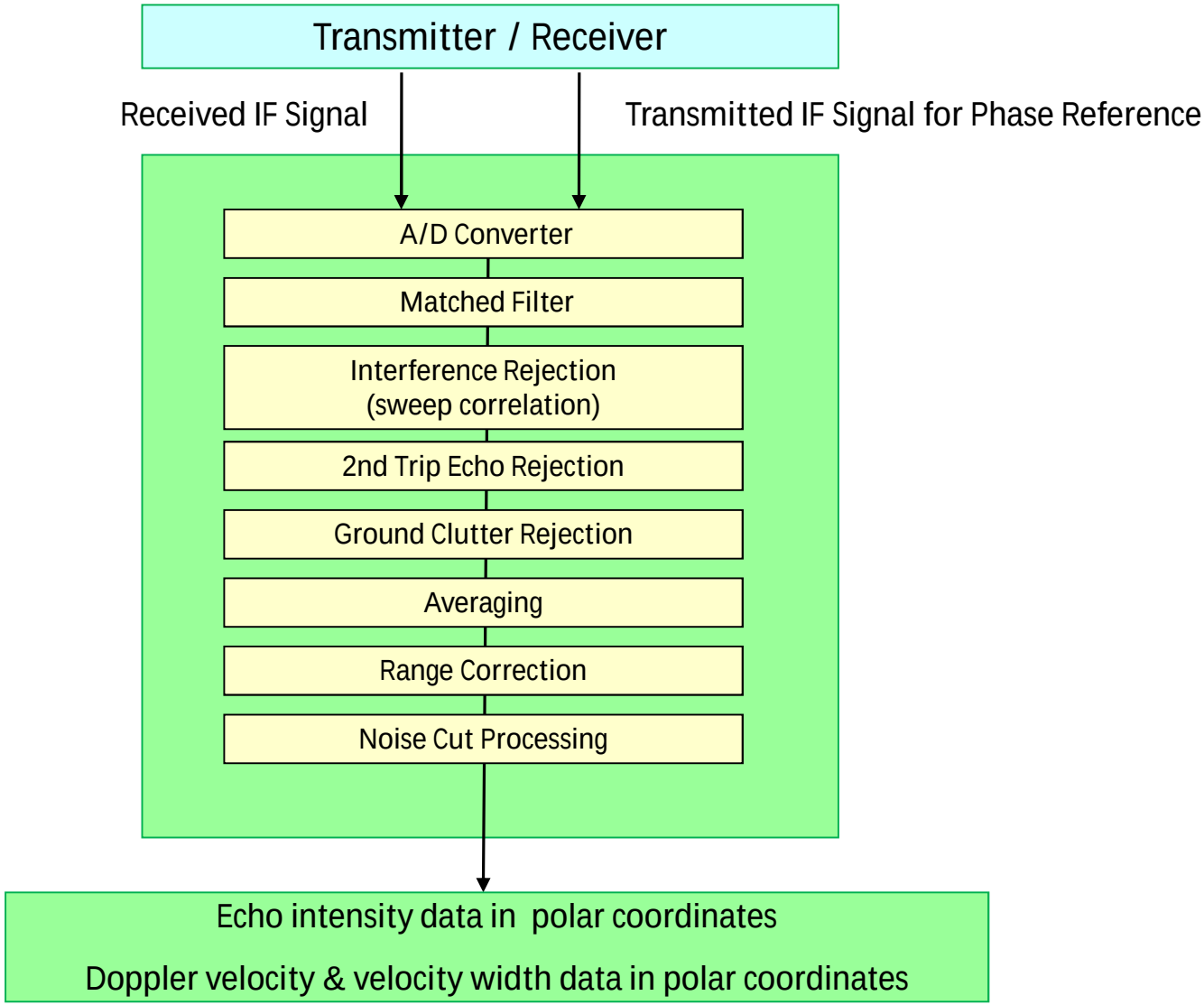
Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items	Interval
IF signal conversion characteristics	6
Range correction characteristics	6
Ground clutter rejection	W
Range and sweep integration	6
Interference rejection	W
2’nd trip echo cancellation (except the magnetron radar)	6
Abnormal data correction and other various function	W
Signal processing parameter calibration with receiver characteristics	6

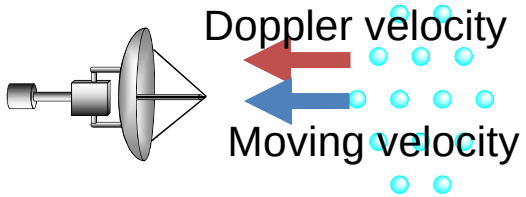
Daily Maintenance Items



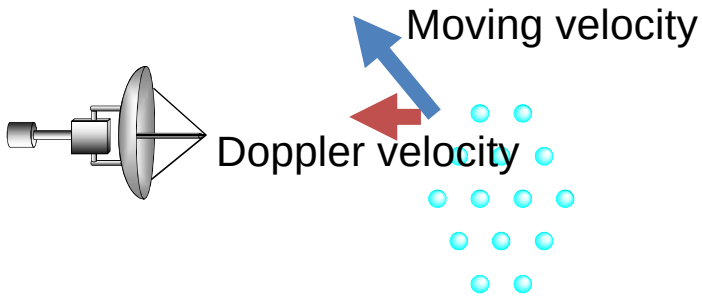
(Review) Signal Processor Schematic Diagram



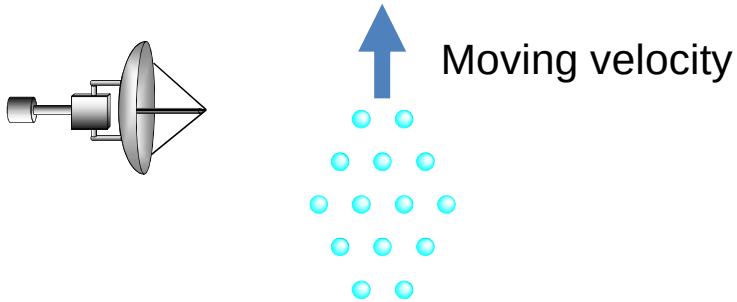
(Review) Wind Observation by the Doppler Radar



The Doppler velocity
= Moving velocity

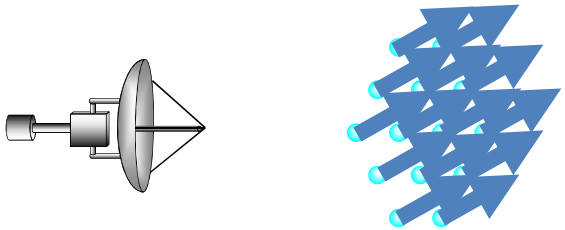


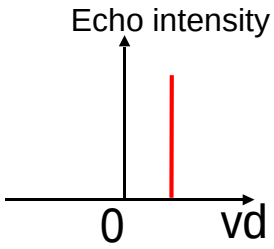
The Doppler velocity is the line-of-sight component of the moving velocity.



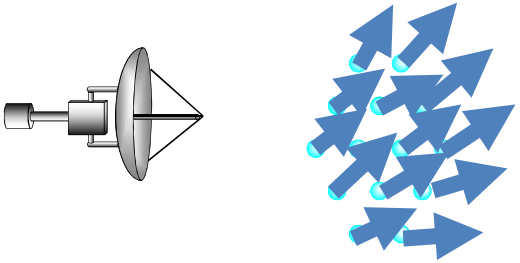
The Doppler velocity becomes zero.

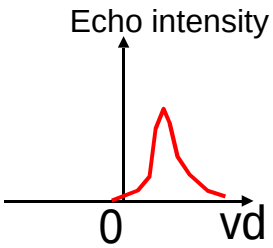
(Review) Wind Observation by the Doppler Radar



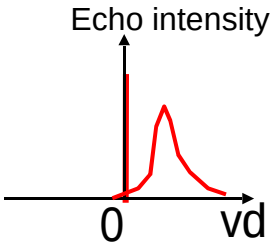


If each precipitation particle in the illuminated volume has exactly the same velocity in magnitude and direction, the observed Doppler spectrum would be sharp.





Actually each precipitation particle has distinct velocity vector, which makes the spectrum broad. Usually, the spectrum peak is employed as “Doppler velocity” of wind.

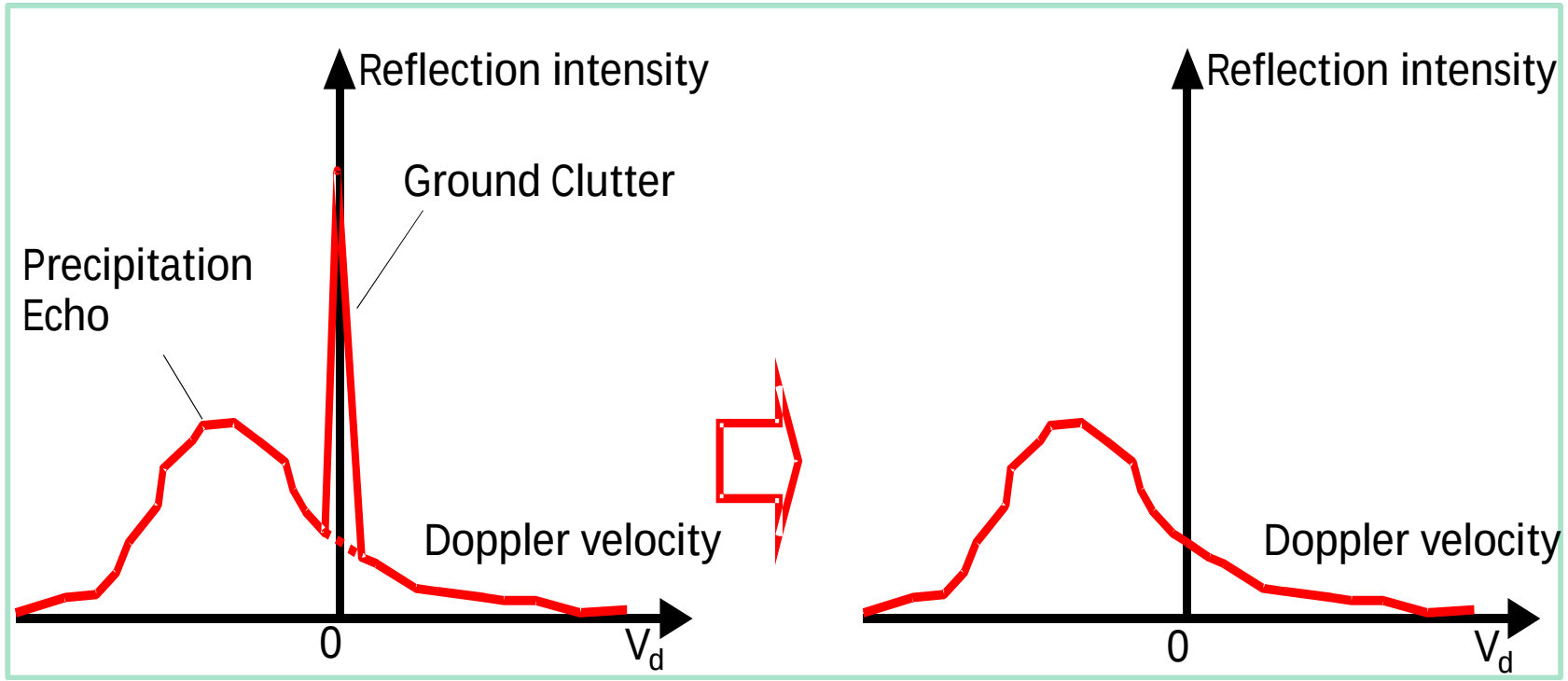


In the low elevation scan, topographic influence (ground clutter) is also found on the Doppler spectrum, which deteriorates data quality.

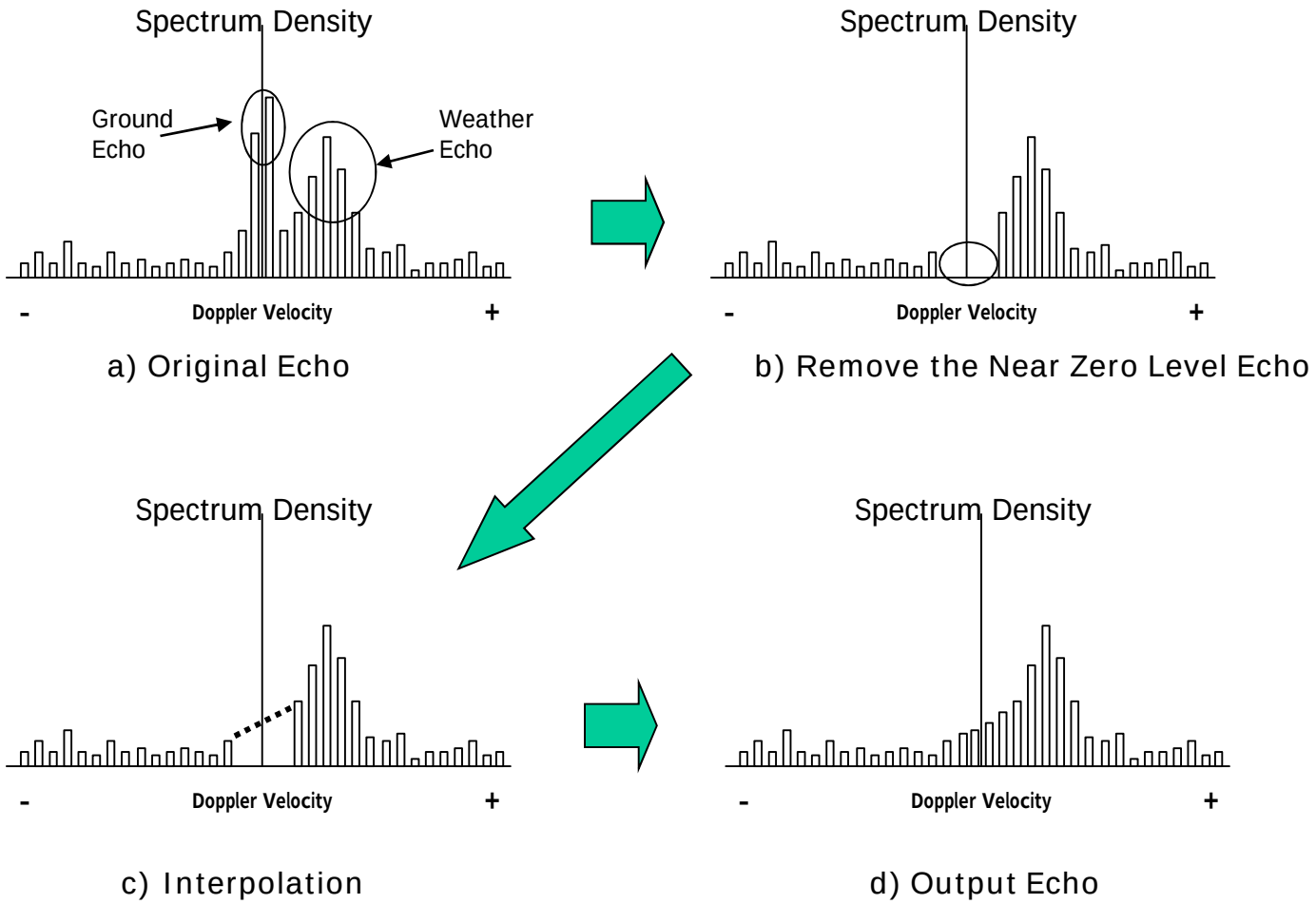
(Review) Ground Clutter Suppression Technique (Coherent MTI)

Components with zero Doppler velocity are considered as ground clutter and rejected to determine reflection intensity.

MTI: Moving Target Indicator



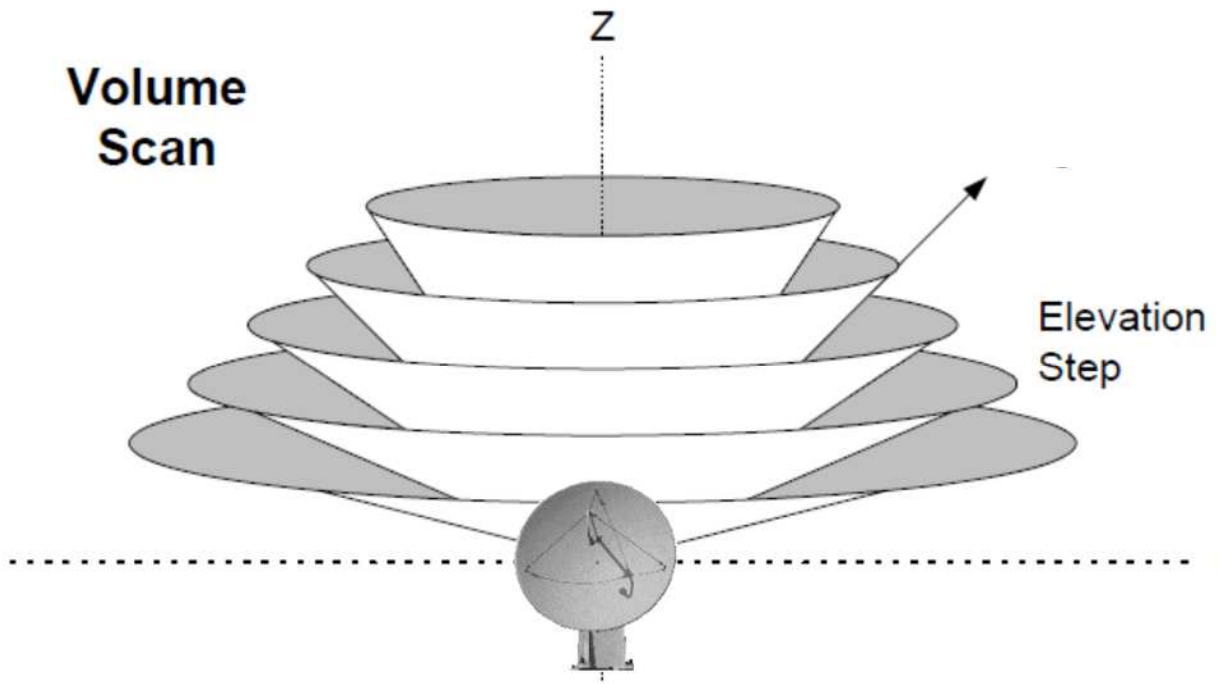
FFT Clutter Filter for FFT Processing



(Review) Antenna Volume Scan

< Volume Scan >

- Scanning in PPI (Plan Position Indicator) mode
- Repeat PPI scanning after changing elevation angle.

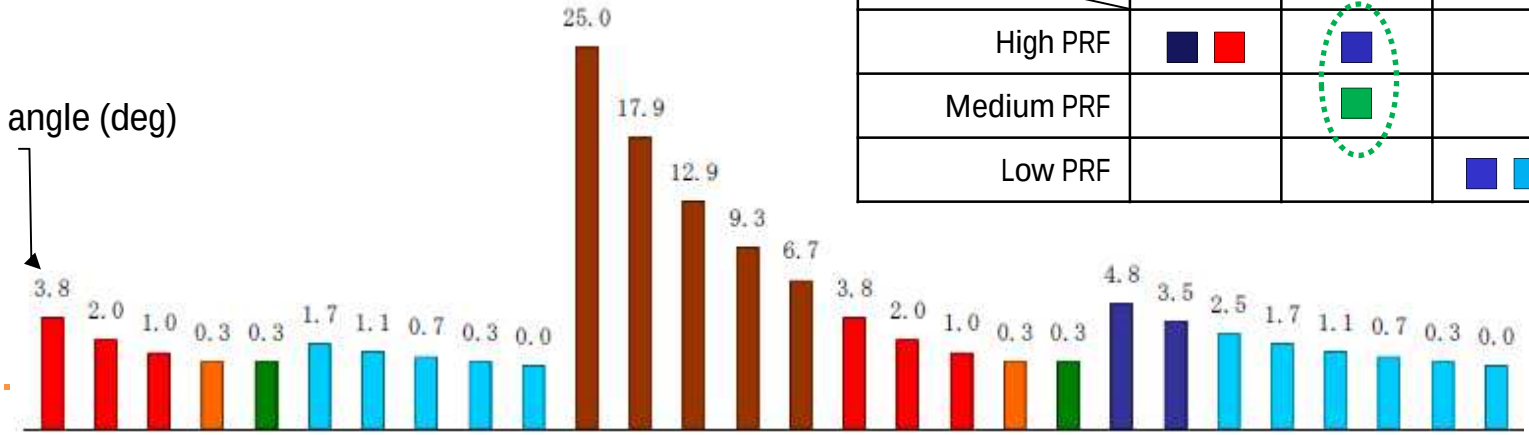


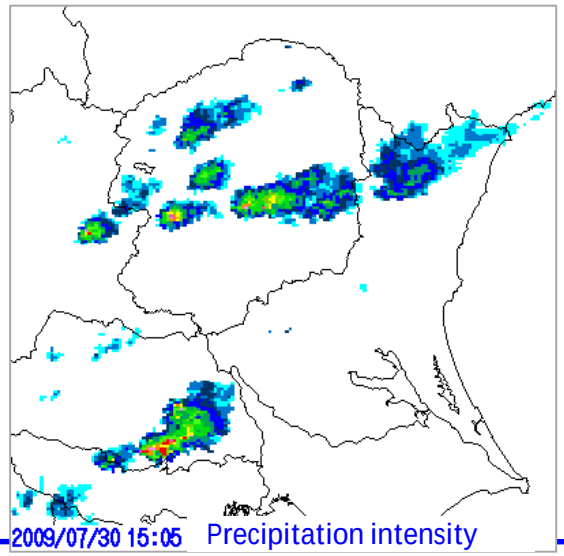
(Review) Scan Sequence (for Tokyo Doppler Radar)

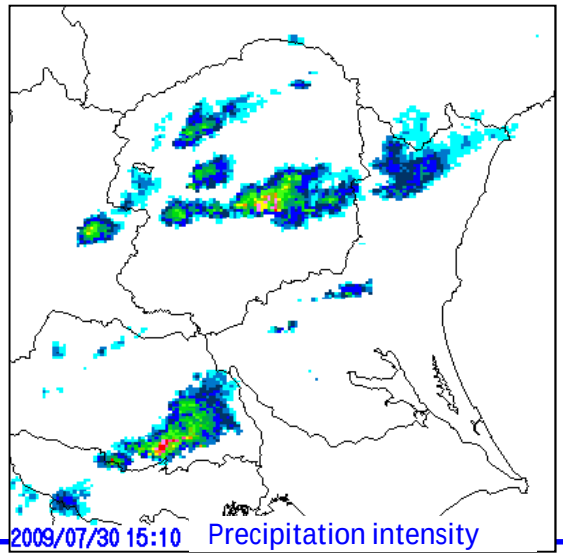
PRF \ Range	150km	250km	400km
High PRF	■ ■	■	
Medium PRF		■	
Low PRF			■ ■

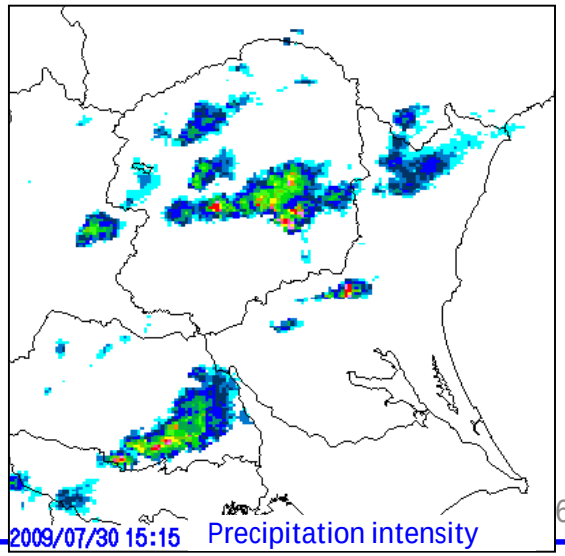
elevation angle (deg)

10 min.









Why does PRF have to change high and low PRF for the scan sequence?

Detectable Maximum Velocity

$V_{max}\ (m/s) = V_{max1}\ (m/s) \times N_2 = V_{max2}\ (m/s) \times N_1$

fr1 : 700Hz
fr2 : 560Hz
Ratio: 5/4

V max1 (m/s) = λ x fr1 / 4 = 0.05 (m) x 700 / 4 = 8.75 (m/s)

V max2 (m/s) = λ x fr1 / 4 = 0.05 (m) x 560 / 4 = 7.00 (m/s)

V max (m/s) = 8.75 (m/s) x 4 = 7.00 (m/s) x 5 = 35 (m/s)

Detectable Maximum Range

$R_{max}\ (m) = C\ (m/s) / (2 \times fr\ (Hz))$

R max (m): Detectable maximum range
fr (Hz) : Pulse repetition frequency
C (m/s) : Light speed 3×10^8 (m/s)

R max (m) = 3×10^8 (m/s) / (2 x 700 (Hz))
= 214 (km)
fr: 700Hz

Doppler Dilemma!!!

R max (m) x V max (m/s) = C (m/s) x λ (m) / 2

fr: 300Hz (Intensity Mode)

V max (m/s) = 300 (Hz) x 0.05 (m) / 4 = 3.75 (m/s)

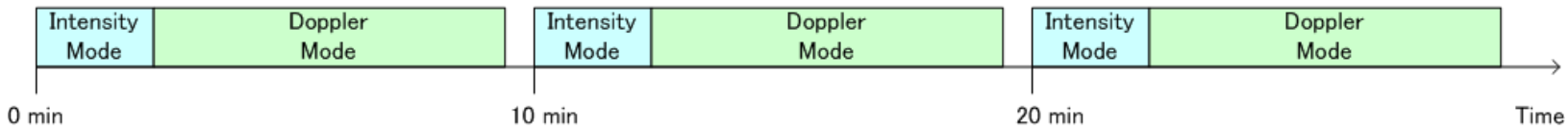
R max (m) = 3×10^8 (m/s) / (2 x 300 (Hz)) = 500 (km)

fr: 700Hz (Doppler Mode)

V max (m/s) = 700 (Hz) x 0.05 (m) / 4 = 8.75 (m/s)

R max (m) = 3×10^8 (m/s) / (2 x 700 (Hz)) = 214 (km)

Avoidance of Doppler Dilemma



Periodic Maintenance Items for Power Supply System

(8) IT, PDB, AVR and UPS Check

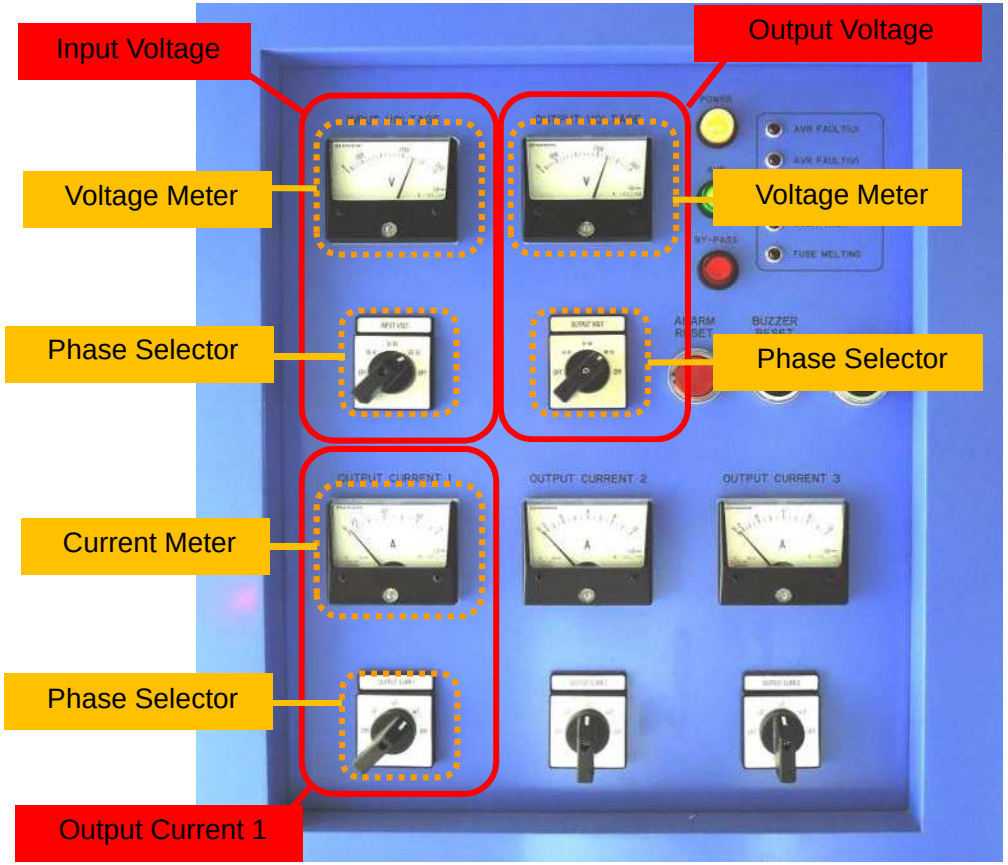
Interval= D: Daily, W: Weekly, 1: Monthly, 3: 3 Monthly, 6: 6 Monthly

Periodic Inspection and Maintenance Items		Interval
IT		
	Humming sound (...Bmmmm...)	D
	Condition of the surge arresters and capacitors	D
	Condition of the main/earth wiring cable and terminal	6
PDB & AVR		
	Voltage and current	D
	Operational status (power on/off, AC voltage stabilization)	D
	Condition of the NFB's, meters/indicators, PCBs, electric parts, wiring	6
UPS		
	Voltage and current	D
	Operational status (back-up operation)	M
	Condition of the PCBs, batteries, transformers, capacitors, wiring	6

Daily Maintenance Items

IT Monitoring Panel

AVR Operation Panel



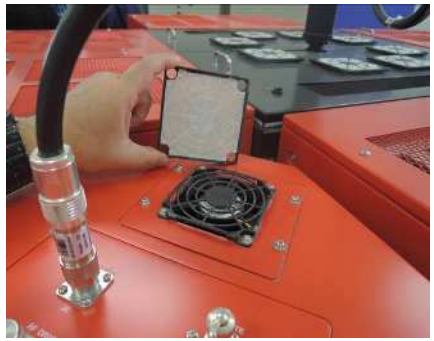
6 Monthly Periodic Maintenance Items

Cleaning of the air filters in the DRSP




Cleaning of the air filters for SSPA Transmitter




Caution Point

(1) Basic precautions

a. To make a logbook for the results of inspections, tests, adjustments, and its treatment as well as fault conditions

b. At least two people have to work together

- When you work inside of the transmitter/receiver equipment cabinet (Such as transmission tube replacement)
- When you work in the radome for the antenna maintenance

In particular, that the inspection of the high voltage modulator, mechanical inspection of the antenna.

Caution Point

(2) Caution for using the test instruments

a. When carrying out measurement and adjustment, it is necessary to preheat instruments enough time (approximately 30 minutes) for its accuracy and stability.

b. For instruments which have a self-calibration function, the self-calibration should be performed before measurement.

c. Before measuring the cable loss, check the status of the cable. (disconnection, poor contact, etc.) .

d. The test instrument has an upper limit of input level. If it gets more than limit level, the protection circuit will be activated. But, in some cases it will lead to failure.
Check the maximum input level with the instruction manual before measurement. it must be necessary to attenuate the signal using some attenuator if necessary.

Caution Point

(3) Precautions for handling special tubes (Magnetron, klystron, TR tube, Thyratron)

a. Necessary to record about replacing a special tube

b. Be careful when handling TR tube that radioactive material is incorporated.

c. For replacement of magnetron or klystron, turn off the power with the breaker, discharge the high-voltage remained by using the discharge rod.

Cleaning and Check

a. General Cleaning and Check

- The power supply should be disconnected before carrying out any of these cleaning operations.
- The accumulation of dust on components would cause a general increase in the cabinets' internal temperatures.
- Increase in the cabinets' internal temperatures could lead to malfunctions or faults in certain components.
- In order to prevent this happening, the equipment must be kept clean at all times.

b. Cabinet Cleaning

- Even though the cabinets are fitted with air filter, regular cleaning of the internal parts is required to stop dust accumulation.
- This can be done using a vacuum cleaner, a clean dry cloth or a small brush.
- It would be good to carry out this cleaning operation at least once a year.

Cleaning and Check

c. Air Filters
- The air filter on the cabinet's panel must be disassembled and cleaned to remove dust.
- The cleaning schedule will depend on the length of time the fans work and the quantity of dust.
- It would be good to carry out cleaning at least once a year.

d. Indicator Lights and Lamps
- Make sure the lamps are inserted firmly into their holders.
- Replace the lamp when the bulb becomes blackened.

e. Fuses
- Fuse terminals are liable to oxidation and this oxidation and dust increase the circuit's resistance.
- The ends of the fuses should be cleaned with a cloth.
- The fuses should be taken out one at a time to ensure that they are put back in their correct.
- The value stamped on the fuse must be the same as that stamped on the fuse housing.

Copyright Notice