Profiler Operator's Manual:

- **MP-3000 A**
- **MP-2500 A**
- **MP-1500 A**

MCM-C Hardware Configuration

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Revision G

Release Notes Concerning this Manual

- Revision A of the Operator's Manual (April 2013) applies to profilers configured with the MCM-C hardware, serial number 3131A and later.
- Revision B of the Operator's Manual (August 2013) incorporates UL / IEC approval and documents new labels for UL / IEC compliance.
- Revision C of the Operator's Manual (February 2015) incorporates corrections and new information from previously published stand-alone service bulletins.
- Revision D of the Operator's Manual (August 2015) incorporates newly added appendices (J – K).
- Revision E of the Operator's Manual (August 2017) corrects minor errors in graphics. (not published)
- Revision F of the Operator's Manual (August 2017) is to bring the revision of the Operator's Manual into agreement with the Appendix.
- Revision G – corrects minor content issues, updated LN2 procedure to specify that it is only for V-Band, and to use TIP Cal for K-Band.
- Address questions regarding this Operator's Manual to

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CAUTION

The radiometer cabinet cover is closely fit to seal against intrusion of insects, spiders, wind-blown dust, sand, water and ice. Caution should be used if it is necessary to remove the cabinet cover. After unbuckling the latches on both sides of the cabinet, the cover should be evenly and gently lifted by using the handles on the cabinet cover. Forcing the cover unevenly can result in damage to the radiometer and voiding of the Warranty.

Substitution of another computer for the Control Computer supplied by Radiometrics, or changing the factory software load and settings, may void our software and control computer Warranty support obligation. Should such changes result in need for RDX remote support, Radiometrics will invoice these services to you at our normal hourly support rates.

1 General Description

1.1 Introduction

This manual provides information about the operation of Radiometrics MP-3000A, MP-2500A, and MP-1500A advanced portable profiling microwave radiometers. Throughout this manual, the term “Profiling Radiometer” is used to refer to the MP-3000A model. The manual will also default to the description of the MP-3000A model, but will mention differences regarding the MP-1500A and MP-2500A where appropriate.

Radiometrics Profiling Radiometers produce vertical profiles from the surface to 10 km. The MP-3000A produces high-resolution temperature, relative humidity and water vapor profiles, and low-resolution liquid profiles.

Figure 1-1. MP-3000A with Azimuth Positioner and IRT

1.2 Manual Organization

This manual covers the installation and operation of the MP-3000A Microwave Profiling Radiometer System. We have organized the manual in a logical structure, with information grouped in chapters that are based on how the operator will use the system. Each chapter of the manual is a separate electronic document, which makes searching for specific information easier and faster.

Specifically, this manual covers the following:

Chapter 1. General Description – An introduction to Microwave Profiling Radiometer System, an overview of the MP system, and a Safety overview.

Chapter 2. Profiler Description – A description of all hardware components, followed by a high-level block diagram.

Chapter 3. Installation – Detailed instructions on unpacking and installing the radiometer system.

Chapter 4. Initial Operation and Test of the Instrument – Instructions on initial start-up and test. Once the radiometer system is installed and operating normally, this section will be the reference for ongoing system operation and data collection.

Chapter 5. Configuration, Control, and Data Processing – General descriptions, specifications, and instruction sets for the MP radiometer. There is also information on system configuration, control and data processing using the visualization software.

Chapter 6. Maintenance and Troubleshooting – Information about maintenance and calibration, as well as Control Computer maintenance. Instruction for field replaceable units (FRUs) is contained in this chapter.

Chapter 7. Warranty and Service Form – In addition to the warranty and service details, there is contact information for Radiometrics Corporation and a Feedback form with which to report problems with the manual and suggest improvements.

Appendices – The appendices include a VizMet-B user's guide, instructions for FRUs, lists of error messages, and other information.

1.3 System Overview

The MP-3000A incorporates two radio frequency (RF) subsystems in the same cabinet. These RF subsystems share the same antenna and antenna pointing system. The temperature profiling subsystem utilizes sky brightness temperature observations at selected frequencies between 51 and 59 GHz, or V-band. The water vapor profiling subsystem utilizes sky brightness temperature observations at selected frequencies between 22 and 30 GHz, or K-Band. The MP-1500A incorporates only the K-Band receiver, while MP-2500A incorporates only the V-Band receiver.

Surface meteorological sensors (Met Sensors) are included to measure air temperature, relative humidity and barometric pressure. A rain sensor is also standard. An optional, internally mounted, zenith-pointed infrared thermometer (IRT) allows the profiling radiometer to improve the measurement of water vapor and cloud liquid water profiles.

All Profiling Radiometers have been designed for ease of use, accuracy, reliability, portability, and low power requirements. They only use "passive technology", thus they do not emit radiation detectable by any normal means. The MP-3000A is shown in Figure 1-1 with the Azimuth Positioner mounted on the Radiometrics model TP-2000 Telescoping Tripod.

Profiling Radiometers are installed outdoors, normally on the TP-2000 Tripod. However, the user may supply an alternative compatible mounting platform. The instrument must be located where primary power is available (normally 115VAC or 230VAC), and the antenna system shall have a clear view of the sky, from horizon to horizon, in at least one vertical plane. A clear view of the sky is required for all azimuth and elevation angles of interest. Detailed installation requirements are provided in Section 3, Installation.

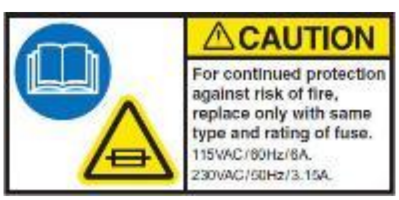
All Profiling Radiometers are controlled by Radiometrics proprietary software, referred to herein as the “Operating Code”.[1] The Operating Code is supplied pre-installed on a dedicated “Control Computer”. The Control Computer may be connected directly to the Profiling Radiometer via the supplied RS-422 cable, or it may be connected to the Control Computer via a local area network (LAN) using a remote RS-422 serial port server.[2] Data is stored on the computer in an “operational” folder that can be configured to be accessible over a LAN. The included Ethernet cable provides a way to easily update firmware in the two receivers and the radiometer Main Control Module (MCM).

The Operating Code begins logging data to *level0* files (raw sensor data), *level1* files (brightness temperatures), *level2* files (profile retrievals), *TIP* calibration data files, and health status files. Real-time graphics of the *level1* and *level2* products, related to the specific option selected, can be displayed. Real-time graphics for the MP-3000A include:

- Met Sensor time series (*level1* data)
- Brightness Temperature time series (*level1* data)
- Temperature, Water Vapor, Liquid Water, and Relative Humidity (RH) Profiles and column integrated vapor and liquid (*level2* data)
- TIP calibration derived values of Noise Diode Temperatures (Tnd_TIP)
- LN2 calibration derived values of Noise Diode Temperatures (Tnd_LN2)

1.4 Safety

Below is a table of the UL and IEC 61010-1 safety labels that appear on the Profiling Radiometer. These labels provide information about potentially dangerous situations that can result in death, injury, or damage to the instrument and other components. If the equipment is used in a manner not specified by Radiometrics Corporation, the protection provided by the equipment may be impaired.

	This label is located on the Superblower, on the front.		Rotating pinch hazard x2: 1 on each side of the azimuth drive.
	This label is located on the Superblower, on the front.		Vertical pinch hazard x2: 1 on each side of the radiometer hood, between front and middle hasps. Be careful when lifting.

[1] Future operating code releases may include additional features or features slightly different from those described here.
[2] For information on compatible serial port servers, contact Radiometrics Customer Service.

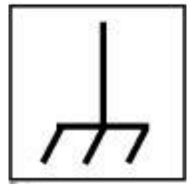
	This label is located on the Superblower, on the front.		Chassis ground: This label is located on the underside of the radiometer, beside the grounding stud.

Table 1-1. UL and IEC safety standards labels

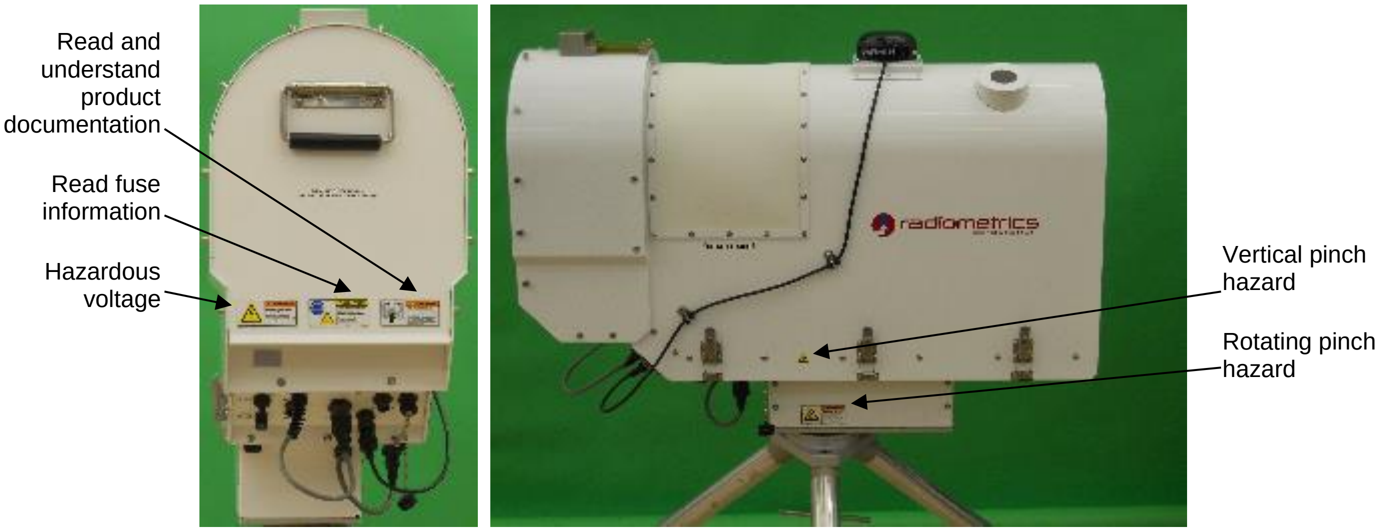


Figure 1-2. Label locations

1.4.1 Hazard locations, descriptions and avoidance

1.4.1.1 Fuse replacement hazard

Located toward the front of the Radiometer, this label indicates the nominal usage voltage to which the fuse ratings apply and directs the customer to read the manual when replacing the fuse. Specifically, the customer will refer to **MCM-C Profiler Appendices, Appendix F, Section IX, Replacing the Front Connector Panel Fuse**, which also gives the customer lock-out instructions.

1.4.1.2 Hazardous voltage

Located on the front of the Radiometer, this label directs the customer to follow lock-out instructions, prior to servicing. Within the Radiometer, guards have been put in place to prevent contact with voltages. Always disconnect the power cable before performing any service or maintenance.

1.4.1.3 Rotating pinch hazard

Located on two sides of the Azimuth Drive, this label directs the customer to keep loose clothing, jewelry and hair away from rotating parts. This hazard exists if the radiometer

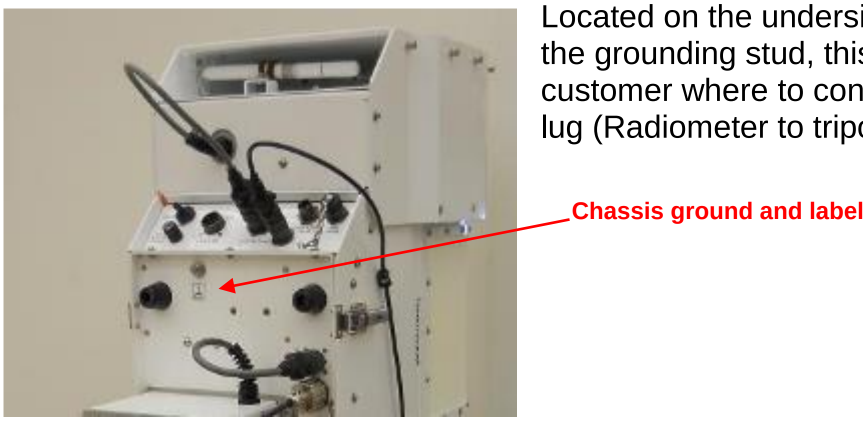
- has an Azimuth Drive, and
- is in operation

The hazard is negated when
- there is no Azimuth Drive, or
- the Radiometer is turned off

1.4.1.4 Vertical pinch hazard

Located on two sides of the Radiometer hood, this label warns customers about the possibility of having their hands or fingers pinched when removing the hood. Customers negate this hazard when they only lift the hood by its two handles.

1.4.1.5 Chassis ground



Located on the underside of the Radiometer, beside the grounding stud, this label is to inform the customer where to connect the grounding cable ring lug (Radiometer to tripod).

Figure 1-3. Underside of Radiometer

CAUTION

All other service functions not specifically detailed in this manual and appendix are to be referred to Radiometrics.

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2 Profiler Description

2.1 System Architecture

All Profiling Radiometer models share a common modular architecture, with the only differences being the number of, and type of receivers. The block diagram in Figure 2-1 provides an overview of the primary system level components in the MP-3000A. All system level components are plug-compatible and factory interchangeable for ease of maintenance and repair. Most are also field replaceable units (FRUs).

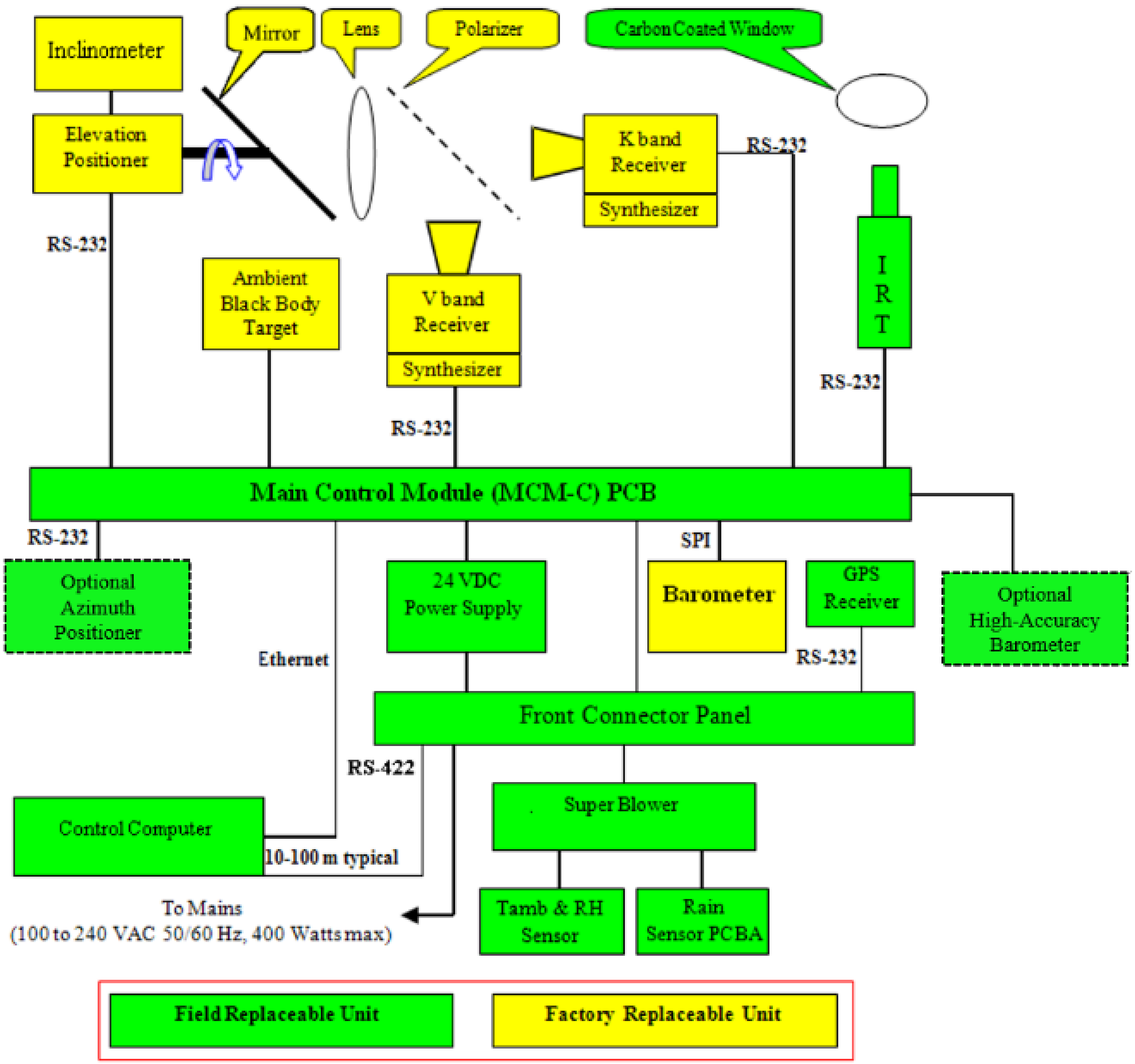


Figure 2-1. MP-3000A Block Diagram

2.2 Functional Description of Components

Primary power enters the instrument via a twist-lock connector on the Front Panel. Primary power is controlled by a toggle switch on the left side. A fuse protects the mains. DC power is supplied to all components from the 24VDC power supply, which is the only component that connects to primary power. A 26 conductor ribbon cable connects all front panel connectors (except primary power) to the MCM-C. The two RS422 ports on the Front Panel have 2000V optical isolation incorporated on the back side of the Front Panel Assembly. The Main Control Module PCB (MCM-C) serves as a power and communications distribution hub.

An Ethernet port provides a high-speed connection to the MCM-C, for uploading firmware and configuration data to the MCM-C.

The Superblower supplies high volume airflow over the radome for Rain Effect Mitigation. A field replaceable HC2-S3 ambient Temperature and RH sensor is mounted in the air intake of the Superblower, thus assuring both minimal solar bias and robust aspiration of the sensor. Digital communication between the HC2-S3 sensor and the Main Control Module (MCM-C) eliminates noise and offsets errors common to analog sensors. A field replaceable rain sensor is mounted on the top of the Superblower.

A field replaceable GPS Receiver is mounted on the top of the cabinet and connected to the Front Panel via RS232 cable. The GPS Receiver supplies Time, Date and Position data to the MCM-C. The Control Computer uses GPS data to maintain the accuracy of the Windows System Clock, and to place a position stamp in the data files.

The MCM-C controls all the other components in the radiometer. It consists of a microprocessor, logic circuits, analog circuits, and voltage regulators. The MCM-C is a Field Replaceable Unit (FRU). The firmware can be upgraded in the field with a laptop, or via the Control Computer. The MCM-C communicates with the Control Computer via an optically isolated RS-422 cable and an Ethernet cable, responding to high-level Control Computer commands with status and data as required.

The Control Computer is a Windows 7 (or later) computer with Radiometrics Operating Code and ancillary applications preinstalled. Users communicate with the instrument from the Control Computer using the mp.exe operating code interface, or the optional VizMet-B (version 3.0 or higher) user interface. Normally, a factory or user-defined Procedure is selected by the user (Refer to the **Appendix B**: VizMet-B User's Guide.), and executed by the Control Computer to sequence through a series of specified calibrations, sky observations and data processing events. Data is logged to files stored in the Operating Folder on the Control Computer, and accessible via LAN and the Internet (if connected and enabled by the user).

When the Control Computer issues a command to make a set of radiometric observations, the MCM-C points the antenna to the elevation and azimuth angles required. Then it sets the receiver local oscillator (synthesizer) to the first required frequency and commands the appropriate receiver to make the first observation. When the receiver completes the observation on the first frequency, the MCM-C commands the synthesizer to tune to the next required frequency and then commands the appropriate receiver to make the next observation. This sequence is repeated until all channels requested by the Control

Computer have been observed. Then the data is sent from the MCM-C to the Control Computer.

The 45º Flat Mirror, 150 mm Lens and Wire Grid, form the antenna beam. The Lens acts as a phase correcting device that focuses plane wave fronts on the phase center of the corrugated feed horns. Special baffles and absorbing collars are included to minimize errors due to side lobes and reflections. The result is higher gain and lower side lobes than can be obtained with a horn alone, while maintaining small size. Antenna characteristics are summarized in Table 2-1.

Antenna Characteristic	22 GHz	30 GHz	51 GHz	59 GHz
Full width half power beam width	6.3	4.9	2.5	2.4
Gain, dBi	30	32	36	37
Side lobes, dB	<-23	<-24	<-26	<-27

Table 2-1. Antenna Performance

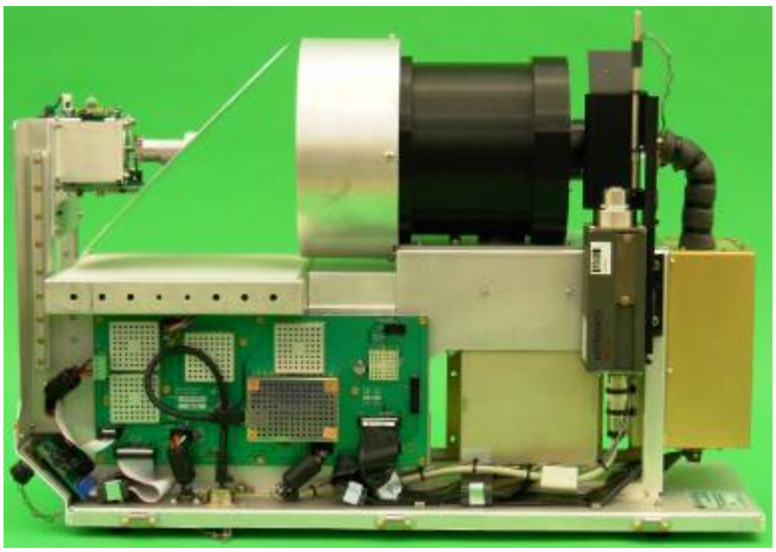
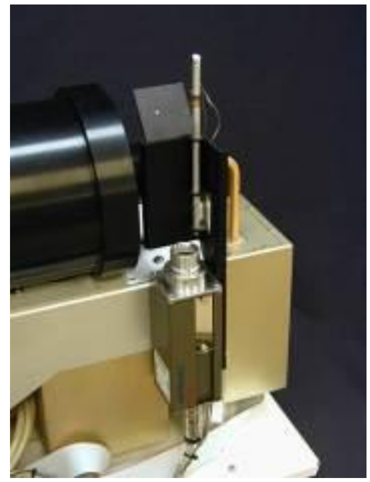


Figure 2-2. MP-3000A Flat Mirror, Lens and Gaussian Optical Antenna

Incoming microwave energy passes through the radome (not shown in Figure 2-2) and is reflected by the Mirror into the Lens, where the energy is focused on the microwave corrugated feed horns associated with each Receiver. The Wire Grid separates incoming microwave energy into two paths, passing the vertically polarized waves straight through the grid to the K band horn, and reflecting the horizontally polarized waves down to the V band horn.

The Elevation Positioner can rotate the Mirror 360º to point the beam to any elevation angle. When pointed straight down (270º), the antenna points to the internal ambient Black Body Calibration target. When the Control Computer sends a command to the MCM-C to calibrate the receivers, the MCM-C commands the Elevation positioner to 270º and collects a set of observations on all channels to be calibrated. The MCM-C sends the observation data and physical temperature of the ambient Black Body Target to the Control Computer where the receiver temperatures (Trcv) are calculated and logged.

A 2-axis inclinometer is mounted on the top of the Elevation Positioner. This device measures the north-south and east-west instrument tilt angles. This provides the means to correct the elevation angles for any static offset due to instrument leveling error. The Elevation Positioner microprocessor digitizes the analog tilt values and sends them to the MCM-C.



The IRT Assembly (Figure 2-3, top) consists of the KT-15 IRT, mounting bracket, IR Black Body target, a low-loss carbon coated window and 2 temperature sensors. The IRT and window are field replaceable. The IRT communicates with the MCM-C via RS232.

The Azimuth Positioner (photo on the right; bottom view) is installed between the instrument and the Tripod to provide full spherical coverage. It is powered and controlled by the instrument via a connector on the bottom of the instrument. With the Azimuth Positioner installed, the antenna can be pointed to any azimuth and elevation angle.

Figure 2-3. IRT Assembly (top) and Azimuth Positioner (bottom)

2.3 Detailed Description of Microwave Receivers

The Profiling Radiometers utilize a single heterodyne, direct double sideband down conversion receiver architecture. All receivers are similar in architecture and construction, except for the frequency ranges observed. Microwave channels are selected using a high stability frequency synthesizer with 1 MHz resolution to tune to any available channel in each band. There are 800 programmable channels in both the K-Band and V-Band receivers. The resulting frequency agility is a patented feature of Radiometrics Profiling Radiometers, making them unique in their ability to scan many channels without the high cost and complexity of filter-bank technology. Standard receivers are supplied with 21 *calibrated channels* in the 22-30 GHz band and 14 calibrated channels in the 51-59 GHz band.[3] Any of the other available channels can be factory calibrated to meet specific customer requirements.

The ability to tune any in-band frequency also enables these Profiling Radiometers to emulate other microwave profilers for comparative measurements. For microwave communications link studies, Sky brightness temperatures can be measured at any in-band frequency of interest.

The receivers accept input power from the antenna system and down convert the input spectrum to a common IF frequency band. The IF Module amplifies, filters and detects the signal. The square law detector output voltage is nearly proportional to system temperature (combined antenna and receiver noise). The detector output is amplified within the IF Module to a high level (1-2V typical), low-pass filtered and then digitized by the Baseband Processor (BBP). Receiver frequency selection is accomplished by setting the desired local oscillator frequency in the L.O. Synthesizer. Each Receiver has a noise source (Noise Diode), used for system gain measurement, controlled by the BBP. The physical temperature of the microwave components is stabilized to ~30 mK RMS by Peltier devices controlled by a PID control loop in the BBP.

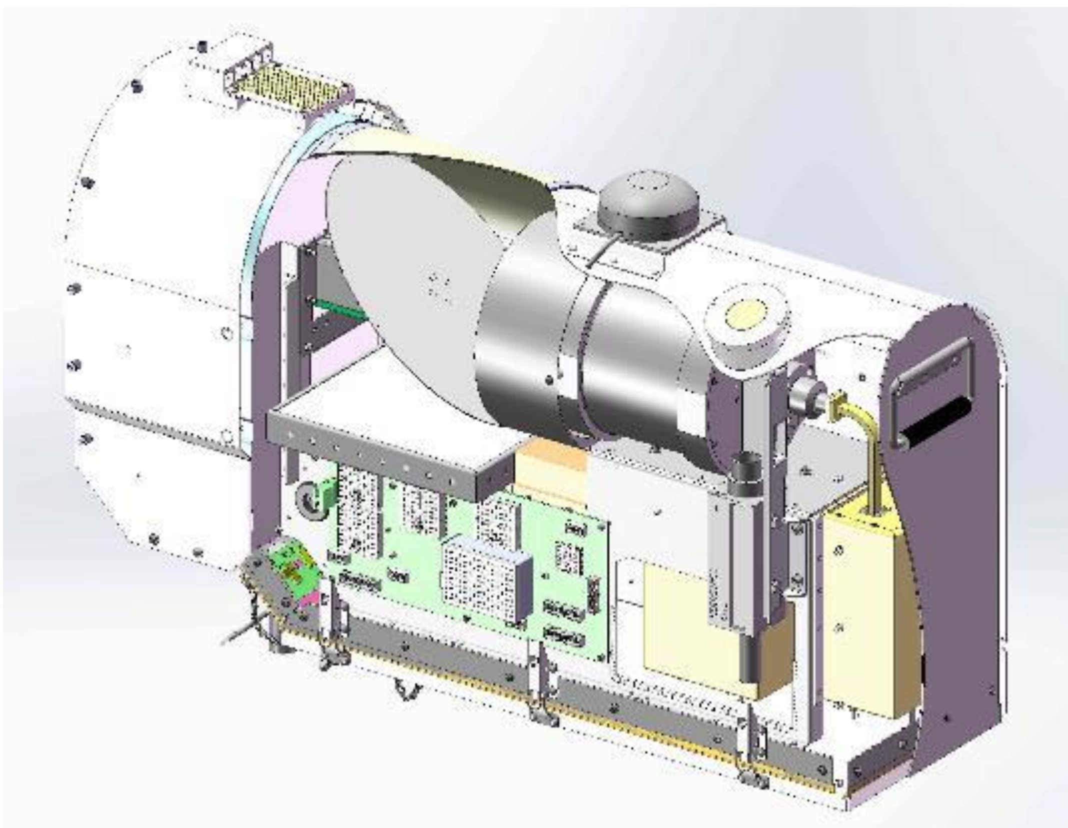


Figure 2-4. MP-3000A cut-away diagram

A cut-away diagram of the Profiling Radiometer is shown in Figure 2-4. Liquid water on the antenna radome (also referred to as the "microwave window") can cause error in the observed brightness temperature. To minimize such error, the Profiling Radiometer radome

[3] The 21 K and 14 V band calibrated channels include the 12 legacy channels used in older Radiometrics models.

is made hydrophobic to repel liquid water, and a special blower system (the Superblower) is used to sweep water beads and snow away from the radome. The ambient temperature and relative humidity sensors are integrated in the inlet of the blower system to ensure a steady flow of ambient air over the sensors. A rain sensor is mounted on the top of the blower system. The ambient barometric pressure sensor is located inside the cabinet to minimize the range of sensor ambient temperature. The IRT views the sky via a user-replaceable low-loss window in the cabinet.

2.1 Profile Retrievals from Observations

Extensive analysis indicates that artificial neural networks outperform other methods for retrieving water vapor, cloud liquid water, and temperature profiles from radiometric data. The Profiling Radiometers therefore use this mathematical inversion method for profile determination. Neural networks supplied by Radiometrics are derived using the *Stuttgart Neural Network Simulator* and a history of radiosonde profiles. A standard back-propagation algorithm is used for training, and a standard feed-forward network is used for profile determination. Profiles are output at 58 height levels, starting with 50 meter steps from the surface up to 500 m, then 100 m steps to 2 km, and 250 m steps from 2 to 10 km. Although the number of independent measurements (Eigen values) is less than the 58 retrieved layers, the finer “resolution” provides better displays and easier processing in subsequent data processing steps. Above approximately 7 km, the atmospheric water vapor density and temperature approach the climatological mean values.

3 Installation

The MP-3000A radiometer includes the following items (shown in Figure 3-1 below):

- Profiling Radiometer instrument
- Control computer with software
- Power cable
- Communications cables (RS422 and Ethernet)
- Mounting Plate and T-Bolt (secures instrument to mount)
- Azimuth Positioner
- Spares, including misc. hardware, 2 radomes, 2 fuses and a Superblower inlet filter
- Maintenance Tool Kit
- Reusable Hard Transport Case
- VizMet-B Web server Software for remote access and advanced features
- TP-2000 Telescoping Tripod[4]
- KT-15 IRT Assembly[5]

Figure 3-1. Radiometer case and contents

Additionally, the following components typically ship separately:

[4] Recommended for most installations. If the Tripod is not used, customer must provide an equivalent level mount.
[5] Recommended for all MP-3000A instruments. Required for MP-3000A cloud-base determination.

- Funnel, gloves and goggles for transferring LN2
- One 25-litre Dewar
- Cryogenic LN2 Calibration Target with saddle[6]

Before starting the installation, check to verify that all required components are on hand. Notify Radiometrics Customer Support and the transportation provider if any items are missing.

To install the instrument, follow the steps below.

3.1 Summary of Installation Process

- A summary of the radiometer system installation process includes the following:
- Selecting a site – suitability, logistics and contamination issues
- Preparing a site – permanent vs. temporary location, earth ground
- Assembling and setting up – anchoring tripod and properly lifting the radiometer
- Leveling the tripod – using bubble levels with telescoping tripod legs
- Securing the tripod – anchor chain or other methods
- Mounting the profiling radiometer with the Azimuth Positioner
- Connecting control panel and securing cables – cables leading from the control panel

3.2 Site Selection

Select a suitable site for the Profiling Radiometer. The Profiling Radiometer can be set up on the ground (concrete, asphalt, or other firm surface), or on the roof of a building. When selecting a site, it is important to consider the following factors:

- It is essential to select a site where the antenna field of view will not be obscured or contaminated by earth surface features, such as mountains, trees, buildings, etc. The antenna elevation angle changes during normal operation from near the horizon in one direction to near the horizon in the opposite direction. The antenna "looks out" through the radome, so the elevation angle changes in the plane orthogonal to the radome. For best TIP calibration performance, it is desirable to position the antenna down to an elevation angle of 30 degrees in each direction. To prevent earth surface radiation from contaminating the TIP calibration, there should be no surface feature above 10 degrees in elevation angle if within ± 10 degrees of the elevation steering plane.
- The site must have a solid surface for mounting and securing the tripod. It is not necessary for the surface to be level[7], but it must be stable so that the instrument will remain level over time and changing wind load. Under strong wind conditions

[6] Required for calibration. One target can be used for all instruments at one location.
[7] The instrument is leveled by adjusting the tripod leg-length. Therefore, the tripod can be mounted on a moderately uneven or sloped surface.

(>100 km/hr), the side loads are very high, producing high forces on the legs. The best way to ensure the integrity of the system under strong wind conditions is to use both the center pull chain and bolts in the tripod feet. See **Appendix A** and Figure 3-5 for details.

- Access to the instrument will be necessary for maintenance. A site should be chosen that provides security from unauthorized persons, while making access for maintenance convenient.
- The standard power cable is 30 m long. Longer cables can result in low voltage. Therefore, primary power should be available within 30 m.
- The standard RS-422 data cable is also 30 m long. If the Control Computer needs to be located more than 30m from the instrument, a cable made to any custom length up to 100m may be ordered. For longer distances, consult the factory for advice. In these cases, it may be better to pull the cable first and add connectors in the field.
- The standard Ethernet cable is also 30 m long. The maximum length is 100 m.
- The surface meteorological sensors are high-performance devices, but the data can be biased by local sources of air contaminated by roof top exhaust vents, nearby roads, etc. Therefore, the Profiling Radiometer site should be separated a reasonable distance from all local sources of contaminated air.
- The Profiling Radiometer uses one or more sensitive, wideband microwave receivers. To minimize the risk of contamination from radio transmitters, a site should be chosen free of all in-band radio frequency interference greater than –144 dBm/MHz (30 dB below kTB). Out-of-band interference can also result from HF, VHF, UHF or microwave transmitters very near the Profiling Radiometer.

3.3 Site Preparation

Once sites have been selected for the Profiling Radiometer, make provisions for the Tripod anchoring technique chosen, and the routing of cables. If the installation will be permanent, the use of conduit pipe(s) for the cables should be considered. Conduit will help protect the cables from rodent damage, moisture and lightning induced transients.

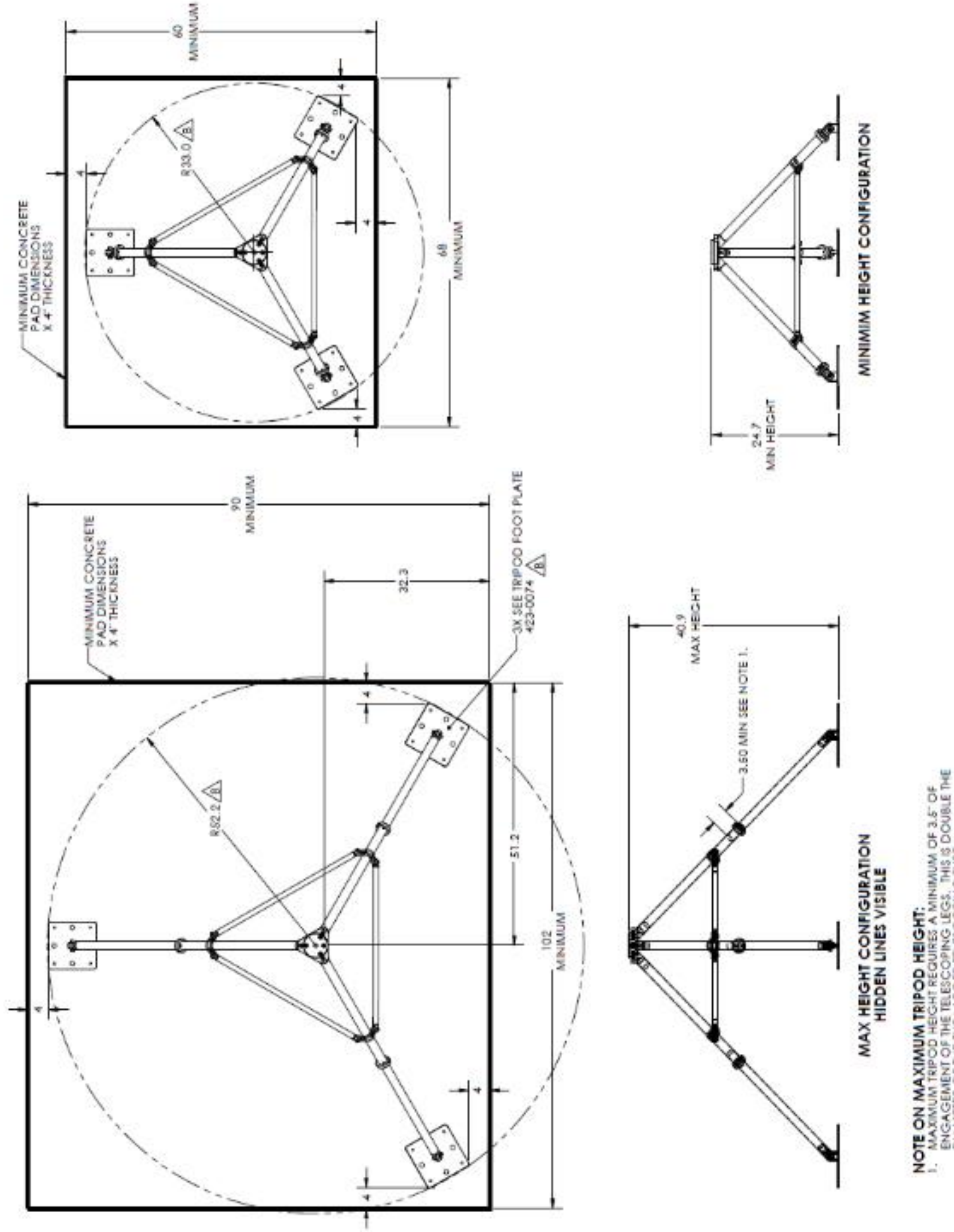


Figure 3-2. Configurations and concrete pad dimensions

Configurations and concrete pad dimensions

The maximum and minimum dimensions for the tripod are shown in Figure 3-2. Additionally, dimensions for concrete pads are included.

If the radiometer is to be mounted on a concrete pad, the recommended pad dimensions for minimum pad size (tripod at minimum height/leg extension) is 60 in x 68 in x 4 in (154 cm x 173 cm x 10 cm).

A larger pad size is recommended, as it allows for maximum flexibility in tripod installation. Refer to pad dimensions above. To allow for optimum tripod adjustment, mounting holes should not be drilled in the concrete pad until the tripod is place and the radiometer is leveled. Radiometrics recommends using the supplied center-pull anchor chain and turnbuckle assembly (Figure 3-5), with an eye bolt. This method is especially useful when the height may need to be adjusted occasionally. A single secure anchor bolt can be located directly under the tripod.

If bolting the tripod feet to the concrete pad, there are eight (8) holes in each foot plate that can take bolt anchors. Customers may choose to use either 3/8 in or 3/4 in bolt anchors. Customers should apply at least one bolt anchor on each foot plate.

Concrete mixture is not critical. Use the standard recommended mix for floors, driveways and sidewalks: a mixing ratio of 1 part cement, 2.5 parts sand, and 3 parts gravel is sufficient.

Foot plate dimensions and views

The foot plate bolt holes and dimensions are shown below (Figure 3-3).

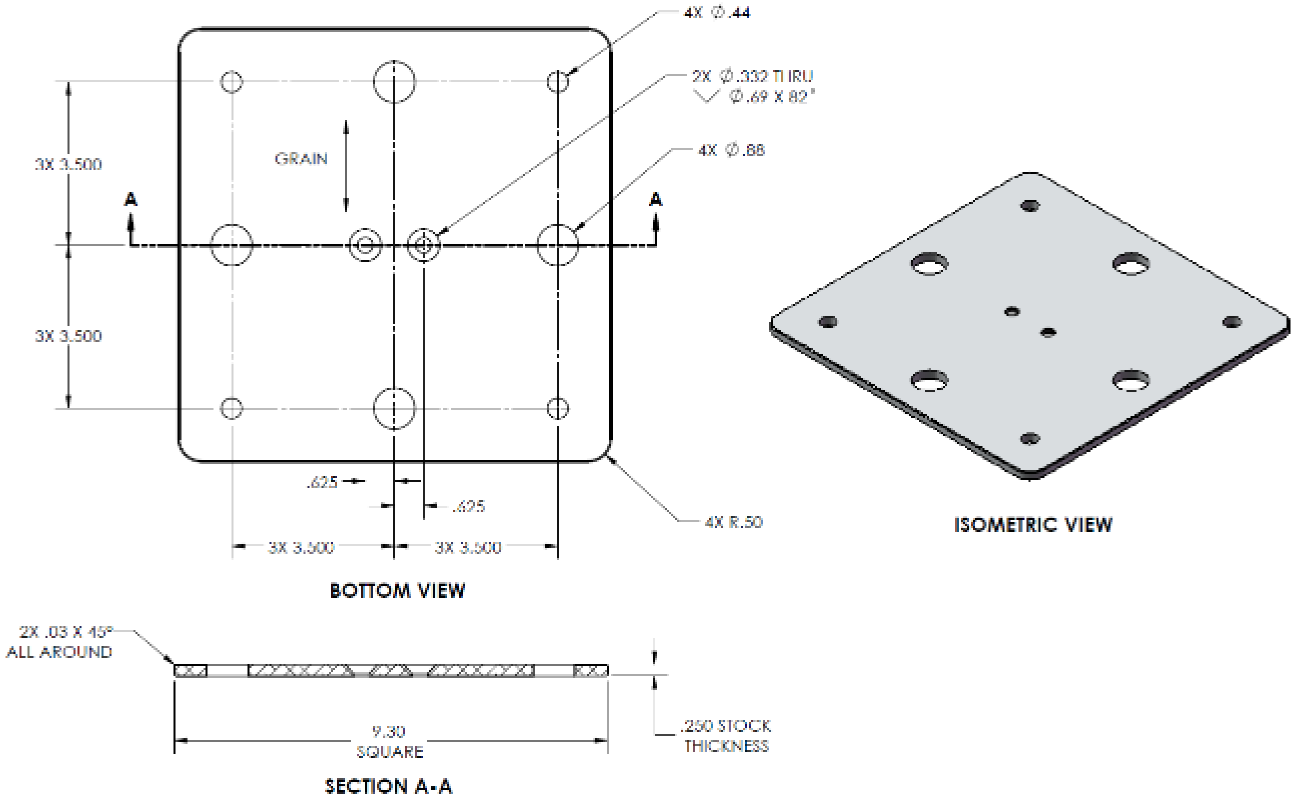


Figure 3-3. Foot plate

A low-impedance earth ground must be connected to the Tripod. Refer to Figure 3-4.

Figure 3-4. Tripod with clamp (upper left), close up of clamp (lower left), cable-to-Earth ground (right)

3.3.1 Connecting radiometer to ground

1. Connect the lug ring of the (supplied) radiometer grounding cable to the chassis ground screw on the underside of the radiometer.

2. Connect the stripped and prepared end of the (supplied) radiometer grounding cable to the clamp on the tripod cross strut (Figure 3-4).

3. Connect one end the customer-supplied 8 AWG grounding cable to the same clamp on the tripod cross strut (Figure 3-4).

4. Connect the other end of the customer-supplied 8 AWG grounding cable to a 5-foot long ground rod, sunk into the ground (Figure 3-4).

3.4 Assembly and Setup

The Model TP-2000 telescoping aluminum tripod is typically furnished with the Profiling Radiometer. The tripod is shown in Figure 3-5 with a MP-3000A radiometer and Azimuth Positioner mounted. Detailed tripod assembly instructions are included in **Appendix A**.

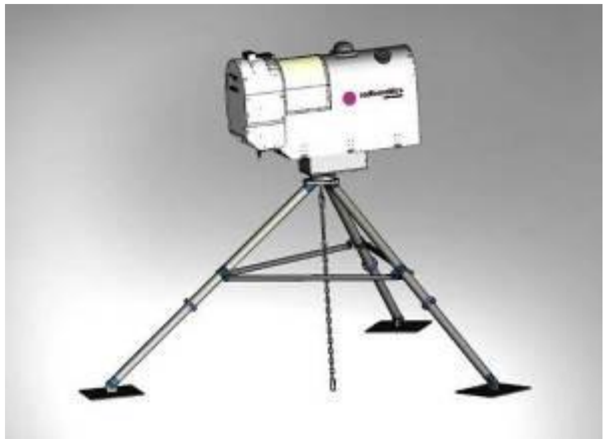


Figure 3-5. Tripod and anchor chain with Profiling Radiometer

CAUTION

Only lift the instrument by its handles or base. Radiometrics strongly recommends having two people to mount the radiometer on the tripod.

NOTE:
The instrument hood contains a foam dielectric radome. Do not use the instrument cover to support or lift the Profiling Radiometer. The microwave radome will be degraded by abrasive contact and foreign matter. It should not be touched intentionally.

3.5 Leveling the Tripod

Before installing the Profiling Radiometer, the mounting surface must be leveled using the bubble level supplied with the TP-2000 Tripod (or similar). The instrument must be mounted on a level surface to ensure accurate antenna elevation angles and TIP calibrations. If the triangular Tripod Top Plate is not level within 1/8th of a bubble in all directions when the tripod is in position at the installation site, adjust one or more of the telescoping tripod legs to different lengths as required to make it level. First, align the level in the plane of the leg to be adjusted first. Then loosen the leg collar clamp on that leg using the 1/4" Allen wrench as shown in Figure 3-6. The lower leg will slide freely inside the upper leg. To adjust the leg length, move the lower leg up or down as necessary. When the bubble in the level is centered, tighten the collar clamp. Repeat for each leg as necessary to make the triangular Tripod Top Plate level in all directions.

Figure 3-6. Leveling the TP-2000 Tripod

1. Align the level in the plane of the leg to be adjusted first.
2. Then loosen the leg collar clamp on that leg using the 1/4” Allen wrench as shown in Figure 3-6.

   The lower leg will slide freely inside the upper leg. To adjust the leg length, move the lower leg up or down as necessary.
3. When the bubble in the level is centered, tighten the collar clamp.

4. Repeat for each leg as necessary to make the triangular mounting plate level in all directions.

Refer to Figure 3-7, for a quick leveling reference.

Figure 3-7. Leveling directions

NOTE:
Exercise reasonable care when assembling the Tripod to avoid denting or damaging the Tripod legs. Dents in the legs will prevent the inner tube from being extended/shortened.

3.6 Securing the Tripod

Secure the tripod to the ground or building roof using one of the methods recommended in **Appendix A**. The supplied center pull anchor chain and turnbuckle provide a robust, flexible way to secure the tripod to the surface below using a single eyebolt. This method is especially useful when the height may need to be adjusted from time to time. The addition of anchor bolts in the feet is advised if the height and location are permanent. After securing the tripod, check to make sure it is still level, *as secured*. If the tripod is not level within 1/8th bubble, loosen the chain and/or foot security bolts/stakes as required, and refine the leveling as described in Section 3.5. Then retighten all fasteners.

3.7 Mounting the Profiling Radiometer

NOTE:
Before proceeding with this step, if the center pull chain method is used to secure the tripod, the chain should be *temporarily* loosened as required to turn the T-bolt to mount the Profiling Radiometer.

NOTE:
Two persons are required to lift and carry the radiometer. Using the lifting handles located on each end of the Profiling Radiometer, lift the Profiling Radiometer from its shipping container. When installing the Azimuth Positioner, follow the separate instructions supplied with the Azimuth Positioner to install it on the bottom of the Profiling Radiometer. Place the Profiling Radiometer (with Azimuth Positioner if installed) on the Tripod Top Plate and secure with the 5/8-11 T-bolt. If an Azimuth positioner is installed, the connector panel should be oriented due east. If the center pull chain was loosened, retighten the chain.

Figure 3-8. Securing the Profiling Radiometer with the T bolt

3.8 Attaching the Power Cable

NOTE:
It is important to use only the factory-supplied Power Cable. If damage is observed on the power cable, Radiometrics Corporation will supply a new cable, so contact Customer Support as quickly as possible.

To ensure safe operation, the power cable must be connected to a properly grounded mains receptacle. The power cable is normally supplied with a mains connector pre-installed for the receptacles used in the region to which the Profiling Radiometer is delivered.

Figure 3-9. Power cable to radiometer, supplied by Radiometrics

Mate the power cable plug and secure by rotating the locking collar into the detents. Connect the other end of the power cable to the mains receptacle. The Profiling Radiometer can be protected from power failures by utilizing an uninterruptible power supply (UPS). The power cable should be connected to a grounded outlet for safety, as well as static and transient protection.

Always disconnect the power cable from the main supply *before* disconnecting the cable from the Profiling Radiometer. This ensures ground integrity in case of a fault condition. Only qualified personnel should service this equipment. Hazardous voltages are accessible between the Front Panel and the Power Supply after removal of the cabinet hood.

If a UPS is installed, always ensure that power is turned *off* at the UPS output (i.e., connection to the radiometer) *prior* to connecting the radiometer to the UPS. If not using a UPS, connect power before switching on the radiometer power switch.

Locate the connector panel at the base of the Profiling Radiometer, on the Superblower end, as shown in Figure 3-10.

Figure 3-10. Front Panel

3.9 Attaching the RS-422 Cable

Figure 3-11. Data cable

The RS-422 Data Cable connects the Profiling Radiometer to the Control Computer. This cable has an RS-422 to USB converter on the Control Computer end. If the cable is to be installed in a conduit, the end with the circular connector should be pulled through the conduit from the Control Computer end.

Plug the USB connector into any available USB port on the Control Computer. Drivers for the USB adaptor are preinstalled. The circular connector end of the RS-422 data cable should be plugged into the Profiling Radiometer RS-422 port marked **COMPUTER RS422**.

NOTE:
An auxiliary RS-422 port is furnished for special applications. Due to the wide variety of protocols that RS-422 connected devices use, the standard Operating Code does not support the use of this port. Contact Radiometrics for information on custom versions of the Operating Code if the use of this port is desired.

3.10 Attaching the Ethernet cable

The Ethernet Cable also connects the Profiling Radiometer to the Control Computer (Figure 3-13). The supplied Ethernet cable is for connection to the Control Computer through a network, router, or switch. A crossover cable is required for direct connection to the Control Computer; do not connect directly to the Control Computer. This cable is designed for outdoor use. If the cable is to be installed in a conduit, the end with the circular connector should be pulled through the conduit from the Control Computer end.

The Ethernet cable is not required for normal operation. Customers may use it to update radiometer codes and firmware.

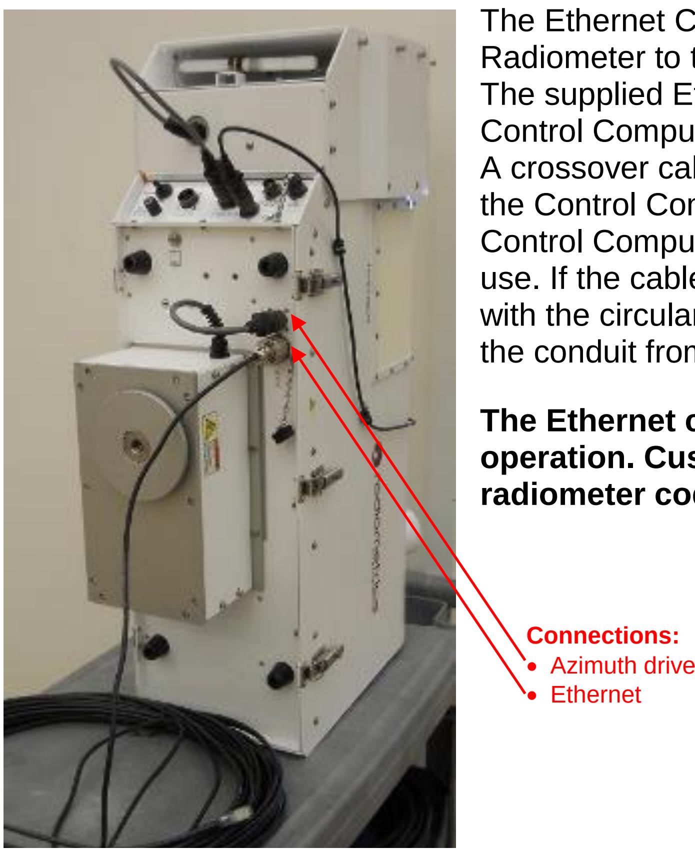


Figure 3-12. Radiometer underside showing Azimuth drive and Ethernet connections

3.11 Securing the Cables

The cables should be secured to a tripod leg using tie wraps or tape. If the Azimuth Positioner is installed, it is necessary to provide a service loop in the cable bundle as shown in Figure 3-13 so that it does not become restricted when the Profiling Radiometer changes azimuth position.

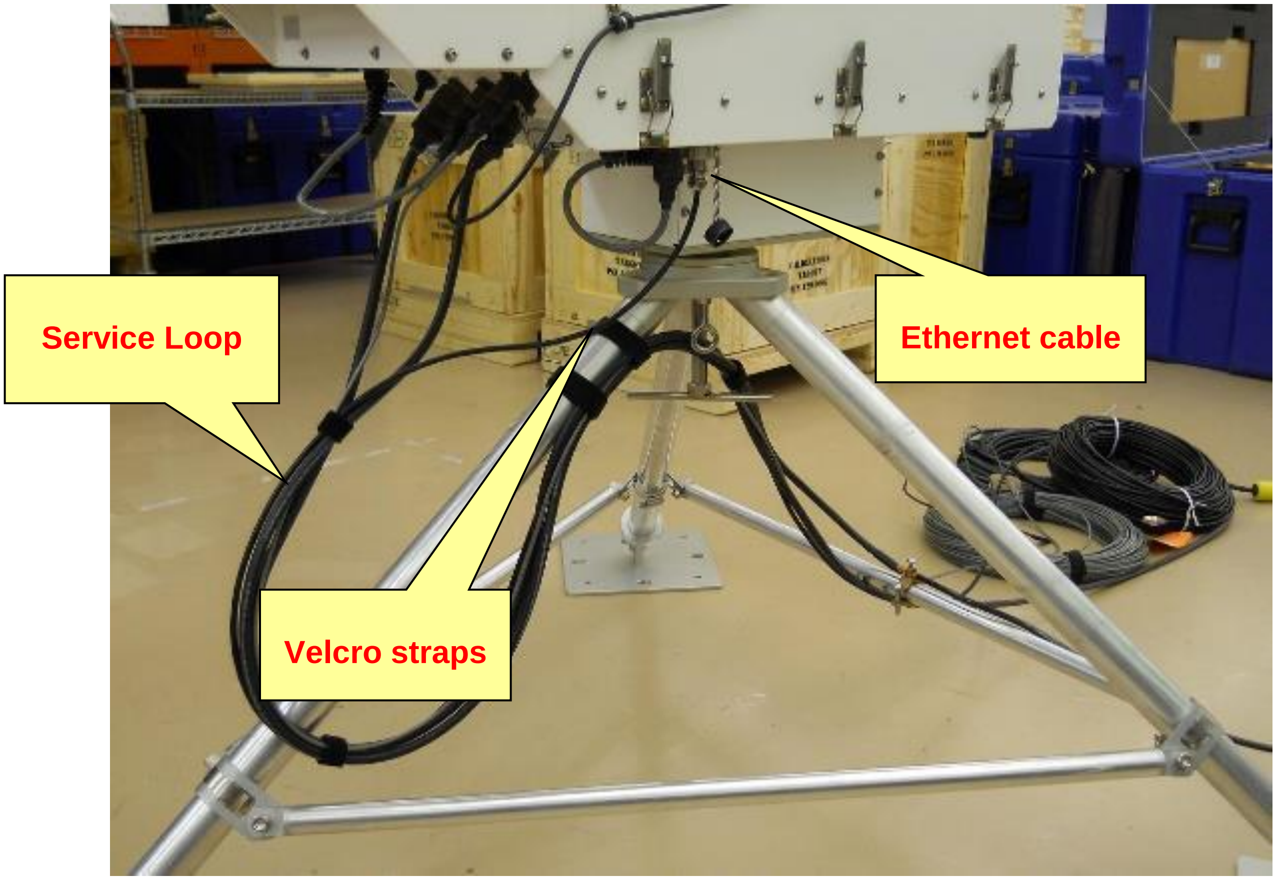


Figure 3-13. Cable service loop for use with Azimuth Positioner

3.12 Connecting to a Control Computer

The Control Computer should be located in a suitably protected indoor environment. Connect the USB connector on the data cable to an available USB port on the left side of the radiometer. Connect an RSS422-to-USB adapter to any USB port on the Control Computer.

Connect to the Control Computer via a router or switch by connecting the Ethernet cable to the Ethernet port, on the underside of the radiometer (Figure 3-13). If connecting Ethernet directly to the Control Computer, you must use a crossover cable.

All software is preloaded at the Radiometrics factory, and the Control Computer is preconfigured to connect to the radiometer via RS422-USB and Ethernet.

The radiometer system and data files (configuration file, neural network files, Procedure Files) are stored in one folder, referred to herein as the “Operating Folder”. The Operating Folder can have any name, and it can be located anywhere within the disk directory structure. As delivered from the factory, “shortcuts” (aliases) for the Operating Folder, Microsoft Notepad (Notepad), and VizMet-B are located on the desktop. All output files are stored in the Operating Folder.

3.13 Connecting to a Different Computer (replacement for Control Computer)

If it becomes necessary to replace to Control Computer, any similar model of Windows 7 PC can be used. To set up the new computer, contact Radiometrics for support and additional information:

Phone: +1-303-449-9192
Fax: +1-303-786-9343

4 Initial Operation and Test of the Instrument

To begin operation of instrument, locate the power switch on the connector panel of the Profiling Radiometer and move it to the ON (up) position. The Superblower will start. If installed, the Azimuth Positioner may turn to seek its index position, and the elevation stepper motor will be heard stepping to its index position. Once the Profiling Radiometer reaches its azimuth index position, it must be reoriented to align the antenna to the north-south observation plane. To align the Profiling Radiometer, loosen the T-bolt slightly and gently rotate the Profiling Radiometer so that the connector panel points due **East**, the "North" arrow on top of the superblower points **NORTH,** and then **retighten** the T-bolt. This alignment only needs to be performed the first time the Profiling Radiometer is turned on after installation, or after movement of the tripod or Profiling Radiometer.

NOTE:
If an azimuth drive is installed, then the radiometer must be properly oriented to North at the time of installation: the front of the Superblower should face East, and the "North" arrow on top of the Superblower will point to the North. This ensures that the radiometer accurately orients to the azimuthal directions contained in the procedure file. If an azimuth drive is not installed, the radiometer should be oriented so that off-zenith observations are made in the preferred directions. In which case, the N and S directions displayed in VizMet-B will indicate "Nominal" and "Supplemental" directions, with "Nominal" corresponding to the direction of the "N" arrow on top of the Superblower.

NOTE:
If the Superblower is not heard when power is first turned on, check the fuse in the connector panel (Figure 3-10) by turning the fuse cap counterclockwise, removing the fuse, and visually inspecting. If in doubt, use a DVM (Digital Volt Meter) set to continuity or resistance to test for continuity. If the fuse is good, check the power source with a DVM (set to AC voltage). If unable to determine the cause of the lack of power, contact Radiometrics Customer Support for assistance.

NOTE:
Before attempting to calibrate the instrument or collect data, the instrument must reach its stable operating temperature. If the Profiling Radiometer is initially in equilibrium with ambient air temperature, it will require up to 30 minutes for the microwave receivers to thermally stabilize (depending on the ambient temperature). Immediately following the movement of the Profiling Radiometer from one environment to another (i.e., from a warm warehouse to cold outdoors), then up to 5 hours may be required for the Profiling Radiometer to reach complete equilibrium. The Profiling Radiometer may be operated safely during the period it is stabilizing, but the data may be slightly biased.

Locate the Control Computer power switch and turn it on. The computer will start and the Windows Desktop will appear on screen. The radiometer will automatically begin operation after turning on the control computer. If installed, VizMet-B starts automatically and will run the last scheduled procedure file. Open Mozilla Firefox browser to view VizMet-B (http://localhost). See **Appendix B: VizMet-B User's Guide** for details.

5 Configuration, Control, and Data Processing

This section provides detailed information on the configuration and operation of the Profiling Radiometer. It builds on the definitions, procedures, and information introduced in Section 4 and **Appendix C** on radiometer calibration. Users unfamiliar with the Operator Interface and basic commands should review those sections before proceeding with Section 5. In this section, the user will learn more about the Modes of Operation, Input Files used to configure and control the Profiling Radiometer, and Output files generated by the Profiling Radiometer.

NOTE:
The VizMet-B software adds a powerful combination of web server and GUI technology. Refer to the **VizMet-B User's Guide** (**Appendix B**) for information about the operation of the radiometer. VizMet-B op-server is a high level supervisory program that runs the operating code for the user via a web based GUI.

5.1 Input Files

There are four types of input files used by the Profiling Radiometer:

- **1 Configuration File**
- **1 or more Procedure Files**
- **Macro Files (optional)**
- **Neural Network Files (optional)**

These files are used by the Operating Code to configure the system, schedule observations, and convert raw data to higher level products. All the programmable features and options available in Profiling Radiometer are specified by the user through these files.

5.1.1 Configuration File

The configuration file contains all the static parameters needed to specify how the Profiling Radiometer will operate, and the calibration information necessary to convert *level0* data to *level1* observations. Figure 5-1 illustrates a typical configuration file[8]. The configuration file may be edited in Notepad (or another text editor) to change the configuration. Care should be exercised not to inadvertently change any parameter unintentionally. In particular, care should be taken to save changes to the file in plain text format only (no formatting).

The configuration information is grouped in logical blocks with block headers for each highlighted in red in this manual. Generally, parameters are specified in the first field of each line, with comments following a colon delimiter. The use of each field is explained below.

In the MP TYPE block, the specific model and serial number are specified. These fields are specified by the factory and used by the Operating Code to determine what features are

[8] The details of the configuration file format are operating code version dependent. Earlier and later versions of the operating code may differ slightly in the list of configuration parameters and the format.

enabled for the specific instrument. The Serial Number specified appears in the real-time displays to distinguish different instruments under the control of one computer. The COM port used by the controlling computer is specified on the next line. The COM port specified must be in the range 1-9, and correspond to the Windows COM port connected to the Profiling Radiometer, which is found in the computer's Device Manager -> Ports. Setting the "debug" parameter to 1 will enable a serial data link traffic log. The log is stored in the operating folder with a file name in this format:

yyyy-mm-dd_hh-mm-ss_ser.txt.

```
# Radiometrics V6.00 configuration file for 3105A
# Configuration File Format: 6.00
# No more comments

MP TYPE:
MP-3000A 3105A :Model & Serial Number
4          :Windows com port (1 to 9)
1          :debug (1=on; 0=off)
1          :PC Clock Sync to GPS (1=on; 0=off)

TIP CONFIGURATION: (For all TIP Commands)
0.98        :regression coeff for a good tip
0.0         :Default Azimuth Angle
5          :Number of Elevation Angles
30          :Tip Elevation Angle #1
45          :Tip Elevation Angle #2
90          :Tip Elevation Angle #3
135          :Tip Elevation Angle #4
150          :Tip Elevation Angle #5
0          :0=No tips when rain sensor on, 1=allow tips w/rain on
0.8         :rain sensor tip threshold (volts)

BLOWER SETTINGS:
0.80        :Rain sensor blower threshold (volts)
70          :RH threshold (%)
30          :Blower speed (rain and RH both below threshold)

SYNTHESIZER TYPE:
4          :1 = Microsource 11.0-15.0 GHz; 2 = 11.0-15.3 GHz; 4 = Spinnaker Microwave 11.0-15.0 GHz

CHANNEL CALIBRATION BLOCK:
2012/01/17 19:59:11 :Date of last factory LN2 calibration
2012/01/18 18:11:59 :Date of last user LN2 calibration        2012-01-18_16-43-10_lv0    2012-01-18_16-43-10_tip
10,10.0,2.5,1,200   :ln2 calibration integration parameters
.90              :target tolerance for ln2 cal
35               :number of frequencies
Frequency,Rcvr,MRT,Window Coef,ND drive,IF Atten,alpha,dtdg,k1,k2,k3,k4,Tnd
 22.000,0,275.0,.000140, 32860,18.5,0.98641, -0.61873428E+06, 0.16552952E+03, -0.16797976E+01, 0.44810639E-02, -0.46433101E-05, 389.19
 22.234,0,275.0,.000140, 30665,18.5,0.98531, -0.56325850E+06, 0.27947977E+03, -0.26487038E+01, 0.72539921E-02, -0.73564476E-05, 321.23
 22.500,0,275.0,.000140, 30665,18.5,0.98326, -0.45119162E+06, 0.47044898E+03, -0.47731193E+01, 0.16079795E-01, -0.17981678E-04, 305.58
 23.000,0,275.7,.000150, 30665,19.0,0.98611, -0.42160549E+06, 0.35827655E+03, -0.36831119E+01, 0.12603610E-01, -0.14356378E-04, 288.79
 23.034,0,275.7,.000150, 30665,19.0,0.98594, -0.42164813E+06, 0.33439000E+03, -0.34484621E+01, 0.11817757E-01, -0.13457270E-04, 290.11
 23.500,0,275.7,.000150, 30665,19.0,0.98775, -0.45578882E+06, 0.21934848E+03, -0.20312081E+01, 0.62844035E-02, -0.65118070E-05, 314.58
 23.834,0,276.0,.000150, 28470,18.5,0.98937, -0.41244588E+06, 0.26852572E+03, -0.25622278E+01, 0.81516131E-02, -0.86526846E-05, 287.46
 24.000,0,275.7,.000150, 28470,18.5,0.99049, -0.43545979E+06, 0.33379880E+03, -0.33841307E+01, 0.11450928E-01, -0.12933041E-04, 298.23
 24.500,0,275.7,.000160, 28470,18.5,0.99362, -0.40431930E+06, 0.23642837E+03, -0.22860500E+01, 0.74224842E-02, -0.81063097E-05, 311.99
 25.000,0,275.4,.000160, 28470,18.5,0.99158, -0.51282767E+06, 0.51247359E+03, -0.50765294E+01, 0.16814566E-01, -0.18630738E-04, 330.36
 25.500,0,275.4,.000160, 28470,18.5,0.99097, -0.48230281E+06, 0.51240946E+03, -0.52089970E+01, 0.17636046E-01, -0.19885678E-04, 311.26
 26.000,0,275.4,.000170, 28470,18.0,0.98790, -0.50977331E+06, 0.38361635E+03, -0.38073944E+01, 0.12660623E-01, -0.14141751E-04, 319.90
 26.234,0,275.4,.000170, 30665,18.0,0.98694, -0.47111980E+06, 0.37591316E+03, -0.36085561E+01, 0.11586251E-01, -0.12457895E-04, 361.69
 26.500,0,275.4,.000170, 30665,18.0,0.98462, -0.51386321E+06, 0.63749879E+03, -0.63501749E+01, 0.21166339E-01, -0.23618729E-04, 357.49
 27.000,0,275.4,.000170, 30665,18.5,0.98337, -0.52496762E+06, 0.37188566E+03, -0.36941876E+01, 0.12304234E-01, -0.13750352E-04, 355.01
 27.500,0,275.4,.000180, 30665,19.0,0.98900, -0.48532285E+06, 0.39869196E+03, -0.38372004E+01, 0.12358856E-01, -0.13337309E-04, 330.61
 28.000,0,275.4,.000180, 30665,19.0,0.99217, -0.48594097E+06, 0.56092564E+03, -0.57138144E+01, 0.19200887E-01, -0.21596378E-04, 325.09
 28.500,0,274.1,.000180, 30665,19.5,0.99647, -0.49609549E+06, 0.34558652E+03, -0.34256708E+01, 0.11288210E-01, -0.12361329E-04, 304.63
 29.000,0,274.1,.000180, 30665,19.5,0.99521, -0.51678051E+06, 0.56743422E+03, -0.56479265E+01, 0.18739557E-01, -0.20727801E-04, 320.87
 29.500,0,274.1,.000190, 30665,19.5,0.98442, -0.48540158E+06, 0.33834682E+03, -0.34135868E+01, 0.11491872E-01, -0.12910455E-04, 314.67
 30.000,0,274.1,.000190, 32860,20.0,0.97897, -0.44205776E+06, 0.28239717E+03, -0.27492248E+01, 0.89561186E-02, -0.97720922E-05, 315.31
 51.248,1,274.1,.000330, 32860,18.5,0.97277, -0.91285066E+06, 0.24253657E+03, -0.24829452E+01, 0.84490822E-02, -0.95555408E-05, 325.09
 51.760,1,274.1,.000330, 32860,18.5,0.97222, -0.80608886E+06, 0.24580693E+03, -0.24140922E+01, 0.78224070E-02, -0.83473953E-05, 318.88
 52.280,1,274.1,.000330, 32860,18.0,0.97269, -0.74182710E+06, 0.33630927E+03, -0.34073425E+01, 0.11482145E-01, -0.12867618E-04, 336.33
 52.804,1,274.1,.000340, 32860,17.5,0.97998, -0.83981714E+06, 0.16935851E+03, -0.16117526E+01, 0.49737834E-02, -0.49303145E-05, 343.82
 53.336,1,274.1,.000340, 32860,17.0,0.99046, -0.10195484E+07, 0.50704810E+03, -0.50995713E+01, 0.16995735E-01, -0.18877926E-04, 366.39
 53.848,1,274.1,.000340, 32860,16.5,0.99299, -0.90029195E+06, 0.62354826E+02, -0.58612085E+00, 0.17116899E-02, -0.14897249E-05, 343.67
 54.400,1,274.1,.000350, 32860,16.0,0.99094, -0.87296572E+06, 0.39422046E+03, -0.38945312E+01, 0.12855721E-01, -0.14185598E-04, 339.36
 54.940,1,274.1,.000350, 32860,16.0,0.98792, -0.87669780E+06, 0.32552637E+03, -0.33548683E+01, 0.11407874E-01, -0.12793340E-04, 343.95
 55.500,1,274.1,.000350, 32860,16.5,0.98167, -0.83458820E+06, 0.23725238E+03, -0.23048125E+01, 0.74176202E-02, -0.79002259E-05, 315.34
 56.020,1,274.1,.000360, 32860,16.5,0.97627, -0.85216924E+06, 0.30444887E+03, -0.31882616E+01, 0.10860035E-01, -0.12258885E-04, 335.52
 56.660,1,274.1,.000360, 32860,16.5,0.98066, -0.86550481E+06, 0.11883351E+03, -0.11233224E+01, 0.34236137E-02, -0.33210022E-05, 313.82
 57.288,1,274.1,.000370, 32860,16.0,0.99553, -0.97899503E+06, 0.39717539E+03, -0.39532900E+01, 0.13114886E-01, -0.14501751E-04, 306.85
 57.964,1,274.1,.000370, 32860,15.0,0.99553, -0.89466971E+06, 0.23724946E+03, -0.23983795E+01, 0.80350724E-02, -0.89166837E-05, 274.61
 58.800,1,274.1,.000370, 32860,14.0,0.98123, -0.76838684E+06, 0.32696305E+03, -0.33196721E+01, 0.11134266E-01, -0.12327275E-04, 246.90

COEF:        :Coefficients for LN2 calibration and surface sensors
13.0        :LN2 liq depth in cm
68.23        :LN2 BP C0, the LN2 boiling point linear equation
0.009037       :LN2 BP C1
0.0078        :LN2 interfaces correction
6.08e-6       :LN2 polystyrene dielectric loss coef ~ 1.14e-5 K/K-cm-GHz
5.1         :LN2 Styrofoam thickness (cm)
+600.00,200.00 :Air press C0,C1 (P=C0+C1*Volts)
+0.16,4.135    :East/West tilt offset C0, X-Axis scale factor C1.
+0.77,4.132    :North/South tilt offset C0, Y-Axis scale factor C1.
.050,.065     :IRT window reflection, absorption

USER CORRECTIONS:
+0.00        :Pressure sensor offset
+0.00        :Tamb correction (edit with values for this instrument)
+0.00        :Rh correction   (edit with values for this instrument)
+0.00        :IR sensor correction (default= -1.50)

GPS:
15          :Cut-off elevation angle
0           :Minimum SNR
```

Figure 5-1. Configuration File for V6.x.x Operating Code (mp.cfg)

GPS Time Sync: 0 = off, 1 = on

If **on**, control computer clock synchronizes to GPS time, when the instrument starts or restarts, provided the MS Windows™ clock is 5 minutes from GPS time. Set the MS Windows™ clock to within ±5 minutes to ensure synchronization.

The TIP configuration block specifies all parameters used by the TIP calibration algorithm. The regression coefficient is a threshold for data quality checks. It should be adjusted to a value between 0.97 and 0.99 normally. Higher thresholds impose a higher quality standard. The default Azimuth Angle specifies the azimuth for TIP calibrations when the Azimuth Positioner is installed. The next line specifies the number of elevation angles the instrument will use for the TIP calibration. This number must match the number of lines below, each specifying a specific elevation angle. In general, it is recommended that the 5 default values specified in the example be used. TIP elevation angles less than 20° may result in some side lobe contamination. More angles can be used, but the extra time required must be considered. Longer times to complete the TIP can introduce sampling error as the atmosphere changes. In all cases, it is desirable (but not required) to specify TIP angles in complementary pairs (e.g., 045° and 135°, 030° and 150°) so that leveling error and atmospheric gradients tend to be averaged. Following the last angle, a switch is provided to either allow, or not allow TIPs when the rain sensor detects rain. The last line in the block specifies the threshold defining when the rain sensor flag is switched as described in **Appendix C**.

In the Superblower Settings block, the user can specify the conditions for the Superblower flow rate to be reduced from its maximum rate. The Superblower flow will be automatically set to the maximum rate (100%) if the rain sensor voltage exceeds the specified threshold (.8V typical), or the surface RH exceeds the specified threshold (70% typical). If neither condition is met, then the Superblower flow will be set to the specified low blower speed value (30% typical). To turn off the Superblower, set both thresholds very high (i.e., 2V and 101%) and the low blower speed to 0. To force it on all the time, set the rain or RH threshold to 0. Note that the Superblower is always set to 100% while an LN2 user calibration is running.

The Synthesizer Type is set at the factory and **must not** be changed.

The CHANNEL CALIBRATION BLOCK contains all the factory and user LN2 calibration data. This block is set up at the factory and should not be edited by the user, except to manually transfer a new TIP calibration as discussed in **Appendix C**.

The COEF block contains all the parameters needed by the Operating Code to compute the effective LN2 target temperature, and for the conversion of *level0* Met Sensor data to *level1*. These values are set at the factory and, except for LN2 depth, should not normally need to be adjusted by the user.

The User Corrections block can be used to *add* an offset adjustment to the ambient pressure, temperature and RH. The factory calibrations for these three sensors are very accurate and do not normally require further adjustment. If a new Temperature/RH sensor, or barometer, is purchased, Radiometrics will send the offset parameters with the sensor. The user must manually put the offset values in this block. In general, no offset value should be added unless the user has access to high accuracy standards for calibration of these three sensors.

The GPS block is reserved for future use.

5.1.2 Procedure Files

A Procedure File is a list of high level commands that define a specific series of observations and retrievals to be performed. Two basic types of procedures can be defined: “relative” and “absolute”. Relative procedures are command lists that execute sequentially, with each command beginning immediately following the completion of the previous command. Absolute procedures are command lists in which each command is specified to execute at a specific time of day. Procedure files provide the user with a simple, but powerful way to customize the operation of the instrument for automatic data collection. All Procedure Files are ASCII text files with the extension “.prc” (e.g., *ZenithRet.prc*). Procedure files can be generated using any text editor, such as Notepad. However, long absolute procedures with many repeating commands are more easily generated using a spreadsheet to automatically compute the series of **absolute** command execution times.

5.1.2.1 Procedure Commands

Procedure Commands are the basic building blocks used to create a procedure. There are 10 high level commands available. Each command occupies one line in a Procedure File, starting in the first column of the line, and terminated by a carriage return (**CR**). Commands with required or optional parameters are delimited by one or more spaces, or one tab or one comma character may be used between fields in command lines.

NOTE:
All procedure commands must be specified in lower case letters only.

5.1.2.1.1 Antenna Coordinate System

The coordinate system used in all commands to specify the antenna pointing vector is given in Table 5-1. The elevation angle is defined for the state when az=000° (north). Therefore, if the azimuth is rotated to 180° (south), the antenna will point to the southern horizon when el=000°.

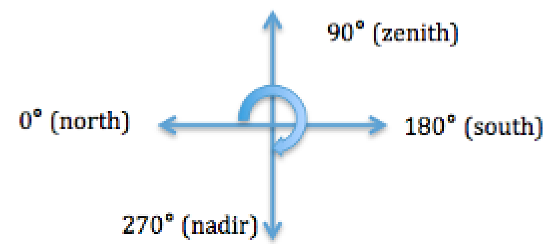
Azimuth (az)		**Elevation (for az=000)**	
000°	north	000°	north
090°	east	090°	zenith
180°	south	180°	south
270°	west	270°	nadir
Mirror orientation for Azimuth = 000, as viewed when standing behind the radiometer.			

Table 5-1. Antenna Coordinate System

NOTE:
There are always two az/el specifications that produce the same pointing direction. For example, the direction given by az=000°/el=045° is equivalent to the diction az=180°/el=135°. The Operating Code automatically chooses the coordinates that will reposition the antenna faster, regardless of which way the user specifies the coordinates.

NOTE:
The elevation drive resolution is 0.45° (800 steps per revolution). If an angle is specified that is not an even multiple of 0.45°, then the Operating Code rounds the number to the nearest angle available, and the angle actually used is logged in the output files. For example, if the user specifies an elevation angle of 30.00°, the radiometer will use and record 30.15°.

*5.1.2.1.2 **relative**, **absolute** and **repeat** Commands*

The first line in all Procedure Files must contain either the "**relative**" or "**absolute**" command. These commands define whether all the commands that follow are to be executed sequentially, with no delay between commands, or executed at a specified time. With both relative and absolute procedures, the command sequence specified will continue to execute until the operator presses the Control Computer **Q** key to Quit, or the end of the procedure is reached, whichever occurs first. If the command "**repeat** xxxxx" is added as the last command in a relative procedure, then the complete procedure will be repeated xxxxx times before the program terminates, where xxxxx is any positive integer. **Relative**, **absolute** and **repeat** commands do not add to the execution time of the procedure.

*5.1.2.1.3 The **trcvcal** Command*

The **trcvcal** command causes the Profiling Radiometer to calibrate the receiver noise temperature for all microwave receivers present. This calibration produces a new value of system temperature for all specified channels, from which a new value of receiver temperature (Trcv_bb) is calculated (Trcv_bb = TsysTkBB) for all specified channels. This value of Trcv_bb is used in the calculation of all real-time *level1* and *level2* data products.

The receiver temperature is very stable over a period of minutes, but will drift slightly with large ambient temperature changes. Thus, **trcvcal** commands should be included periodically in all procedures.

In choosing a **trcvcal** command frequency, several factors should be considered. Very frequent **trcvcal** commands will result in the best theoretical absolute accuracy. But **trcvcal** commands take approximately the same execution time as the **obs** commands. Thus, a **trcvcal** command preceding every sky observation may produce the smallest drift error, but it reduces the available sky observation time. Practical experience suggests one **trcvcal** command every 5 minutes, with many **obs** commands in between, is adequate in nearly all cases.

The command format for the **trcvcal** command is:

hh:mm:ss trcvcal nsec,nint,n0,n1,f01,…,f0n0,f11,f12,…f1n1

…where:
nsec is reserved for future use (set to 0)
nint is the integration time in milliseconds
n0 is the number of RCV0 frequencies to calibrate
n1 is the number of RCV1 frequencies to calibrate
fij is jth frequency in MHz for ith receiver. Must be in order by receiver and frequency.

*5.1.2.1.4 The **cal21** Command*

The **cal21** command is applicable to the MP-3000A. It causes the Profiling Radiometer to collect a set of 22-30 GHz observations at elevation angles specified in the configuration file. From these observations, estimates of the Noise Diode temperatures (Tnd) for all 21 K band channels are derived. These estimates of Tnd are logged to the current yyyy-mm-dd_hh-mm-ss*_tip.csv* file for calibration use as described in **Appendix C**.

The command format for the **cal21** command is:

hh:mm:sscal21 az int-time

…where the value **az** = azimuth angle to be used for the **cal21** observations (if the Azimuth Positioner is installed), and **int-time** is the integration time in milliseconds for one channel (200 msec typical). Since the TIP Calibration process uses the latest available surface met data and Trcvcal data as input, it is best to precede all **cal21** commands with a **met** command and trcvcal command within the previous 1-2 minutes.

*5.1.2.1.5 The **obs** Command*

The **obs** command directs the Profiling Radiometer to point the antenna to a specific elevation angle (el), and if the Azimuth Positioner is installed, to a specific azimuth angle (az), and then measure the brightness temperature on all specified channels for the specified integration times. If no Azimuth Positioner is installed, a dummy value of az = 000 should be included in the command. The command format for the **obs** command is:

hh:mm:ss obs az,el,nint,n0,n1,f01,…,f0n0,f11,f12,…f1n1

…where:

az is the observation azimuth
el is the observation elevation
nint is the integration time in milliseconds
n0 is the number of calibrated RCV0 frequencies to observe
n1 is the number of calibrated RCV1 frequencies to observe
fij is **jth** frequency in MHz for **ith** receiver. Must be in order by receiver and frequency.

NOTE:
If the procedure file includes Neural Net retrieval (nnret) commands, then the elevation angles in the obs command must match the elevation angles in the associated Neural Net files. Additionally, the obs command must, as a minimum, contain the frequencies used in the Neural Net files. Contact Radiometrics Customer Support for additional information.

*5.1.2.1.6 The **met** Command*

The **met** command logs the current surface met sensor data (Tamb, RH, Pressure, IRT temperature and Rain. There are no parameters. The command format is:

hh:mm:ss met

*5.1.2.1.7 The **eng** Command*

The **eng** command logs the current values of 48 housekeeping data parameters (aka engineering data) in the level0 file, record type 91. There are no command line parameters. The values logged are as follows:

MCM & Frame Readings	
Index	**Description**
0	V0 / Rain voltage
1	V1
2	V2
3	TEMP0 / BB0
4	TEMP1 / BB1
5	TEMP2 / Cabinet
6	TEMP3 / IRT0 - Reflected (BB)
7	TEMP4 / IRT1 - Transmitted
8	TEMP5 / Spare
9	TEMP6 / Spare
10	TEMP7 / Spare
11	Vdist MCM
12	+12VD MCM
13	+8VD MCM
14	+5VD MCM
15	+3.3VD MCM
16	+2.5VD MCM
17	-5VD MCM
18	2.5VR MCM
19	Pressure Sensor Temp
20	Pressure Sensor Output
21	Pressure Sensor Reference
22	Computed Pressure
23	S3 Temp
24	S3 Humidity
25	IRT Temp

Receiver 0 Readings	
Index	**Description**
26	RCV0 TECV
27	RCV0 TEC Duty Cycle
28	RCV0 Antenna Temperature (T1)
29	RCV0 TkND (T2)
30	RCV0 TkIF (T3)
31	RCV0 Case Temperature (T4)
32	RCV0 +8V
33	RCV0 ND On Voltage
34	RCV0 ND Off Voltage

Receiver 1 Readings	
Index	**Description**
35	RCV1 TECV
36	RCV1 TEC Duty Cycle
37	RCV1 Antenna Temperature (T1)
38	RCV1 TkND (T2)
39	RCV1 TkIF (T3)
40	RCV1 Case Temperature (T4)
41	RCV1 +8V
42	RCV1 ND On Voltage
43	RCV1 ND Off Voltage

Elevation Readings	
Index	**Description**
44	Home Offset
45	East / West Tilt
46	North / South Tilt

Other	
Index	**Description**
47	SuperBlower Speed

Table 5-2. Housekeeping Data Parameters logged by "eng command"

*5.1.2.1.8 The **tdp** Command*

The **tdp** command logs the current GPS time, date and position in the level0 file, record type 31. Additional data about the current status of the GPS is also included in the type 31 record. The command format is:

hh:mm:ss tdp

There are no command line parameters for the **tdp** command.

*5.1.2.1.9 The **mac** Command*

mac commands function like subroutines in software codes. They provide the means to create time saving custom user commands consisting of any valid series of standard commands often repeated. Commands within a macro file do not require a time at the beginning of the command line. They are executed like a relative procedure, with no delay between the commands. Valid commands for inclusion in a macro file include all except the **mac** and **repeat** commands. **mac** commands cannot be “nested”. The format is:

hh:mm:ss mac macro

…where **macro** is the file name of a macro stored in the macro subdirectory, located in the operating folder.

As an example, suppose a user needs to routinely repeat a sequence of observations at 6 azimuth angles evenly spaced 60 degrees, at an elevation angle of 30 degrees, on 2 K and 2 V band frequencies. The macro file contents might look like this:

trcvcal	0,200,2,2,23834,30000,51248,58800
obs	0.0,30.0,200,2,2,23834,30000,51248,58800
obs	0.0,150.0,200,2,2,23834,30000,51248,58800
obs	60.0,30.0,200,2,2,23834,30000,51248,58800
obs	60.0,150.0,200,2,2,23834,30000,51248,58800
obs	120.0,30.0,200,2,2,23834,30000,51248,58800
obs	120.0,150.0,200,2,2,23834,30000,51248,58800

Now suppose the macro file is given the name “**mac1**” and the file is stored in the macro subdirectory. With this macro stored, procedures can use the following command to execute all 7 commands listed in the macro:

hh:mm:ss mac mac1

When executed, the **mac1** command will calibrate the receiver temperature on 4 frequencies (22000, 23834, 51248 and 58800 MHz) using 200 msec integration time, then point the antenna to az=0.0; el=30.0 degrees and collect brightness temperatures on the same 4 frequencies using 200 msec integration time, then repeat the observations at the next 5 az/el pointing angles. Because azimuth moves are relatively slow (15 degrees/sec) compared to elevation moves (180 degrees/sec), this macro uses 3 azimuth angles (0, 60 and 120 degrees) and alternating elevation angles (30 and 150 degrees) to save time.

*5.1.2.1.10 The **nnret** Command*

The **nnret** command produces neural network derived level2 data from current level1 data. For the MP-3000A, 5 neural network retrievals are typically provided for each site where the instrument will be used. These include retrievals for profiles of temperature, RH, vapor and liquid plus scalar values of integrated vapor and integrated liquid. The command format is:

hh:mm:ss nnret nnfilename,1or**0**[9]

…where **nnfilename** is the name of a neural net file located in the operating folder, and **1** or **0** enables/disables surface met substitution into profiles for temperature, vapor, and Rh with nnret flag.

5.1.2.2 Relative Procedures

Relative procedures are generally used when the fastest possible observation cycle time is required, and control over the exact time of the observations is not as important. Relative procedures generally execute more quickly than absolute procedures because there is no wait-state time between commands. To specify that a procedure is a relative procedure, the first line in the procedure file must contain the word "**relative**" followed by a carriage return (**CR**). Subsequent commands in a relative procedure each have dummy time fields with all zeros (00:00:00) followed by the command and parameters, if any.

Relative procedures are also useful to determine the execution times for each of the commands in a sequence of commands that the user desires to execute in an absolute file. The execution time of some commands depends on many variables, some of which cannot be easily predicted. For example, antenna movements from one position to another require different times depending on the specific start and ending angles. Thus, it is not practical to provide exact command sequence execution times for all commands in all cases. However, any user-defined sequence of commands can be timed using a relative procedure. Once the command execution times are known for a given sequence of commands, an absolute procedure can be written to provide sufficient time for the execution of each command, without wasting unnecessary wait-state time between commands.

5.1.2.3 Absolute Procedures

Absolute procedures are recommended for most observing plans because they provide uniform observation and calibration timing in the output files, best suited for most operational scenarios. Unlike relative procedures, each command in an absolute procedure is executed at a specific hour, minute and second, specified in the first field of the command (hh:mm:ss). To specify that a procedure is an absolute procedure, the first line in the Procedure File must contain the word "**absolute**" followed by a carriage return (**CR**). Subsequent commands in an absolute procedure each have execution times followed by the command and parameters, if any. The execution times must be sequential, and the time of execution for all commands must be specified to provide sufficient time for the previous command to complete. Commands specified to execute before the completion of the previous command will be skipped.

Absolute procedures can also be programmed to provide different observation and calibration sequences at different times of the day. For example, a procedure could be written to collect only zenith observations during the day, and TIP calibrations during the night. Or, each hour of the day could be divided into two periods: one set of observations

[9] This enable/disable function begins with code version mp_v6.11.exe, on radiometers serial number 3116 and later, or after September 2012. **nnretfilename** and **nnretfilename,0** both disable the substitution.

for the first 50 minutes, and different observations for the other 10 minutes of the hour. In this way, the user has complete control over the observation sequence and timing.

5.1.2.4 Procedure Timing

As noted above, command execution times vary, depending on integration time, the previous state of the antenna position, and other factors. To insure that all commands complete before the next is scheduled to execute, a new command sequence can be timed by using a relative procedure. Typical execution times can be determined by examining the *level0* file produced by a relative procedure, noting the times of each command execution. For example, if a given configuration and command sequence results in the **obs** command taking 13-14 seconds, the user might allocate 15 seconds for that command to provide some timing margin.

5.1.2.5 Choosing the Integration Time

Longer integration times result in longer command execution times. Thus, for the maximum observation frequency, shorter integration times are desirable. However, shorter integration times result in a higher contribution of random noise resulting from the thermal noise inherent in all radiometers. Figure 5-2 illustrates the impact of integration time on the thermal noise component (ΔTn) of the total random noise.

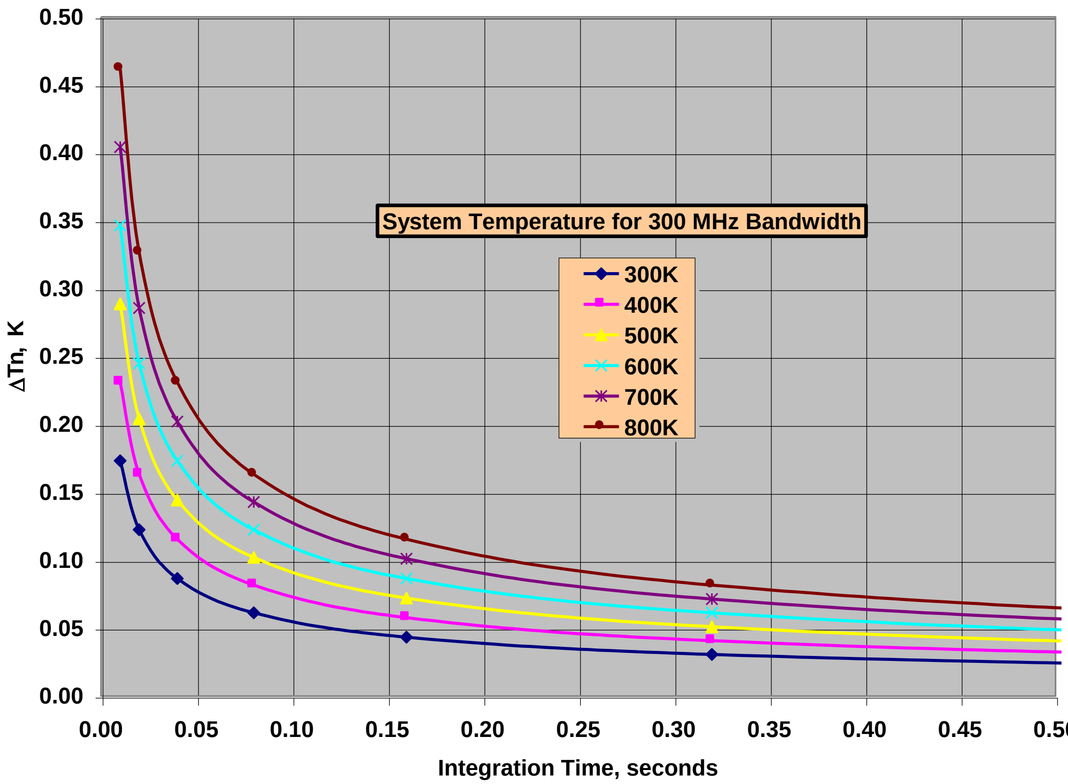


Figure 5-2. Theoretical Thermal Noise for Radiometers

For most applications, an integration time of ~200 msec is optimum for the Profiling Radiometers. Below 50 msec, ΔTn increases rapidly, and due to constant command overhead times, such as for antenna positioning between commands, further reduction of the integration time does little to reduce the command execution time. On the other hand, ∆Tn reaches such a small value above 500 msec that other sources of noise (i.e., atmospheric and residual 1/f) become dominant. Thus, there is normally very little benefit resulting from longer integrations.

5.1.3 Factory Procedure Files

The following standard procedure files are provided (xxx is a site dependent 3-letter code):

Filename	Description
B&I35.prc	Performs alternating a observations of the internal ambient target and an external cryogenic LN2 target; used mainly for diagnostic use.
Tip21.prc	Performs continuous 21 channel tip calibrations.
Zen_35_tb.prc	Performs continuous zenith observations of all 35 brightness temperatures.
xxx_zen_ret.prc	Performs continuous zenith retrievals of temperature, vapor density, liquid density, relative humidity profiles and integrated vapor and liquid scalar values based on 22 zenith brightness temperatures and 4 surface met observations.
xxx_zen_ret_tip.prc	Same as above with added 21-channel tip calibration.
xxx_zen35_ret_scan4f.prc	Performs continuous 35-channel zenith brightness temperature observations, retrievals from the observations as in xxx_zen_ret.prc and an azimuth scan (6 angles) of 4 frequencies at 30 degrees elevation brightness temperatures.
xxx_oz_20.prc	Same as xxx_zen_ret.prc except additional observations are collect at “off-zenith angles” (19.8º and 160.2º) and used for additional retrievals of temperature, vapor density, liquid density, and relative humidity profiles (north, south and average)
xxx_oz_20_tip.prc	Same as above with added 21-channel tip calibration.

Table 5-3. Standard procedure files

5.1.4 Neural Network Files

Atmospheric temperature, humidity and liquid profiles are retrieved from Profiling Radiometer measurements (*level1*) using neural networks. The neural networks are trained using data from historical radiosonde soundings. Several years of radiosonde data from one or more sites in the same climatological region as the observation site are typically used for neural network training. The radiosonde soundings are forward modeled using atmospheric emission models and radiative transfer equations to provide brightness temperatures that would have been observed at ground level. The neural networks find the temperature, humidity and liquid profile (atmospheric state) retrievals that best correlate with the radiometric observations. For GPS observations, a separate neural network file is used. The neural network files are trained using the Stuttgart Neural Network Simulator and a standard back propagation method.

New Profiling Radiometers are delivered with one set of neural network files included. The user must specify the region of operation, or radiosonde site to be used for training. Additional neural network files may be purchased for other sites. Contact Radiometrics Customer Support for further information.

To change neural network files to be used for real-time level2 processing, simply add the new neural network files to the operating folder and specify these files in the **nnret** commands used for retrievals.

NOTE:
Operation of the radiometer with neural network files trained for a different site may produce profiles with significant error. However, the level0 and level1 data will not be affected. In the event the radiometer is operated with incorrect neural network files, the level1 data can be reprocessed with the correct neural network files at a later time.

5.2 Output Files

There are 7 standard output files generated by the Operating Code.

- health status.csv
- LN2.csv
- Lv0.csv
- Lv1.csv
- Lv2.csv
- ser.txt
- tip.csv

Common conventions used in all the files are described below, followed by descriptions of each output file type.

5.2.1 Output File Name Conventions

All output files (except ser.txt) use the .csv extension to indicate to other application programs that the files conform to the industry standard *comma separated variable* data base format. Most mathematical analysis, spreadsheet and database programs can open and manipulate the data in these files with little or no reformatting. All output files are named automatically using the following format:

yyyy-mm-dd_hh-mm-ss_xxx.csv

…where yyyy is the year when the file was started
mm is the month of the year
dd is the day of the month
hh is the hour of the day
mm is the minute of the hour
ss is the second of the minute

…and **xxx** defines the output file type as follows:

xxx=lv0	*level0* file
xxx=lv1	*level1* file
xxx=lv2	*level2* file
xxx=tip	*TIP* calibration file
xxx=ln2	*LN2* calibration file
xxx=ser	com port log

This file naming convention orders the files chronologically when sorted alphabetically by name.

5.2.2 Record Number

All output files contain a sequential record number in the first field, starting with the number 1. In the event a file has been sorted for analysis purposes by record type, elevation angle, or any other parameter in the file, the record number field can be used to restore the order of the file to its original order.

5.2.3 Date/Time Conventions

All output files contain a date/time stamp in the second field of all records that contain time dependent data. All output files use the following date/time stamp convention for each record in the file:

mm/dd/yyyy hh:mm:ss

…where mm is the month
dd is the day
yyyy is the year
hh is the hour
mm is the minute
ss is the second

The time corresponds to the time of the completion (end) of the observation set.

NOTE:
If a file is opened in Excel or similar application, the date/time stamp can be reformatted easily to any other standard format and saved in that revised format.

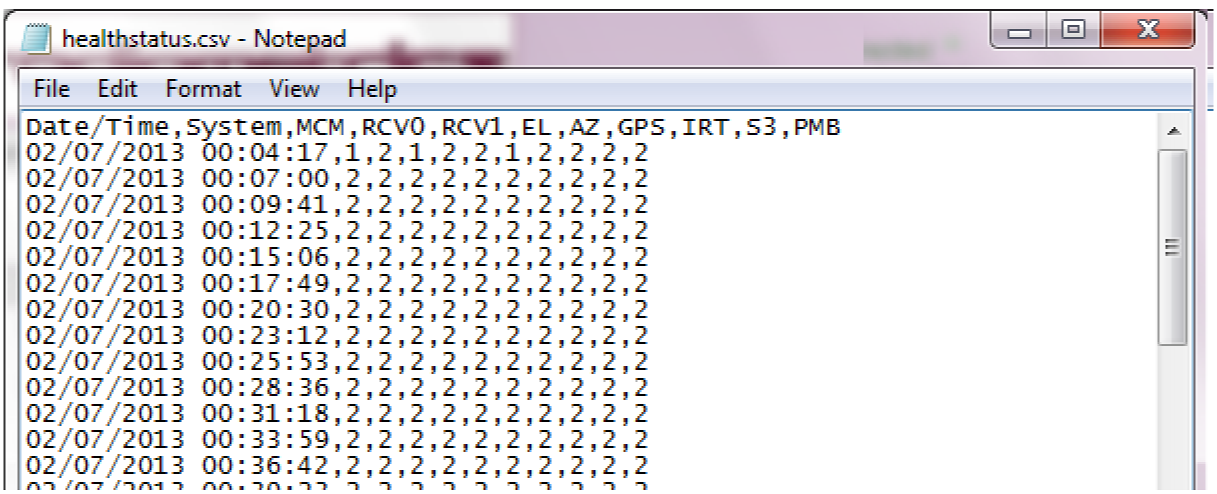
5.2.4 Record Type Conventions

All output files contain a record type number in the third field of all records. The record type number defines the header or data type in that record. Record types for each file type are grouped in blocks and numbered sequentially beginning with the number assigned to the header for that block. Record headers define all the fields in each block.

Data is logged sequentially in the order of the observations. For some types of analysis, it is more convenient to sort the data based on different parameters. Sorting a file by record type is often a useful first step to analysis. When a file is sorted by record type (third column in a spreadsheet, for example), the data automatically sorts into logical blocks with the appropriate header for each block appearing at the top of each block. Second level criteria can be used to sort the data within each block by elevation or azimuth angle, ambient temperature, or any other field appearing in the record.

5.2.5 *Healthstatus* File

Healthstatus files contain the health status values of the radiometer system and subsystems. The operational program produces a regularly updated healthstatus file. Healthstatus files give the type of data shown in Figure 5-3 below.


healthstatus.csv - Notepad
File Edit Format View Help

```
Date/Time,System,MCM,RCV0,RCV1,EL,AZ,GPS,IRT,S3,PMB
02/07/2013 00:04:17,1,2,1,2,2,1,2,2,2,2
02/07/2013 00:07:00,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:09:41,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:12:25,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:15:06,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:17:49,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:20:30,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:23:12,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:25:53,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:28:36,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:31:18,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:33:59,2,2,2,2,2,2,2,2,2,2
02/07/2013 00:36:42,2,2,2,2,2,2,2,2,2,2
```

Figure 5-3. Sample Healthstatus file

The data is numeric (0, 1, or 2) and indicates a subsystem's health status, as indicated in the table below.

Number	Health status
2	Good
1	Check
0	Service

Table 5-4. Health status indicators

At the end of a day, the healthstatus file is saved and stored as a date and time stamped .csv file in the operational folder, and a new healthstatus.csv file begins for the next day.

5.2.6 Level0 File

Level0 files contain raw, unprocessed data in engineering units. A *level0* file is produced for all modes of operation and all options that can be selected from the main menu. *Level0* files contain 100% of the information needed to reprocess the raw data with alternative calibration information or algorithms. *Level0* files contain the following record types:

Record type	Description of Record Type
00	Record type for all error reports
15	Header for sky observations
16	obs command sky observation
17	cal21 command sky observation
25	Header for observation of internal ambient black body
26	BB observation for trcvcal command
30	Header for tdp command (GPS) records
31	GPS time/date/position data
40	Header for surface met records
41	Tamb, RH, pressure, Tir and rain sensor
60	Header for LN2 calibrations
61	Record of LN2 cal data (includes BB, LN2 observations)
90	Header for housekeeping data (eng command)
91	eng command data
99	Record type for echo of mp.cfg file to level zero file

Table 5-5. *Level0* Record Types

5.2.7 *Level1* File

Level1 files contain real-time brightness temperatures for each channel specified in the configuration file. Real-time *level1* files are produced from contemporaneous *level0* data and calibration information in the configuration file. *Level1* files contain the following record types:

Record type	Description of Record Type
40	Header for surface met records
41	Surface met data record
50	Header for sky observations
51	obs command sky observation data record

Table 5-6. *Level1* Record Types

5.2.8 *Level2* File

Level2 files contain records of real-time retrievals of temperature (K), water vapor (g/m^3), relative humidity (%) and liquid water (g/m^3) profiles. The retrievals are produced using the contemporaneous *level1* data and the neural network files specified in the configuration file.

Level2 files contain the following record types:

Record type	Description of Record Type
100	**Header for vector retrieval index**
101	**Vector retrieval index entry**
200	**Header for surface met records**
201	**Tamb, RH, pressure, Tir and rain sensor**
300	**Header for scalar retrieval records**
301	**Scalar retrieval data record**
400	**Header for vector retrieval records (58 heights)**
401	**Temperature vector retrieval data record (profile)**
402	**Vapor Density vector retrieval data record (profile)**
403	**Liquid Density vector retrieval data record (profile)**
404	**Relative Humidity vector retrieval data record (profile)**

Table 5-7. *Level2* Record Types

5.2.9 Ser.txt File

ser.txt files are serial files. They contain the results of continuous communication of the operational program and MCM-C and the rest of the system. Lines of data are labeled **T** (transmit) or **R** (receive). As the serial communication is continuous, the operational program gives a second-by-second account of its internal communications checks.

5.2.10 *TIP* Calibration File

TIP files contain the results of *successful* tip calibration attempts. For each **cal21** command in a Procedure File, the *level0* data is processed in real-time by the TIP calibration algorithm. For each TIP frequency specified in the configuration file, atmospheric opacity is computed for each elevation angle. The TIP calibration algorithm attempts to fit all the opacity values for each frequency to a linear function of air mass (number of equivalent atmospheres for a given elevation angle). If the linear regression for all channels is better than the regression threshold “r” specified in the configuration file, then the tip is considered “good”, and the computed values of Tnd and r for each frequency are included in the *TIP* output data file. *TIP* files contain the following record types:

Record type	Description of Record Type
10	**Header for current calibration data in configuration file**
11	**Current calibration data**
30	**Header for cal21 calibration results**
31	**Values of Tnd @ TkBB=290 K and r values for all frequencies in TIP Cal**

Table 5-8. *TIP* Calibration Record Types

A copy of the current Tnd calibration data contained in the configuration file is copied to the top of the *TIP* file (record types 10 and 11). This provides a quick way to compare new TIP calibration derived values of Tnd to the current operational values as described in the **TIP Calibrations** section of **Appendix C**. The values of Tnd are normalized to the value that would be observed when TkBB = 290 K.

5.2.11 *LN2* Calibration File

LN2 calibration files contain the values of Tnd computed from individual LN2/Black Body observation sets during an LN2 calibration, for all channels specified in the configuration file. *LN2* files contain the following record types:

Record type	Description of Record Type
10	**Header for current calibration data in configuration file**
11	**Current calibration data**
30	**Header for LN2 results**
31	**Values of Tnd @ TkBB=290 K for all frequencies in configuration file[10]**

Table 5-9. *LN2* Calibration Record Types

A copy of the current Tnd calibration data contained in the configuration file is copied to the top of the *LN2* file (record types 10 and 11). This provides a quick way to compare new LN2 calibration derived values of Tnd to the current operational values. The values of Tnd are normalized to the value that would be observed when TkBB = 290 K.

5.3 Time Synchronization

The date/time stamp in files and output file names is derived from the date/time in the Microsoft Windows Operating System. The Windows calendar clock is updated using the GPS receiver time immediately before the beginning of each new set of output files.

5.4 Reprocessing

Users can reprocess *Level0* files with alternative calibration values or advanced algorithms to improve the accuracy or reduce the random noise in *level1* data. *Level1* files can be reprocessed with alternative retrieval algorithms. Contact Radiometrics for support and additional information:

[10] These values are calculated using a simplified receiver model. When the calibration ends, updated values of Tnd, Alpha, and dTdG are calculated and written to mp.cfg.

6 Maintenance and Troubleshooting

This Section provides information on routine maintenance and calibration of the Profiling Radiometer, including Surface Met Sensors, and the controlling computer. Please refer to **Appendix F** for information on removing and replacing FRUs.

6.1 Instrument Maintenance

6.1.1 Radiometer Calibration

Refer to **Appendix C** for detailed information on Radiometer calibration methods.

When installed at a permanent site and configured to operate on a continuous basis, the Profiling Radiometer should remain calibrated within specifications up to 6 months or longer in typical operating conditions. However, the calibration can be effected by radome degradation, long-term drift, extreme weather, changes to the installation environment, and other factors.

The 22-30 GHz channels can be monitored easily by checking the TIP calibrations regularly. If **cal21** commands are included in the procedure in use, pressing the **T** key will produce real-time graphs of all the Noise Diode values (Tnd) in current use (straight lines), and a time series of the most recent values derived from real-time TIP calibrations. The numeric values of Tnd in current use are also indicated on the **T** display. If the daily averages of the new values of Tnd deviate by more than 0.5% from the Tnd values in use, then the user should *consider updating* the values in use as described in **Appendix C**. Note that it is normal for real-time values of Tnd to deviate from “truth” by up to 2% when the atmosphere is changing rapidly, such as when a front is moving through the area. Therefore, the calibration should be changed only if the average of many “good” TIP derived Tnd values deviates from the values in use. See **Appendix C** for the recommended procedures to identify when TIP calibration values are of good quality.

The 51-59 GHz and 22-30 GHz subsystems are predominantly independent. Therefore, the calibration status of one is not necessarily indicative of the other. The 51-59 GHz channels can only be calibrated using an external LN2 target. Therefore, it is recommended that an LN2 calibration be performed every 6 months or sooner if accuracy is in question. Follow the procedures in **Appendix C** to perform an LN2 calibration.

6.1.2 Antenna Pointing Calibration

The accuracy of most sky observations is dependent on accurate antenna positions. The elevation angle accuracy is dependent on the accuracy of the leveling process described in Section 3.5. The instrument should be checked for proper leveling at least annually, following severe wind conditions, and any time TIP calibration attempts fail to pass the internal quality test more often than normally observed. Refer to Section 3.5 for proper leveling procedures.

When the Azimuth Positioner is installed, the instrument azimuth should be checked periodically. To check the azimuth reference position, end any data collection in progress by pressing **Q** on the control computer, then cycle the Profiling Radiometer power by switching the power off for 10 seconds, then back on. Once the Profiling Radiometer reaches its azimuth index position, it should be reoriented with the connector panel due east and the antenna pointed in the north-south plane. To adjust the Profiling Radiometer azimuth reference, loosen the T-bolt slightly and gently rotate the Profiling Radiometer so that the connector panel points due East, and then re-tighten the T-bolt. The user may want to use a compass for this orientation. If so, the magnetic declination at the installed site must be included in the determination of true north.

6.1.3 Cleaning the Hydrophobic Radome Surface

WARNING

Do not touch, wipe or scrub the radome.
Doing so will damage the hydrophobic properties of the coating.

Airborne pollutants will eventually coat the radome. Any foreign matter on the radome may increase the observed sky temperatures. The radome should be cleaned on a regular basis. *It should not be touched or rubbed with a sponge or towel*. Doing so will degrade the hydrophobic material.

Rinse the radome with clean water (preferably distilled water, if available). Only hand-held spray bottle pressure is allowed.

A clean, contaminant-free hydrophobic coating will exhibit continuous water-beading and shedding over the entire radome surface when wetted. Indications of continued contamination (by either dirt and debris, or un-removed surface cleaner) will be any areas that exhibit water collection or “sheeting.”

Note that solar U.V. radiation, as well as some contaminants, will degrade the hydrophobic coating over time. If, after cleaning, water does not bead on the radome, it should be replaced. To replace the radome, refer to **Appendix F, Section X**.

6.1.4 Relative Humidity (RH) and Temperature Sensor Maintenance

NOTE:
Prior to performing any maintenance, ensure that power to the radiometer is removed.

The ambient air probe is a precision instrument that will maintain calibration for 6 months or more in normal service. However, if dust or other local air pollution is excessive, the screen on the sensor may need to be cleaned more often. To access the Temperature and RH sensor, loosen the 10 thumbscrews that secure the Superblower End Cover. Gently remove the cover by pulling outward with the handle while holding the bottom lip. See Figure 6-1. The Superblower End Cover must be properly replaced to its original location prior to restarting the radiometer.

To clean the screen, the probe can be left in the mounting socket. Simply unscrew the screen and remove to the right. See Figure 6-2.

CAUTION

The sensor is a delicate instrument requiring careful handling. Nothing should be allowed to come in contact with the active sensor elements inside the screened protective cover.

Figure 6-1. Superblower End Cover removal

To clean the screen in the field, use pure compressed air. Pure compressed air is available in small cans for cleaning photography equipment, computers, and other electronic equipment. Air should be blown through the screen from the inside to the outside as shown in Figure 6-2**.** Avoid using compressed air from an air compressor because oil and water from the compressor can contaminate the sensor.

If access to ultrasonic cleaning is available, it can be used with distilled water to clean the screen. Avoid chemical cleaners, due to possible contamination.

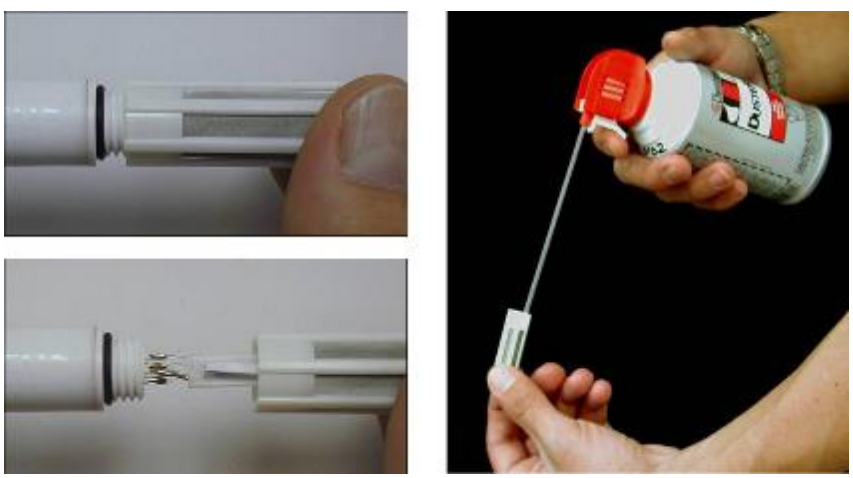


Figure 6-2. Sensor screen removal and cleaning

To remove the sensor for laboratory calibration or replacement, unscrew the Metallic Locking Collar on the probe, which will unplug the sensor from the probe arm.
See Figure 6-3.

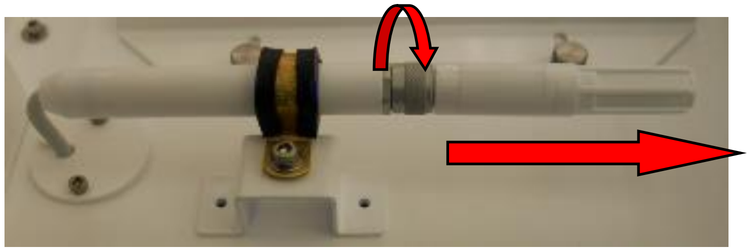


Figure 6-3. Sensor removal

New sensors are available from Radiometrics. Users may calibrate the sensor in the laboratory, if necessary.

If the user has access to high accuracy field standards for Tamb and RH, and wishes to adjust the calibrations in the field, linear offset values may be entered in the configuration file (mp.cfg) in place of the default values (0.0) as follows:

```
+0.00    :Tamb correction
+0.00    :Rh correction
```

Offset values for Tamb and RH are *added* to the measured values. For example, if the temperature observed with a high quality standard (placed close to the inlet of the Superblower) is 0.2K higher than the air temperature recorded by the Profiling Radiometer, then an offset of +0.2 should be entered in the field provided for the Tamb offset in the mp.cfg file. Because the expected difference is normally very small, it may be necessary to average the data for 1-2 hours to obtain a meaningful estimate of the bias.

6.1.4.1 Instructions for Testing Voltages to the Rotronic HC2-S3 Sensor

It is not required that the radiometer hood be removed for this procedure.

Special Tool Requirements:

- A straight-bladed screwdriver might be required to loosen the thumbscrews.
- A voltmeter

Procedure

1. Stop any current procedures running on the Control Computer.
2. Turn off power to the radiometer.
3. Remove the Superblower front panel.

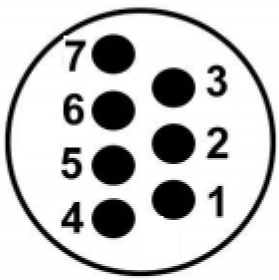
Figure 6-4. Loosened thumbscrews on Superblower cover; cover removed (right)

4. Rotate the Metallic Locking Collar that holds the sensor to the probe arm, until it is free of the threads, and pull sensor to the right to remove.

Figure 6-5. HC2-S3 Sensor removal

5. When the HC2-S3 sensor is disconnected, return power to the radiometer to be able to take measurements.

6. Use the HC2-S3 sensor Pin Out graphic and table below to take measurements.



Pin #	Name	Voltage
1	VDD (+)	3 V
2	GND	Ground
3	RXD	3 V
4	TXD	0 V
5	Out 1 analog (+)	0 V
6	Out 2 analog (+)	0 V
7	AGND	0 V

Figure 6-6. HC2-S3 Pin out diagram and values

7. Start by testing the ground continuity from the cable to the radiometer. Set the Voltmeter to Ohms (Ω), and put the Red lead to Pin 2, with the black lead going to bare metal on the Radiometer. Any reading near 5 Ohms is acceptable.

Figure 6-7. Test and reading for Ground continuity

Typically, bare metal ground can always be found with the bottom-left screw on the power connector port on the radiometer Front Connector Panel.

Figure 6-8. Ground metal on Front Connector Panel

8. Switch the Voltmeter to Volts, and systematically test the remaining pins.

WARNING!

The ground socket is close to +24 V DC; when taking measurements, be very careful to not accidently short these two connections!

Pin 1 test

Figure 6-9. Test and reading for Pin 1

Pin 3 test

Figure 6-10. Test and reading for Pin 3

Pin 4 test

Figure 6-11. Test and reading for Pin 4

Pin 5 test

Figure 6-12. Test and reading for Pin 5

Pin 6 test

Figure 6-13. Test and reading for Pin 6

Pin 7 test

Figure 6-14. Test and reading for Pin 7

9. When testing is complete, return the radiometer to Operational mode, reversing steps 2 thru 6.

6.1.5 Superblower Filter Cleaning and Replacement

NOTE:
Prior to performing any maintenance, ensure that power to the radiometer is removed.

The Superblower impeller produces a high volume of airflow. To protect the radome and impeller, the intake is filtered with a standard aluminum mesh filter. This filter should be inspected and serviced periodically. The frequency of service is site-dependent and must be determined by the user. Following installation at a new site, inspect the radome every 30 days until a maintenance interval can be established by the user, based on local conditions.

To remove the filter, first remove the Superblower End Cover as described in Section 6.1.4. Then loosen the two thumb screws holding the filter retaining bracket, as shown in Figure 6-15. Remove the filter by sliding the retaining bracket down and lifting the filter out.

If the filter is not matted with insects or other difficult-to-remove debris, use compressed air to clean it. For insects and other heavy debris, clean the filter with water and mild detergent, compressed air, and then rinse thoroughly. Replace filters that cannot be cleaned (due to excessive debris) with a new filter. Ensure the retaining bracket properly supports the filter, and that the Superblower End Cover is properly replaced to its original location prior to restarting the radiometer.

Figure 6-15. Superblower filter removal and cleaning

Replacement filters are available only from Radiometrics.

6.1.6 Superblower Specifications

The *Superblower* specifications are as follows:

Assembly Weight: 12.5 lb/5.8 kg
Assembly Overall Height: 17.5 in/44.5 cm
Assembly Overall Width: 12.1 in/30.7 cm
Assembly Overall Depth: 7.5/19.1 cm

Impeller Op. Temp. Range: -40 to 80° C
Power Consumption: 24DC, 5A, 106 W
Airflow: 500 CFM

6.1.7 Rain Sensor Board

NOTE:
Prior to performing any maintenance, ensure that power to the radiometer is removed.

The rain sensor board, located on the top of the Superblower, detects the presence of liquid water by measuring the resistance between the inter-digital conductors. Excessive surface contamination from pollution, salt spray, etc. will alter the transfer function (volts/water-drop). This board should be cleaned periodically with fresh water and a nonabrasive cloth or paper towel to remove all foreign matter. The board is gold plated to minimize corrosion, but will degrade over time in severe environments. If the rain sensor fails to provide satisfactory service after cleaning, it may need to be replaced. Replacement boards are available from Radiometrics.

To replace the board, unscrew the four mounting 6-32 screws and gently lift the board up until the small connector on the bottom is visible (2-3 cm). Unplug the small connector on the old board, plug in a new board, and then replace the four mounting screws.

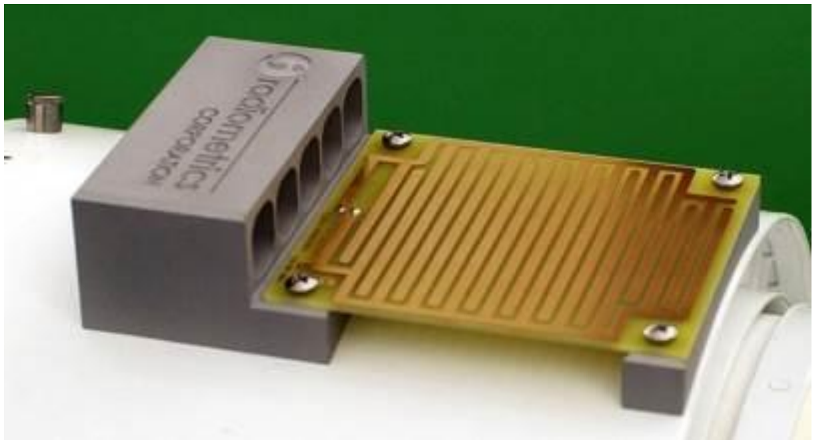


Figure 6-16. Close-up view of Rain Sensor board

6.1.8 IRT Window Maintenance

NOTE:
Prior to performing any maintenance, ensure that power to the radiometer is removed.

The IRT window is located on the top of the Profiling Radiometer. It should be checked periodically for contamination. For accurate cloud base temperatures, the window surface must be free of dust and other contamination. The frequency of service is site-dependent and must be determined by the user. Following installation at a new site, inspect the IRT window every 30 days until a maintenance interval can be established by the user, based on local conditions.

Figure 6-17. GPS Receiver on the left; IRT window on the right

A soiled window can be cleaned with a standard camera lens cleaning kit available from photography stores. Paper towels and many types of cloth are too abrasive, and may damage the surface. Before using a lens cleaning tissue, cloth or brush to clean the window, pure compressed air should be used to remove as much dirt as possible. Replacement windows are available from Radiometrics.

6.1.9 Cables

Normally, the power and data cables do not require any periodic maintenance. However, it is good practice to inspect the cables periodically to ensure that they have not been damaged by weather, accident, rodents, etc.

If damage is observed on the power cable, remove the attachment plug at the power supply source and replace the cable prior to continued operation. Radiometrics Corporation will supply a new cable, so contact Customer Support as quickly as possible.

6.2 Control Computer

No periodic maintenance is required for the control computer hardware beyond what is recommended by the computer manufacturer. Refer to the separate computer manufacturer documentation supplied for computer maintenance suggestions.

6.2.1 Operating System Updates

Microsoft releases updates to the Windows Operating System software (OS) quite often. The OS can be configured to update automatically or notify the user that updates are available. Radiometrics recommends setting Windows to notify when updates are available but not to automatically install those updates. It is generally advisable to keep the OS up to date with revisions as they are released.

WARNING

It is imperative to the proper function of the radiometer that the configuration of many components not be altered by the user. This includes such things as

- allowing Microsoft software updates
- changing the date/time configuration (Control Computer **MUST** remain in UTC time)
- installing separate software that uses large portions of the computer's CPU

If you have any questions about changing the configuration of the control computer, please contact Radiometrics Customer Service:

303-449-9192
supportmwr@radiometrics.com

6.2.2 Operating Code Updates

Radiometrics may release updates to the Operating Code from time to time to enhance performance, add features or fix bugs. Generally, these updates can be installed by replacing the application file (**mp.exe**) in the Operating Folder, without changing any other files. Occasionally, updates require the installation of additional files, or the modification of some existing files. Detailed installation instructions will be provided with all new code releases. Contact Radiometrics Customer Support for information on the latest codes available, and advice on the best code to use for a given application.

6.2.3 Neural Network and Procedure File Updates

Neural networks are specific to the site where the radiometer will be operated. If the radiometer is moved from the original site and the new site has an elevation more than 100 meters different than the old site and/or a different climate, new neural networks should be ordered from Radiometrics. The neural network files (.net extension) and the procedure files (.prc extension) should be placed in the main operating directory. The macro files (.rmc extension) should be placed in the *macro* sub-directory. The new procedure files will then be available for selection when the operating program is run.

6.2.4 Firmware Updates

The MCM-C and microwave receivers store firmware in flash memory. This firmware can be updated from time to time using a code download tool installed on the control computer.[11] In the event any of the firmware needs to be updated, Radiometrics will supply detailed instructions on the procedure.

6.2.5 Virus Protection and Firewall

Radiometrics does not supply virus protection software with control computers. However, if the user connects the controlling computer to the Internet, appropriate firewall and virus protection software may be enabled or added by the user, provided it is configured to operate without restarting the computer from time to time.

6.2.6 Error Messages

If the Operating Code encounters a fatal or non-fatal error, it will attempt to write an Error Message to the level0 file marked record type 0. **Appendix D** contains a list of all the Error Messages that may be written to the level0 file. In the event that the user encounters problems requiring factory assistance to resolve, be prepared to give the technician information about the Error Message history.

[11] The Downloader Tool can also be installed on any other computer as required to update radiometer firmware.

7 Warranty and Service

Radiometrics warrants its' Profiling Radiometers for one year from the date of delivery against defects in workmanship and materials under normal use and service. Radiometrics will repair or replace, at Radiometrics' option, any equipment found to be defective within this warranty period, EXW Boulder Colorado. Customers are responsible for the cost of all inbound and outbound freight, insurance and taxes, if any. This warranty excludes the control computer, which is covered under the original equipment manufacturer's warranty.

For information or service, contact Radiometrics Customer Support as indicated below. Be prepared to describe your problem in detail. If field repair is not considered possible, request a Return Materials Authorization (RMA). Radiometrics will remedy your problem as soon as possible and return the unit.

The Profiling Radiometers are protected under U.S. and foreign patents. The software and firmware are copyrighted.

Please direct inquiries to:

Radiometrics Corporation
4909 Nautilus Court North, Suite 110
Boulder, CO 80301 USA
Phone: +1-303-449-9192
Fax: +1-303-786-9343
email: supportmwr@radiometrics.com

7.1 European Certification

The MP-3000A has received European Certification in conformance with the European Union Directives:

- 73/23/EEC (93/68/EEC) Low Voltage Directive
- 89/336/EEC Electromagnetic Compatibility Directive

Based on the following standards:

- EN 61010 Safety of Electrical Equipment for Measurement, Control, and Laboratory Use
- EN 55022 (Class A) Limits and methods of measurements of radio interference characteristics of information technology equipment.
- EN 50082-1 Electromagnetic compatibility - Generic immunity standard -Industrial environment

7.2 MIL-STD 461F

MIL-STD 461F describes how to test equipment for electromagnetic compatibility.

Various revisions of MIL-STD 461 have been released. The latest revision (as of 2012) is known as MIL-STD 461F, superseding MIL-STD 461E.