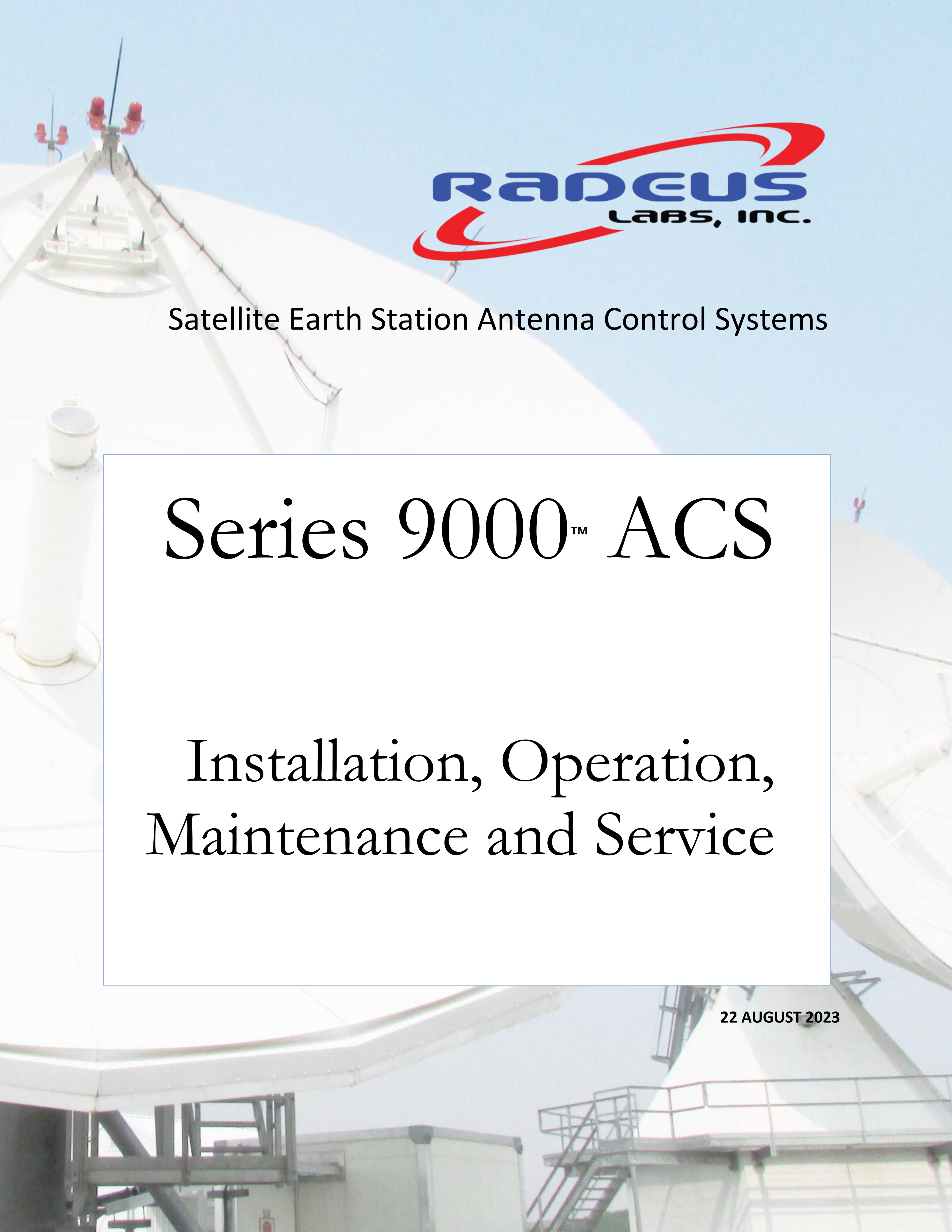

Satellite Earth Station Antenna Control Systems

Series 9000™ ACS

Installation, Operation, Maintenance and Service

22 AUGUST 2023

ANTENNA CONTROL SYSTEMS FOR SATELLITE EARTH STATIONS

Series 9000™ ACS Operation & Maintenance

Document rev. 20230822-1

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Important Precautions

This manual is for knowledgeable, qualified personnel able to work safely with electricity, electronics, and electro-mechanical systems. *It does not try to provide complete safety information for all circumstances or for all installations and sites.*

Installation, operation, and maintenance of this device may involve risks to users and property, including the device and any interrelated systems. All procedures are to be carried out by qualified personnel applying common industry standards, best practices, and due diligence.

Radeus Labs, Inc. shall not be responsible for injury or damage resulting from or associated with improper use of its hardware or software or from its use by improperly trained or inexperienced individuals.

All applicable building codes, fire-related regulations, and other required or advisable safety protocols must be observed at all times.

WARNING

ALWAYS DISCONNECT POWER BEFORE SERVICING

There are electrical shock hazards when installing or servicing electrical equipment.

There are mechanical hazards when working around moving parts.

Review and use all proper safety procedures.

In the event of emergency, be sure all power is disconnected.

About This Document

Documentation for the Series 9000 antenna control system from Radeus Labs, Inc.

Service and Support

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SECTION
1

1 Installation

WARNING

Do not attempt to operate this equipment if there is evidence of shipping damage or you suspect the unit is damaged.

Damaged equipment may present additional hazards to you, to other persons, and to property.

Contact support for advice before attempting to plug in and operate damaged equipment.

1.1 Connect the ACP

1. Verify that the unit is connected to power.

Figure 1-1 Antenna Control Pannel (ACP) (front)

2. Turn on the ACP via the power switch on the top panel. The touchscreen will illuminate when it is ready.

Figure 1-2 Back of the ACP and the power button.

2 Operation System Overview

2.1.1 System Block Diagram

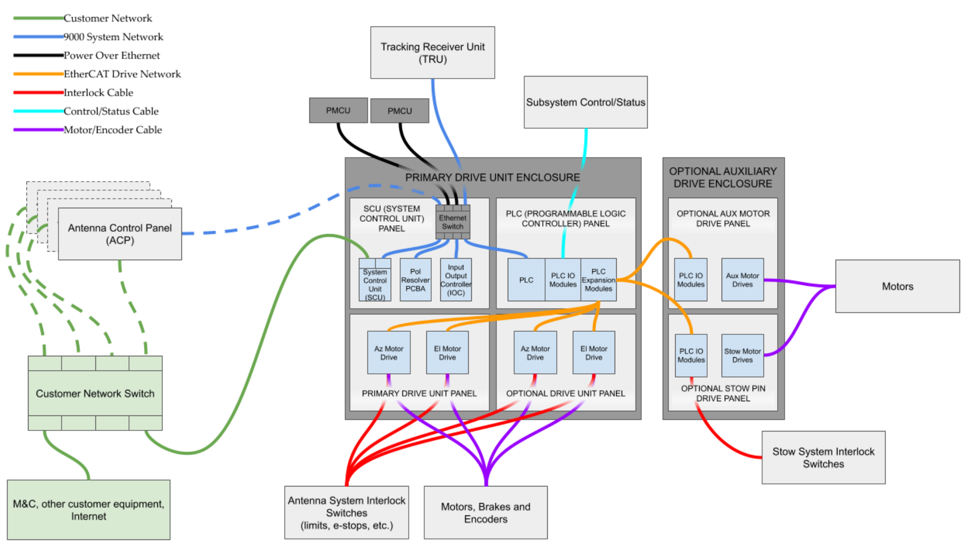


Figure 2-1 System block diagram

2.1.2 Antenna Control Panel (ACP)

The ACP is the primary control interface for the 9000 system. It is a graphical user interface with a touchscreen and optional keyboard and mouse. The ACP is provided in a rack mounted configuration for easy integration into the customer's control center.

Up to 4 ACP's may be connected to the system for control and monitor points at convenient locations on the customer's network.

2.1.3 System Control Unit (SCU)

The SCU is the primary control unit in the system running most of the tracking logic as well as monitor and control of the various control subsystems.

The SCU has four interfaces that allow an operator to control and monitor the system:

- ACP – the primary control interface.
- M&C – the interface used for customer monitor and control applications. SNMP and REST API are supported.
- PMCU – the handheld portable maintenance control unit.
- Web Interface - With software versions after 9k-RC152 the system can support the use of a web interface that will allow users to access an ACP like interface from any computer on the same network.

2.1.4 Antenna Control Unit (ACU)

ACU is a legacy term, there is no single device in the 9000-system known as the antenna control unit, however, ACU is sometimes still used to refer to the system as a whole or parts of it.

2.1.5 Drive Unit

The 9000 Series Drive Unit is designed based on modular panels that can be mounted in a standard control cabinet style or a rack mount style. A standard Drive Unit contains 3 or more standard panels:

- SCU (System Control Unit) Panel – contains interfaces for the system wiring, the main system circuit breaker, contactors for 3-phase power cutoff, Ethernet switches, DC power supplies and circuit boards.
- PLC (Programmable Logic Controller) Panel – Contains interfaces for the system wiring, the Pol Motor and Warning Horn/Light circuit breakers, DC power supply, relays for safety

logic, and a PLC with IO modules for controlling the motors and IO functions.

- Drive Panel 1 – Contains an Azimuth and Elevation servo motor drive unit along with associated circuitry.
- Drive Panel 2+ - Contain optional additional servo drive circuits for Azimuth and/or Elevation.

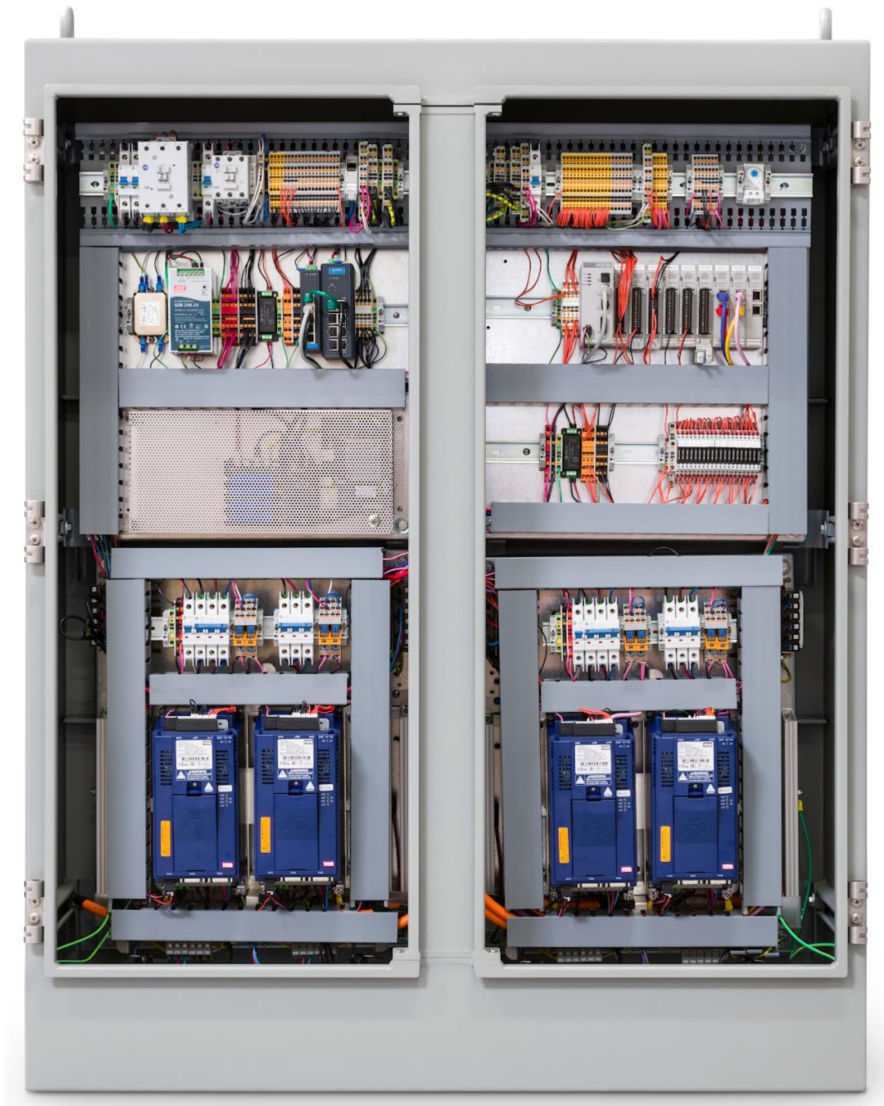


Figure 2-2 Drive Unit 1 with panels open.

Figure 2-3 Drive Unit 1 panels closed

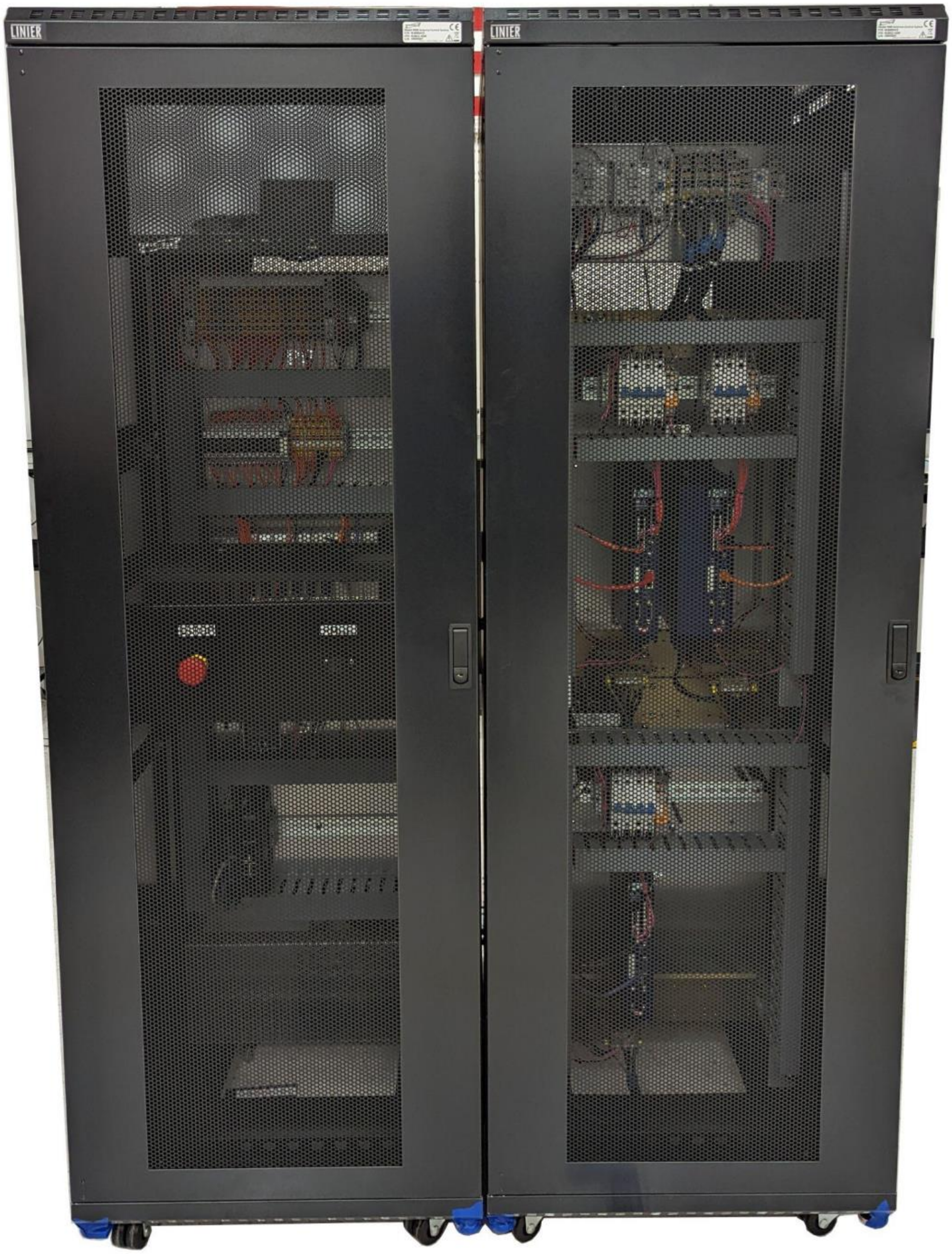


Figure 2-4 Drive Unit 2

2.1.5.1 Emergency Stop

- To stop all antenna motion as quickly as possible, push the red e-stop switch.
- To release the e-stop, twist the knob clockwise.
- During an emergency, disconnect all power sources.
- The e-stop switch works by asserting the SS1 (Safe-Stop-1) feature of the motor drive units. SS1 executes a controlled stop of motion on the drives, enables the brakes and transitions to the STO (Safe-Torque-Off) feature of the motor drive units.
- ⚠ *Activating the e-stop does not remove electrical power from the drive cabinet.*

2.1.5.2 SCU Panel

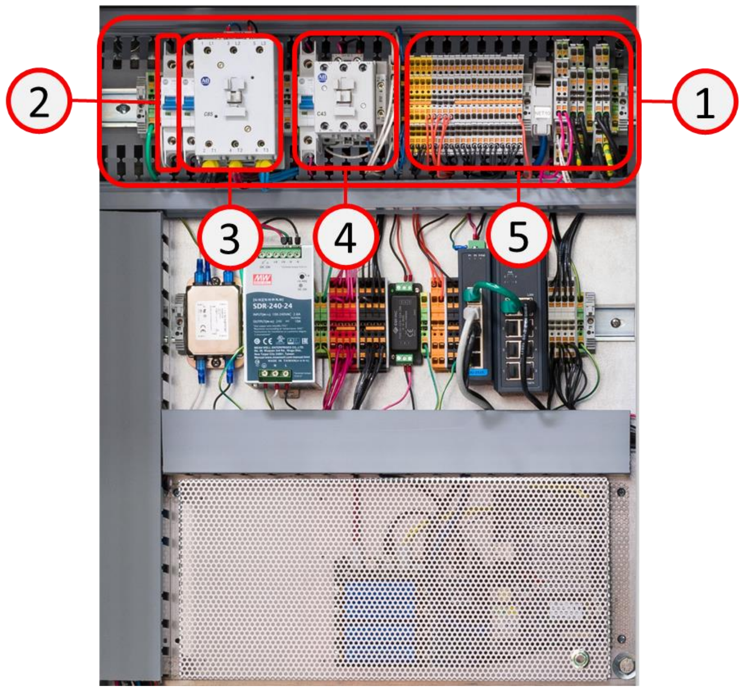


Figure 2-5 SCU Panel (top)

(1) Customer Interface Block – Terminals and power circuits for connection to the antenna system.

(2) Main Circuit Breaker – Disconnect for all power entering the cabinet.

(3) 3-Phase Az/El Motor Contactor and Switch – Power entry point for 400VAC motor power. The contactor is turned off individually by the associated switch/circuit breaker and also by the main circuit breaker along with all other power in the cabinet.

(4) 3-Phase Brakes and Pol Motor Contactor and Switch – Power entry point for 200VAC brakes/warning power. The contactor is turned off individually by the associated switch/circuit breaker and also by the main circuit breaker along with all other power in the cabinet.

(5) Motor Power Terminals and Terminals for connection of antenna system wiring.

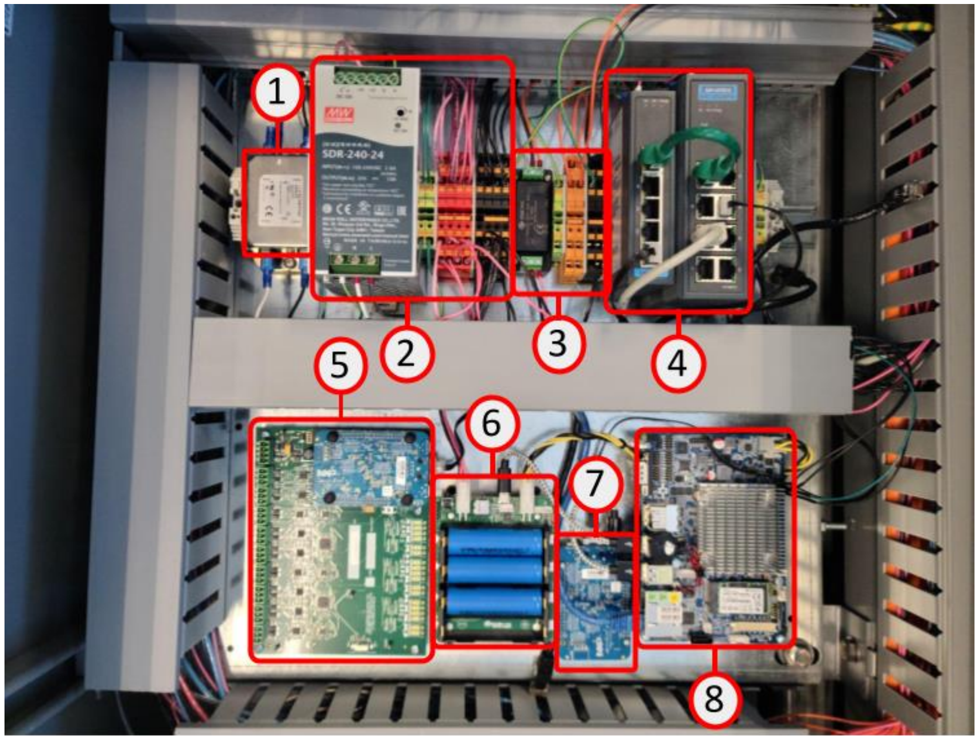


Figure 2-6 SCU Panel Bottom

(1) EMI Filter for 120VAC input.

(2) 24VDC Power Supply and Distribution – power for all electronic circuits.

(3) 24VDC Buffered Power Supply and Distribution – power for 24V switches on antenna system (limit switches, handcrank interlocks, etc.)

(4) Ethernet Switch and PoE Switch – network for internal communications and PMCU.

(5) Resolver Board

(6) UPS for SCU Computer

(7) IOC (Input Output Controller)

(8) SCU Computer

2.1.5.3 PLC Panel

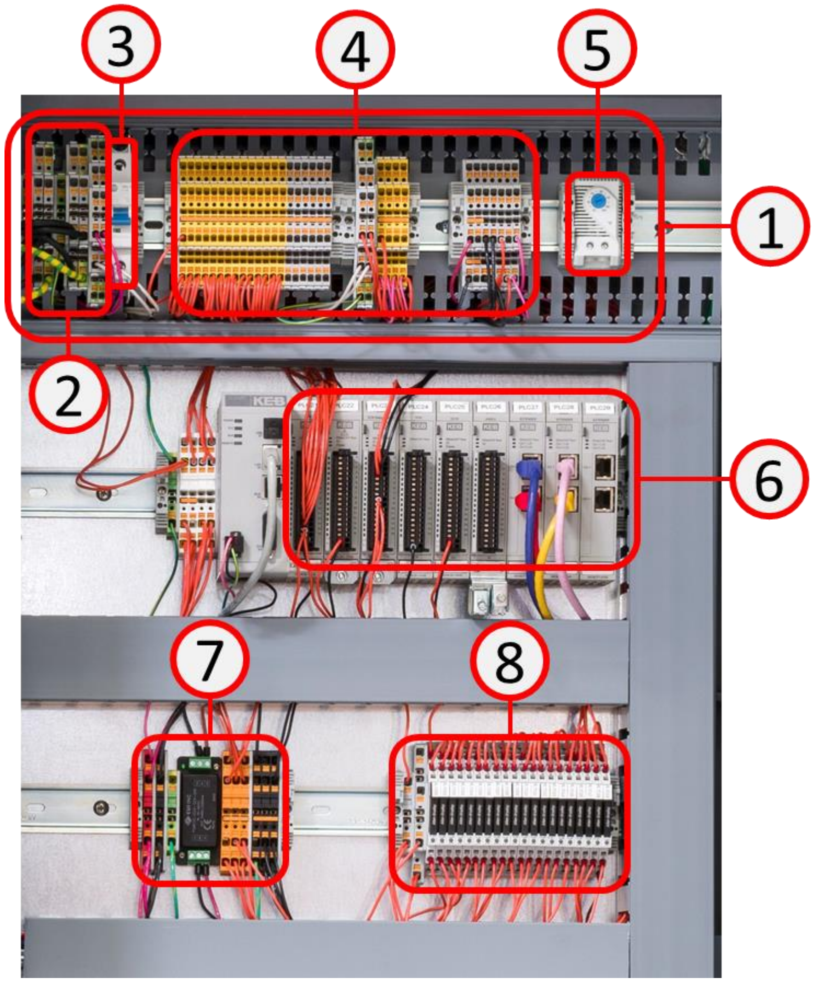


Figure 2-7 PLC Panel

(1) Customer Interface Block – Terminals and power circuits for connection to the antenna system.

(2) Motor Power Terminals

(3) Circuit Breakers for Pol Motor Power and Warning Horn/Light Power

(4) Terminals for connection of antenna system wiring.

(5) Thermostat for control of cabinet fans.

(6) PLC and PLC IO Modules for control of motor and system functions.

(7) 24VDC Auxiliary Buffered Power Supply and Distribution – power for 24V switches on antenna system (limit switches, handcrank interlocks, etc.)

(8) Relay Logic for safety functions (E-Stops, handcrank Interlocks, Final Travel Limits)

2.1.5.4 Drive Panel

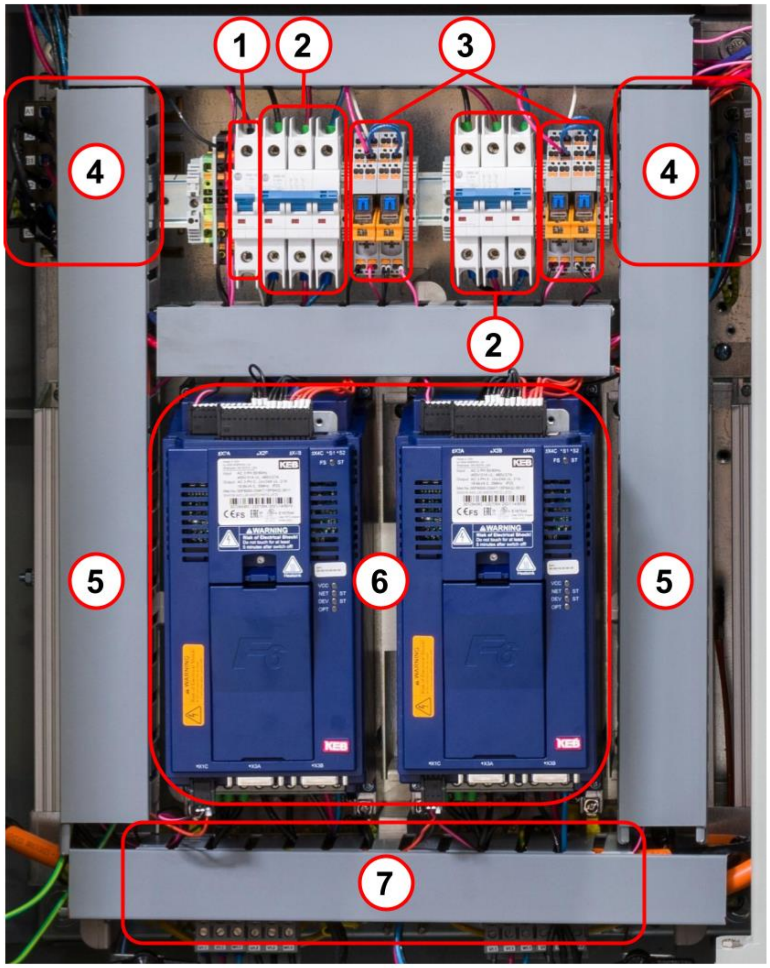


Figure 2-8 Drive Panel

(1) Az/El Motor Brake Circuit Breaker

(2) Az/El Motor Power Circuit Breakers

(3) Az/El Motor Brake Relays

(4) Az/El Mains Input Chokes

(5) Az/El Braking Resistors

(6) Az/El Servo Drive Units

(7) Az/El Motor Power Chokes

2.1.6 Motors and Motor Encoders

The Series 9000 system utilizes 1 or more motor(s) on the Az and El axes. Multiple motor types are supported:

- Synchronous AC Servo motor – The preferred type of motor for 9000 systems due to its small size, precision control capabilities and efficient operation.
- Asynchronous AC motor with encoder – Often found on existing installations. These motors work in the application but are much larger and less efficient compared to Synchronous AC Servo motors.
- Brushless DC Servo motor – Similar but older technology to Synchronous AC Servo motors. These are supported but may suffer efficiency loss.

The Series 9000 system works with motors using various encoders:

- Incremental A-B encoders – often found on existing Asynchronous AC motors
- Resolver – The preferred type for Synchronous AC Servo motors.

Tachometer feedback is not supported.

The Series 9000 system is compatible with axes with single motor(s) per axis up to essentially unlimited number.

2.1.7 Position Encoders

The Series 9000 system utilizes 25-bit optical encoders for both Azimuth and Elevation axes.

The Azimuth axis offers an optional multiturn version of the encoder in cases where there is greater than 360 degrees of travel for tracking LEO or other high dynamics targets.

2.2 Theory of Operation

2.2.1 System Control

2.2.1.1 Sources of Control

The following sources of control can be used with the 9000 System:

- ACP (Antenna Control Panel) – The ACP is the standard interface for an operator to use with the 9000 system. The ACP runs the user interface software on an industrial computer and displays controls and status information on a touchscreen rack-mounted display. Up to four ACPs can be connected to the system to provide multiple monitor or control points for the system. The ACP is not a mission critical device, meaning that if it is disconnected or turned off the system will continue to operate in the mode it was in. This allows for "headless" operation of the 9000 system with no ACP.
- M&C (Monitor and Control) – The M&C interface is used by software to monitor and control the 9000 system over Ethernet. Two standard interface types are provided: SNMP v1/v2 and REST API.
- PMCU (Portable Maintenance Control Unit) – The PMCU is most often used during maintenance operations when control is needed on the antenna platform, by the motors, etc.
- Web interface - The web interface is essentially the same as the ACP but accessible from any computer on the same network. This will allow more convenient control of the unit or even remote operation for units placed in un-manned locations.

2.2.1.2 Lockout of Control

The 9000 system uses a two-level hierarchy of control lockout. When the PMCU is in use the ACP and M&C interfaces cannot make changes to the operational mode.

When the PMCU is not in use the ACP and M&C operate with equal priority on a "last wins" scheme. This means that the last command always overrides any previous command whether received from an ACP or the M&C interface.

2.2.1.3 Level of Control

The ACP supports three levels of control to allow systems to operate without the possibility of inadvertent change of sensitive parameters:

- Monitor – cannot make any changes but can monitor status and view settings.
- Operator – can make changes to targets, tracking operations and diagnostics. The passcode to enter Operator mode is "**1212**".
- Admin – can make changes to all system parameters. The passcode to enter Admin mode is "**5959**".

2.2.2 Motor Control

The 9000 system utilizes a feedback control system for precise position and velocity control of the antennas Az and El motors. In a feedback control system, the motors are equipped with encoders directly on their shaft allowing the shaft position and velocity to be accurately measured and controlled by a smart control system. This motor shaft control is in addition to the position feedback

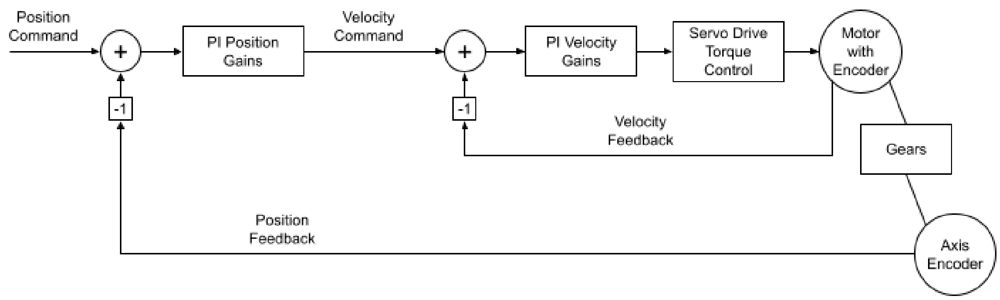


Figure 2-9 Single motor control diagram

The simplified diagram works well for systems that require limited accuracy but due to errors introduced by the gears (primarily backlash and wind up) the system cannot translate the precise motor velocity control into precise axis control. In order to solve this problem for antennas requiring high accuracy the antenna is often fitted with a set (or more) of two motors in a torque biased configuration. Torque biasing on the final drive gear allows the system to eliminate most of the inaccuracies introduced by the gears.

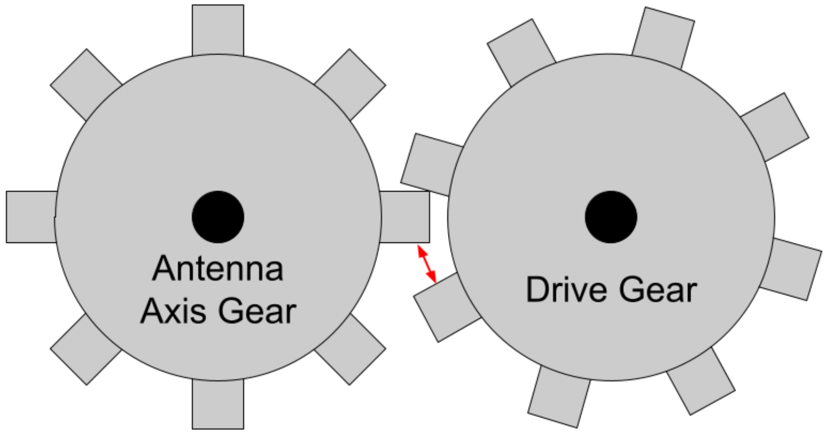


Figure 2-10 Single motor drive system

In a drive system with backlash the drive gear has a gap on one side of the teeth when meshed with the axis gear. This causes the axis gear to not be driven when the drive gear is changing directions. It also allows the antenna gear to coast or be moved by external disturbances in the direction toward the backlash in a way that the drive gear cannot control. The result is that the accuracy of the motor controller in positioning the drive gear cannot translate fully to accuracy on the axis.

To accommodate this backlash, a single motor system uses a position deadband that is larger than the gear backlash so that the control loop gain is reduced when within the deadband of the target position. This prevents the phenomenon of limit-cycling which is when a control system oscillates back and forth across a non-linearity in the system, in this case the gear backlash.

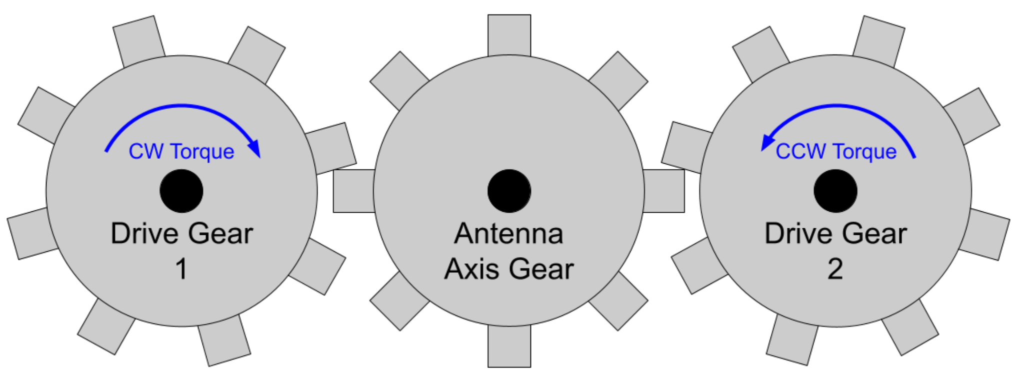


Figure 2-10 Dual motor drive system

In a dual motor drive system, a second drive gear is added. The control system applies a torque to the second gear that is biased against the torque applied by the first gear. This means that there is direct contact from the antenna gear to one drive gear or the other in both directions of rotation. This biasing effectively eliminates the backlash of the gear system allowing for highly accurate control of the axis gear by the motor control.

The position deadband in a dual motor system is set significantly lower than in a single motor system and is used more to establish the reasonable limit of control accuracy than to prevent limit cycling. In a typical system the position feedback resolution is 0.001 degrees, and it is not necessary to control the position much more accurately than this. However, the deadband can still be set to lower numbers if required by the application.

In order to control the two-motor system, the control system must become more complex as compared with a single motor system.

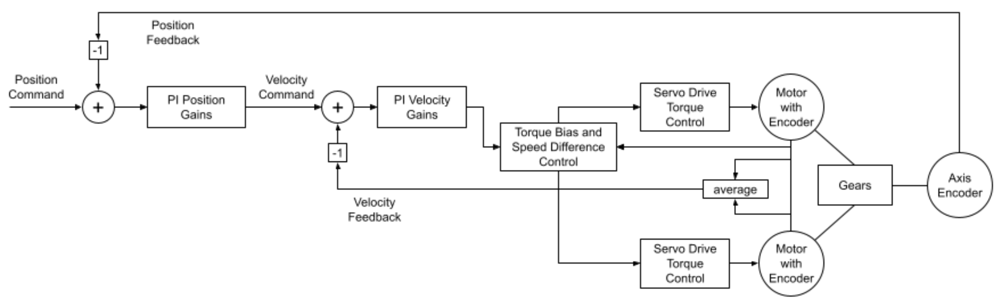


Figure 2-11 Dual motor drive diagram

The design for controlling two motors still includes a single position command and velocity command but now it requires a torque bias and speed difference controller as well as using the average motor velocity as the velocity feedback. The torque bias and speed difference controller ensures that a bias is maintained to eliminate backlash and that the two motors drive in a stable manner, not fighting each other or resonating energy between them through the gear coupling.

2.2.2.1 System Tuning

⚠ *CAUTION: Tuning the control system must be performed by qualified personnel with the required education and experience to understand the tuning method and risks associated. A poorly tuned system can lead to excessive uncontrolled motion that can damage the system and lead to dangerous situations.*

This complex control system must be tuned to the antenna so that it provides optimal performance and remains stable. There are essentially three elements that must be tuned to achieve optimal performance:

- Torque bias and speed difference gains
- Velocity control loop gains
- Position control loop gains

The torque bias is set to a percentage of the maximum motor torque. It should be set high enough to ensure continual engagement of both drive gears against the axis gear. However, setting the torque bias too high will limit the maximum torque available to the system.

The speed difference gain applies a fractional (greater than zero and less than one) multiplier to the difference between the measured velocity of the two motors. The result is summed with the torque command. This is used to dampen any oscillations that may occur between the two drive motors due to mechanical spring built into the drive gear chain.

Tuning of the velocity and position control loops is toward the objective of achieving close to critically damped response to a step function command. This is the fastest response to the command with minimal or no overshoot and fast settling time:

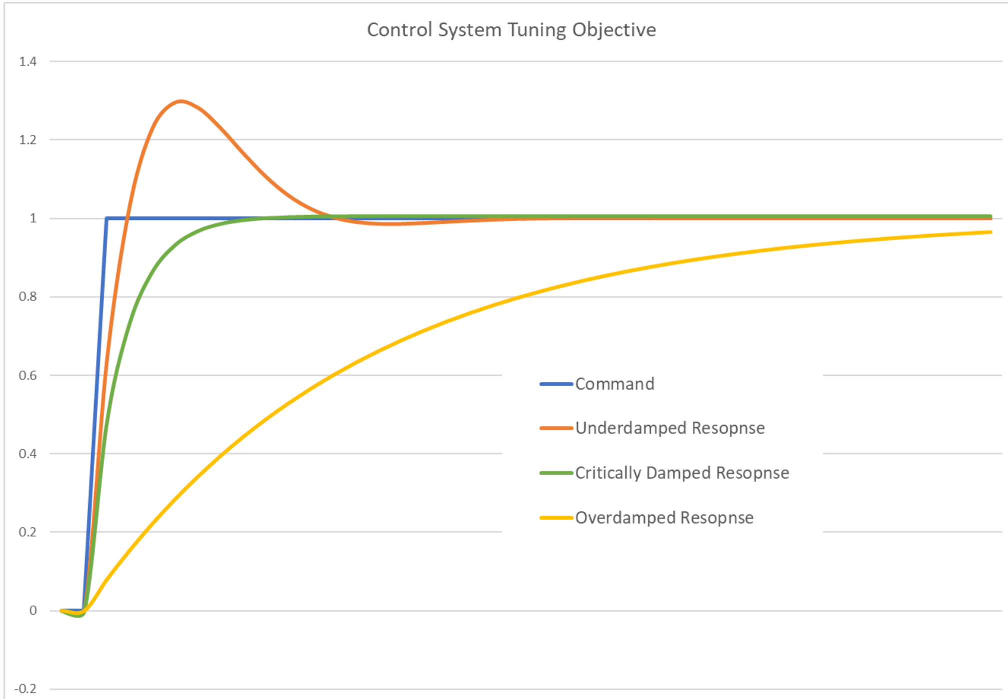


Figure 2-11 Control system tuning objective

When the velocity and position loops are tuned to critical damping then the output velocity and position of the antenna match as closely as possible to the commanded position and velocity.

Tuning parameters available are:

- Torque-Bias in % of max torque
- Km – Velocity difference gain
- Kpv – Proportional gain applied in the velocity loop
- Tiv – Integral time constant applied in the velocity loop
- Ktv – Total gain applied in the velocity loop
- Kpp – Proportional gain applied in the position loop
- Tip – Integral time constant applied in the position loop
- Ktp – Total gain applied in the position loop

Note: for advanced systems the Kpv and Tiv parameters may be made to fit a function vs. velocity instead of using a simple constant. This can be useful when the drive system is significantly non-linear across its operational range but should only be used when necessary as it complicates the tuning and testing of the system.

2.2.2.2 Antenna Performance Limits

Each antenna has velocity, acceleration and jerk performance limits that must be configured into the controller. Once the control loops have been tuned approximately to critical damping the actual response of the antenna becomes governed by the performance limits set. For example, when commanded to move from position A to B the controller will first accelerate at the antenna's set acceleration limit, then when the maximum velocity has been reached the antenna moves at that constant velocity until when approaching the final position, it decelerates to a stop using the deceleration limit (same as acceleration). Ideally the antenna comes to rest perfectly at the set position with no overshoot or undershoot. However, real-world dynamics, such as wind, may cause some minor overshoot or undershoot before the system achieves the final commanded position.

2.2.2.3 Degraded Mode

The dual motor control loop can operate in degraded mode when one or more of the motor systems is non-functional. This is done by simplifying the control down to the single motor control diagram, increasing the position deadband to prevent limit-cycling and reducing the gain of the control loops.

2.2.3 Ephemeris Pointing

Ephemeris means a set of positions associated with time used to describe the motion of a celestial object.

The 9000 Series supports three different modes of ephemeris pointing:

- TLE (Two Line Elements)
- IESS (Intelsat Earth Station System)
- Predictive – Internally generated

2.2.3.1 TLE and IESS

TLE and IESS ephemeris modes are discussed together because, though they are different formats for describing the orbit they operate in identical ways within the 9000 Series control system. These ephemeris types model the orbit of the target using sets of parameters to describe the motion. The models are valid from a particular time forward until a limit when the predictions of the model significantly diverge from the actual motion. When the model is too old to be considered reliable the 9000 presents a warning to the operator but will continue to follow the predictions.

Steptrack tracking cycles can be added to TLE and IESS modes to periodically or upon signal degradation track out the error that has accumulated in the ephemeris model.

When using TLE or IESS modes to follow a target the 9000 system continually updates the position based on calculating the current time from the ephemeris model. There is no stopping and waiting period before making new adjustments, though for very slow-moving targets the antenna may appear to be stationary.

2.2.3.2 Predictive

The predictive ephemeris mode is a model based on the results of previous steptrack convergence data. In this mode, initially the system is only collecting data by performing tracking cycles. Each time a tracking cycle converges on the target a new position set is entered into the predictive ephemeris model. Once enough data is collected to consider the model to be valid (24 hours) the 9000 begins to calculate results of the ephemeris model and continually update the position of the antenna in the same manner as when in TLE or IESS modes.

2.2.4 Steptrack

Steptrack is a basic but effective way of automatically calculating the target look angles based on sequential RF signal strength measurements.

The 9000 system uses a two-point calculation method to calculate the target location and several parameters to set bounds on the motion.

Because the RF signal strength measurement is inherently noisy the accuracy of the steptrack mode depends heavily on atmospheric and other signal related conditions.

2.2.4.1 Beam Pointing

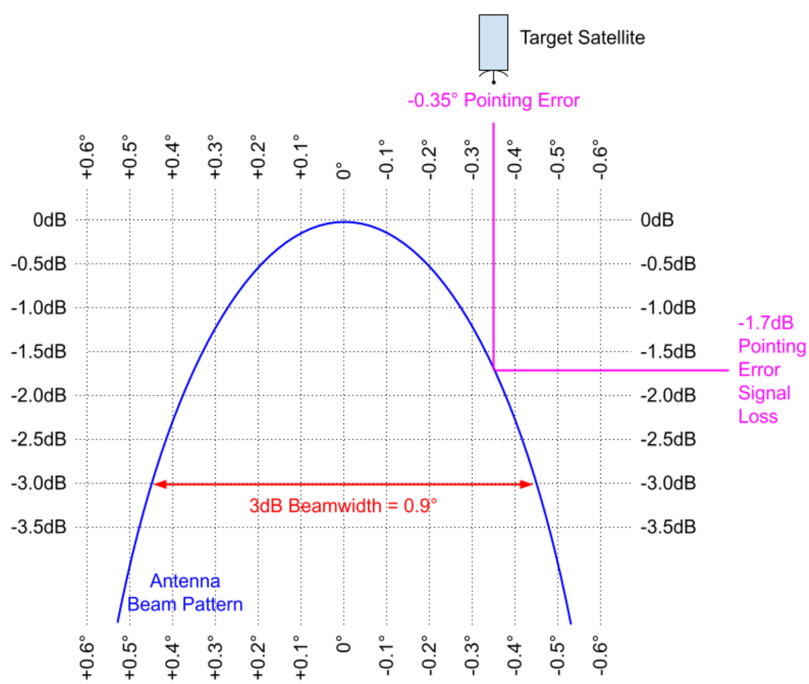


Figure 2-12 Beam pointing chart

To understand how steptrack works it is first necessary to understand the basic concepts of antenna beam pointing.

Parabolic satellite antennas have a characteristic beam pattern that is approximately parabolic close to the center of the beam where steptrack works. The "beam" in a steptrack system is not based on the energy transmitted by the satellite but is actually the gain in dB of the antenna vs. the offset in degrees from the beam center. The energy transmitted by the satellite is assumed to be constant but the received signal level increases or decreases due to the varying gain of the antenna as oriented in the direction of the satellite.

Note: the energy transmitted by the satellite is not actually constant, it can vary based on satellite operations such as modulation or automatic gain control. Additionally, the satellite energy transmission is affected by loss experienced during travel through the atmosphere due to several different functions. All these factors can negatively impact steptrack performance.

Antennas are also said to have a characteristic beamwidth. This is the distance in degrees from the -3dB points on both sides of the beam. In the example given it is approximately 0.9° (0.45° x 2). The beamwidth of the antenna is used in the steptrack calculations to characterize the beam pattern.

It is generally helpful (as illustrated in the example) to normalize the maximum gain center of the beam to read 0dB when pointed directly at a target, then any pointing offset is represented by a loss in dB (negative dB).

In the example given, the -0.35° pointing error results in approximately 0.7dB of signal loss (a signal strength reading of -0.7dB).

2.2.4.2 Steptrack Tracking Parameters

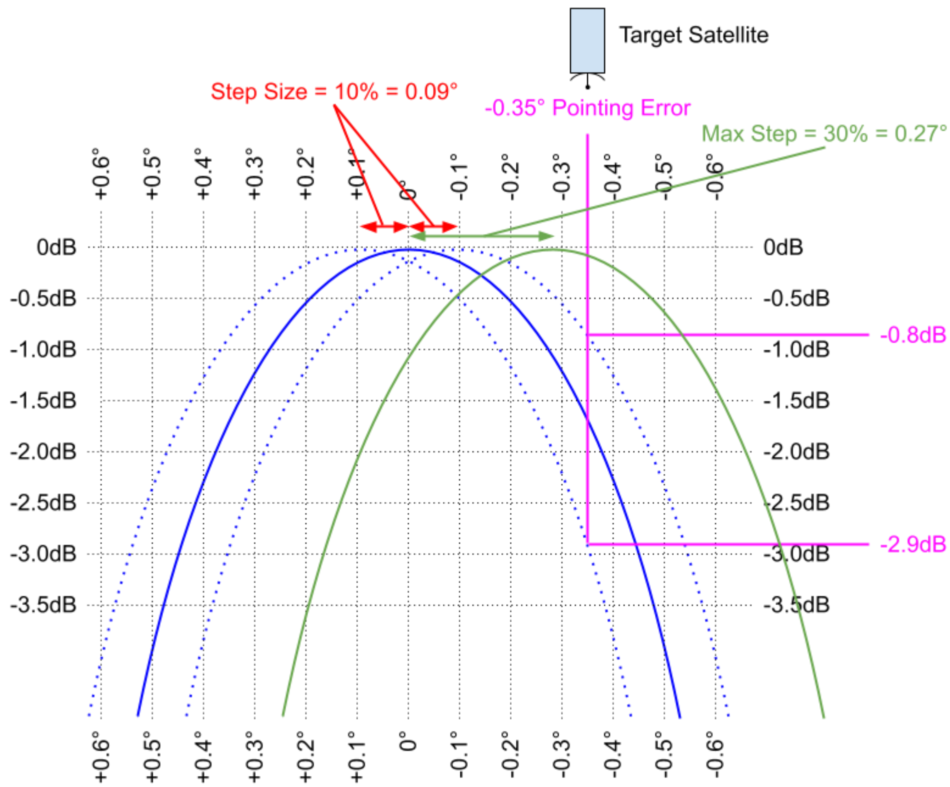


Figure 2-13 Steptrack parameters chart

During a steptrack cycle the controller makes two motions called measurement steps. These are made, one in each direction, the distance set by the user in the target settings called *step size*. 10% is a typical value. In the example presented, 10% of the beamwidth is 0.09°. The figure illustrates how the measured signal strength from the satellite changes at the step locations, one being -0.8dB and the other being -2.9dB. Using these two values and the stepsize the controller calculates the position of the target satellite and makes a motion in that direction. The motion is limited by the user settable parameter called *max step*. This limitation is made due to the noise and other factors that add error to the measured signal levels and can cause the calculation to be incorrect. In the example given, even though the target position is off by 0.35° the controller will only move 0.27° in the direction of the target due to the max step parameter set to 30% (0.27° = 0.9° x 30%).

2.2.4.3 Steptrack Tracking Convergence

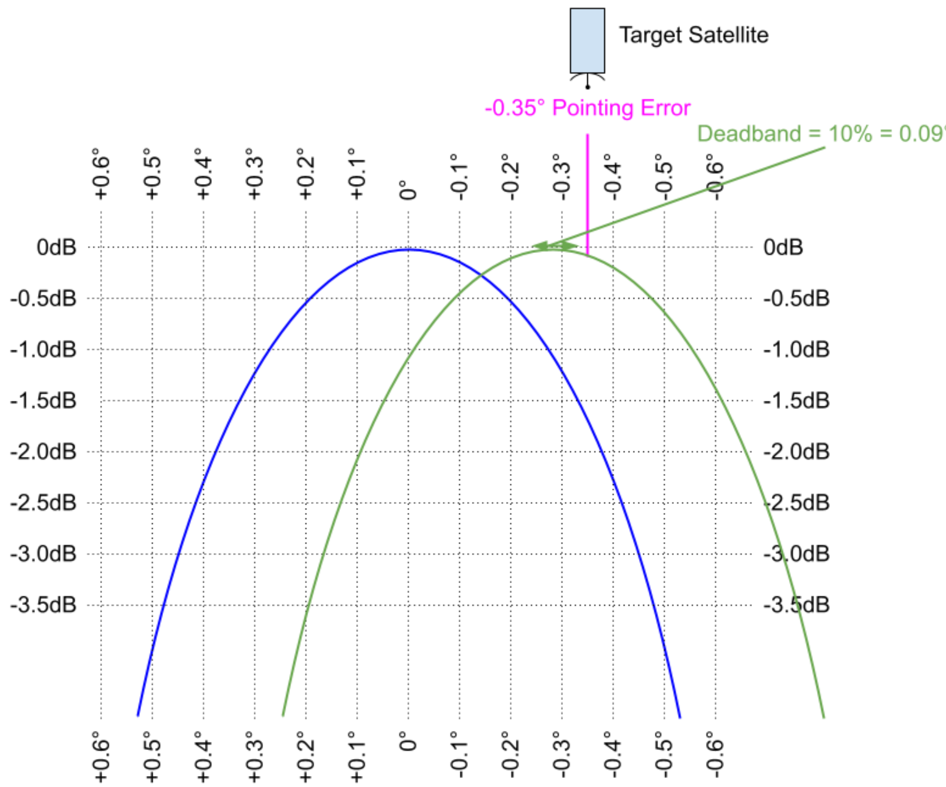


Figure 2-14 Steptrack tracking convergence chart

After the calculated correction step has been made the controller evaluates whether the pointing is within the tracking deadband (not to be confused with the control loop's position deadband). The deadband is set up by the user in the target settings and determines whether the tracking cycle has converged or not. If the calculated peak is within the deadband from the corrected angle, then the tracking is said to have converged, and the tracking cycle is finished.

If the calculated peak is still outside of the deadband then another steptrack cycle will be initiated to attempt to get closer to the peak unless the maximum number of steptrack cycles has already been attempted in which case the controller will abort the tracking cycle and park the antenna back at the original location. This abort can occur due to improperly set tracking parameters such as:

- Deadband is too small – due to noise in the RF signal and other factors it is impossible for the steptrack calculations to consistently be perfect. Therefore, the tracking deadband is needed to determine when the results have gotten *close enough* and stop the process.
- Max step is too small – max step is used to limit potentially incorrect steps that may be taken due to noise. However, if it is set too low then it will take too many steptrack cycles to reach the deadband and the tracking will abort.
- Max cycles is too small – max cycles are used to limit the number of steptrack attempts at getting to the peak because in very noisy situations it will not help and may be detrimental to continue attempting to track. However, in conjunction with the deadband and max step parameters, if not enough attempts are allowed then the tracking will abort.
- Step size is too small – step size is the primary limitation that the user has control over to impact the accuracy of the steptrack calculations. Larger step sizes will result in more accurate calculations and thus faster convergence to the deadband. Conversely, smaller step sizes will result in less accurate calculations which, if excessively so, can cause the tracking cycle to "wander" or "hunt" for the deadband but never find it due to the small step size and resulting inaccuracy.

2.2.4.4 Steptrack Tracking Interval

Since the steptrack measurement steps actually cause signal loss (remember the -2.9dB measurement from the example!) it is generally necessary to limit the frequency of the tracking cycles. The following parameters control the tracking interval:

- Cycle time – The time elapsed from the previous convergence or abort until the start of the next tracking cycle.

- Step below signal – A dynamic threshold for initiating a tracking cycle due to signal loss prior to the expiration of the cycle time.
- Follow model time (if in predictive mode) – The effective cycle time when following a predictive model.

2.2.5 Monopulse

2.2.5.1 Monopulse Radar Background

The terminology *monopulse tracking* used for satellite communications comes from a target tracking method developed for pointing radar antennas. The term *monopulse* refers to a method of transmitting a single pulse of RF energy and then waiting for the echo return of that pulse at the receivers. The receiving system would consist of 4 horns which would combine the received signal in such a way that from the single return pulse the tracking system could determine both direction and distance to the target.

2.2.5.2 Monopulse for SatCom

For monopulse in satellite communications there is no transmitted pulse, only a received signal transmitted from the satellite, but the name *monopulse* is still used to represent the tracking methodology. The

4 or 5 horn configuration is valid for satellite communications.

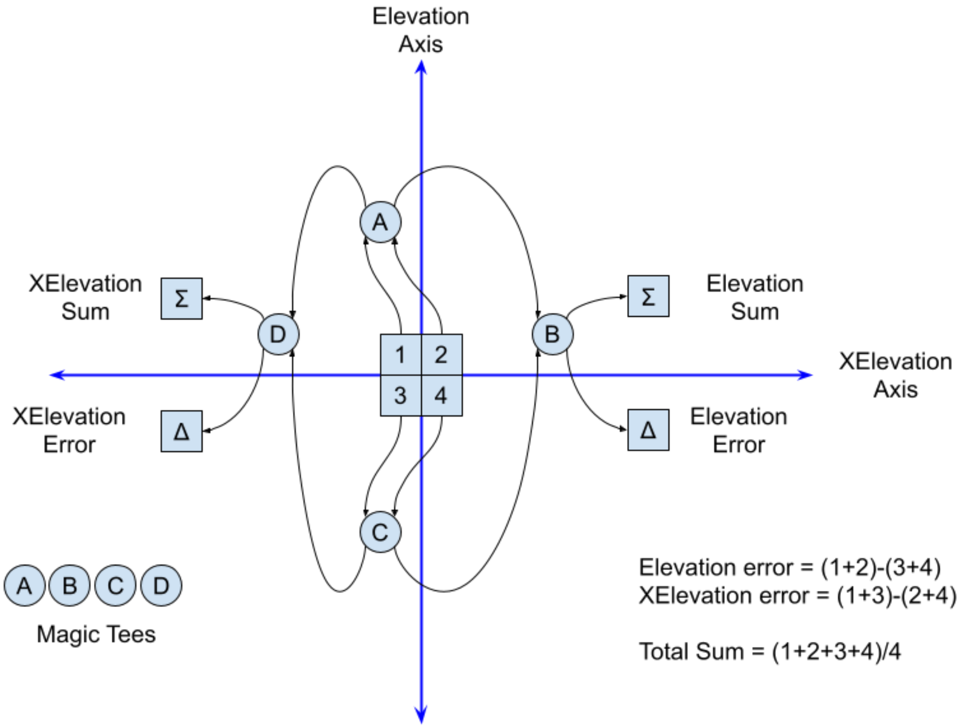


Figure 2-15 Monopulse 4-Horn Feed

A second common approach used for monopulse tracking in satellite communications is to add a TE21 coupler to the communications (COMM) feed network. There are other types of couplers that can be utilized for monopulse but the TE21 with 8 coupling slots is most common as it provides good results for tracking both Circular and Linear polarized downlink signals. Tracking is performed similarly to the 4 horn while minimizing the loss of signal on the comm channel.

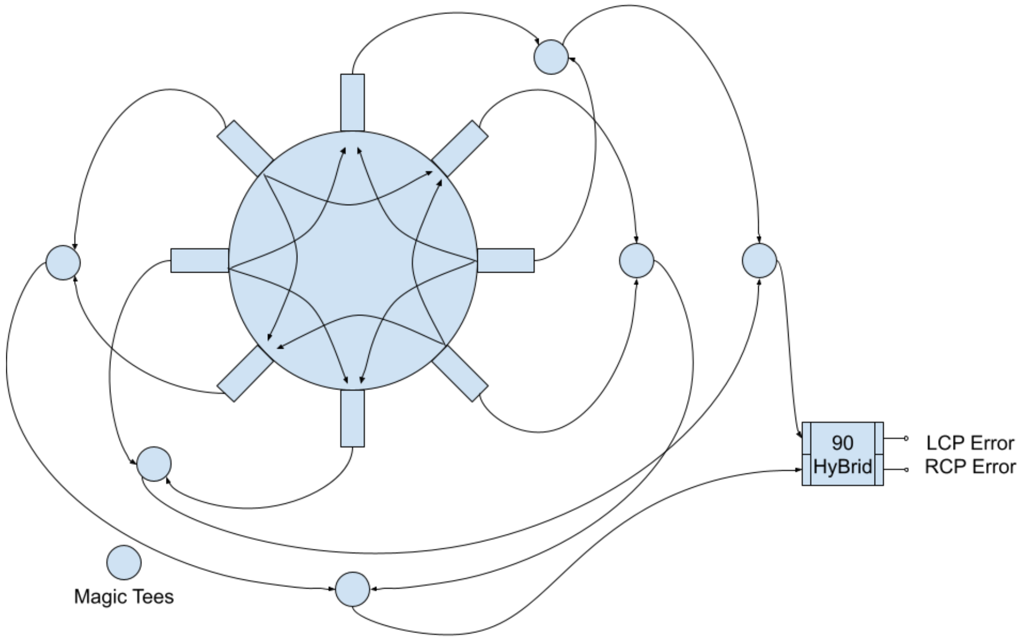


Figure 2-16 Monopulse TE21 Coupler

The TE21 hardware is a circular device. It can be utilized for receiving both Linear and Circular polarized signals from a satellite. When used for tracking a linear polarized signal (Horizontal or Vertical) both signals will be accessible on either "error" port from the 90 degree Hybrid. However, when tracking Circular polarization then one port will be Left Hand CP and the other will be Right Hand CP. It is always important to verify that the error ports are properly identified.

When the feed system consisted of 4 horns for reception the horns were mounted to calling with the Elevation and X-elevation axis. The nice result of this is the two error signals come out exactly on the EL axis and the XEL axis.

With the TE21 coupler that alignment is lost. It is possible to configure (rotate) the coupler into a position where the output errors are aligned with EL and XEL moment, but it is not always practical. For one the error coupler is often large and heavy. The other issue is the alignment will change with a frequency change. So, most of the time the error coupler is fixed and only the feed horn moves if the signals are linear and Horizontal/ Vertical polarization adjustment is needed to optimize signal levels. This means that a means to calibrate the tracking signal errors to the axis motion is needed in the control system.

2.2.5.3 Monopulse Tracking Signals

The goal of the TE21 coupler network is to create an "error" channel pattern. That is a pattern that is nulled exactly below the peak of the sum (reference) channel pattern.

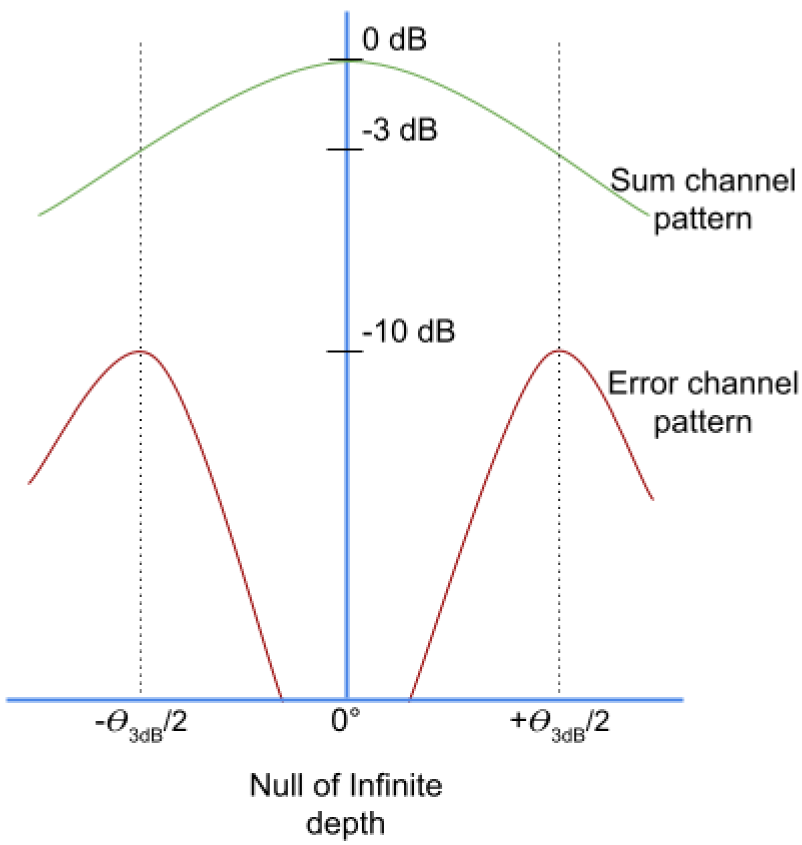


Figure 2-17 Monopulse tracking error channel null

In operation as the horn aperture becomes larger, the "reference" (sum) channel pattern becomes narrower, and the "error" channel pattern peaks come closer together. As such the slope of the pattern toward the axis will become steeper. The sensitivity of the error pattern will increase as the slope into the null increases. The logarithmic "db - scale" would theoretically show an on-axis null of infinite depth with respect to the 0 dB reference pattern maximum. In practice the on-axis value for the null will reach a measured depth of only 40 or 50 db below the reference pattern peak.

The error pattern is interpreted by the monopulse tracking receiver as a voltage pattern for use as a tracking reference. As the target moves off axis the receiver generates the relative error voltage used by the drive system to return the antenna to the "on target" position. The error pattern passes through zero volts at the null and changes sign. Thus, a monopulse tracking system is not actually tracking to the peak of the reference (or Sum) signal, it is tracking to the null of the error signal as represented by the zero-voltage point. The depth and location of the null of the error signal will vary depending on the accuracy of construction of the feed. Sometimes the null is shifted slightly off the reference peak. The feed test data should indicate this shift and how much.

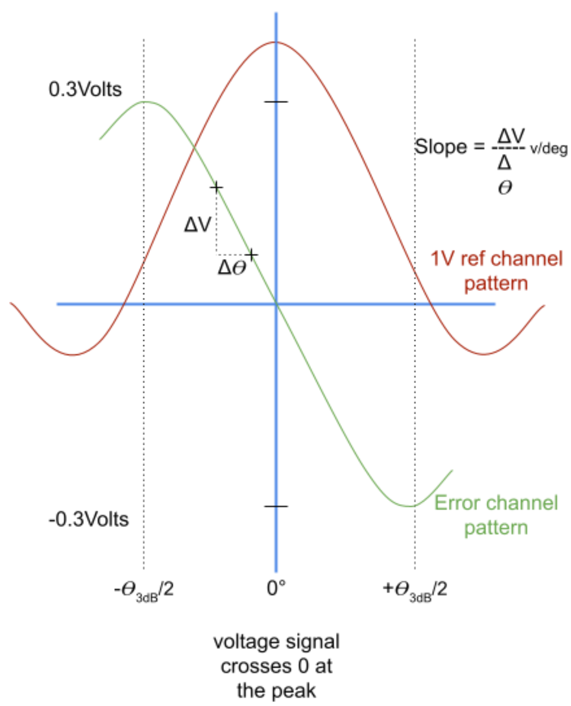


Figure 2-18 Tracking the error channel to the 0-voltage point

2.2.5.4 Two Channel vs. Single Channel

There are two approaches generally available in the market to create tracking information from the sum and error outputs. The older approach is to use two receivers, one for each signal sum and error. Depending on who you talk with this approach is "Monopulse" or also known as "Two Channel Monopulse" tracking. The second approach is to combine the sum and error signals, while manipulating the error signal with a phase shifter and then only use one receiver to recover the signal. This approach has been called "Pseudo-Monopulse" or "Single Channel Monopulse". Like most technical approaches there are tradeoffs between the two approaches. The selection of one over the other will be determined by customer specifications and cost expectations. In general, the single channel approach is lower cost, as in the past the two channel receivers have been very costly. From a performance point of view the single channel can have a slower update rate but often tracking accuracy to null is comparable with the two-channel receiver tracking. Both approaches can utilize the TE21 coupler.

2.2.5.5 Two Channel Monopulse

The two-channel receiver is a term that indicates that at a minimum there is a receiver for the reference signal and a separate receiver for the error signal. There may be more receivers as there are often two reference signals available. It is also possible to "track" polarization in a linear system when the target is in inclined operation.

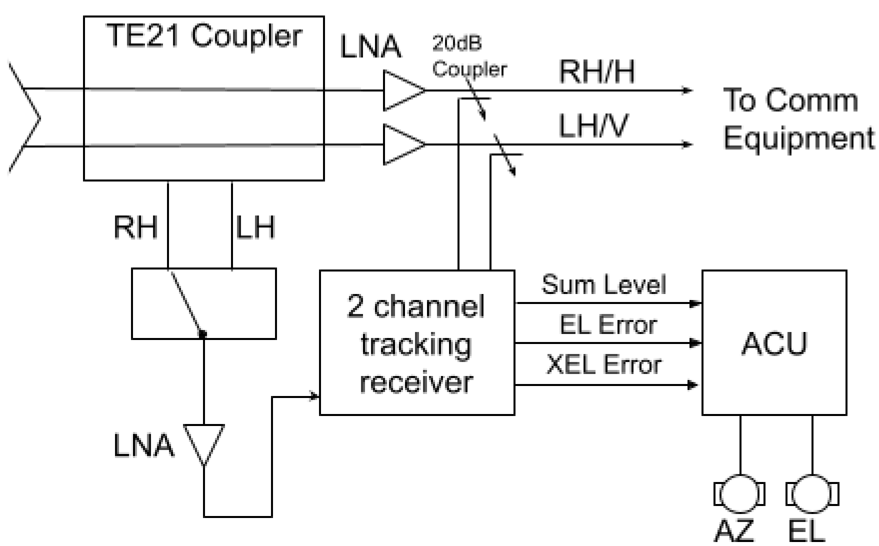


Figure 2-19 Two channel monopulse diagram

The reason for the high cost of the two channel monopulse receiver is that at least one receiver must be able to output a signal level at very low input power levels. For example, if the input Sum level is -90 dBm power input levels the error signal at "null" could be about -140 dBm. Normally a very narrow resolution bandwidth will be needed to achieve these measurements along with a very low residual FM. With the receiver operating with a narrow resolution bandwidth (<1kHz) for a very low signal any drift of signal frequency could cause the signal to be lost - and the error recovery would not be able to detect it. So normally the lock of the receiver on the reference signal is used to also drive the tuning of the error receiver.

For two channel tracking the tracking slope is defined by the output of the TE21 coupler. Because of that the tracking slope is fixed. The manufacture of the monopulse tracking receiver should define the method of calibrating the receiver to the feed for operation.

Generally, it will consist of:

- pointing the antenna at a target which could be a bore site tower or a satellite with minimal motion.
- peak the reference signal to get near to error signal null.
- then adjust pointing to minimize error signal - this becomes the reference peak location
- Move dish off in one axis only a prescribed distance - this sets signal level change to distance and also sign adjustment.
- Return to ref peak location
- Move dish off in the alternate axis a prescribed distance - set signal level change for distance for second axis along with sign adjustment.

2.2.5.6 Single Channel Monopulse

For single channel monopulse there is only one operational receiver that will be recovering signal power from a combined “synthetic” beam.

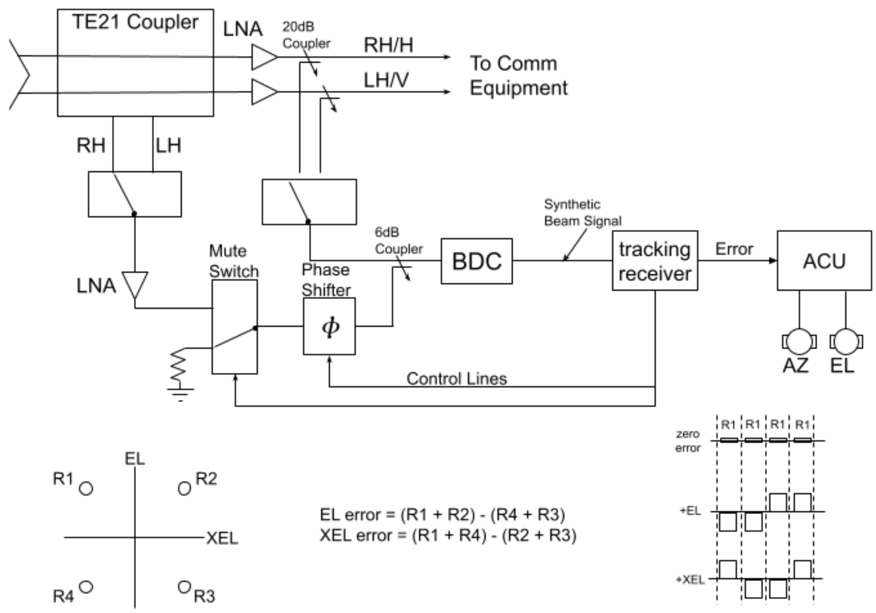


Figure 2-20 Single channel monopulse diagram

The monopulse tracking feed is equipped with a TE21 mode coupler to supply error pattern signals to a track channel. This coupler produces an error output signal with amplitude proportional (to the magnitude of the arrival angle of the signal) and relative to the line of sight of the antenna beam. The phase of the error signal relative to the phase of the sum signal is proportional to the direction of this arrival angle relative to the rotation position of the feed. For example, with proper phasing, the error signal can be made to be in phase with the sum signal for an AZ error to the right and it will be 180 degrees out of phase for an AZ error to the left. At the same phasing, the difference might be 90 degrees for an "up" error and 270 degrees for a "down" error.

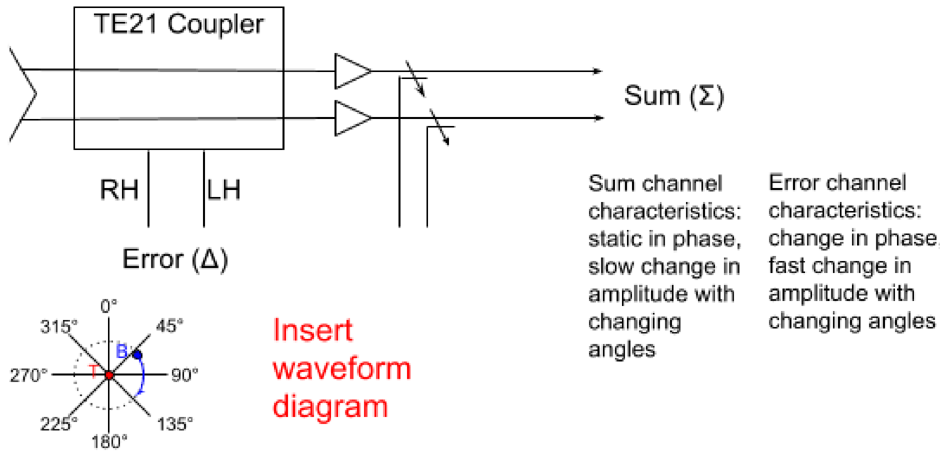


Figure 2-21 Monopulse error signal chart

If the error signal is phase shifted and combined with the sum signal, the peak of the composite signal is shifted relative to the antenna line of sight in the direction where the error signal and the sum signal are in phase. The phase shifter affects this direction. With the phase shifter commanded to zero phase shift, the rotation direction of the peak is determined by the net phase shift between the sum channel path and the error channel path. This net phase shift is referred to as the reference phase.

For monopulse tracking utilizing this arrangement, the tracking receiver will command the phase shifter through repetitive cycles of 0, 90, 180, and 270 (and back to 0) degrees. This action generates a (synchronously modulated) scan pattern; the pattern is a square in the plane normal to the antenna line of sight. The sum and difference patterns and the relative gain between the sum and difference channels determine the size of the square. So, by changing attenuation in the sum path before combining with the error path the tracking slope can be adjusted. The orientation of the pattern in rotation about the line of sight is determined by the reference phase defined above.

It can be shown that the reference phase establishes the rotation of the scan pattern about the line of sight, e.g., a given reference phase might place the beam position with the 0-degree output at 37.5 degrees CCW from horizontal to the right. A 100-degree change in the reference phase would then place the beam at 137.5 degrees CCW from horizontal or at 62.5 degrees CW from horizontal. Accordingly, the correction for the reference phase is simply a coordinate rotation that is a function of the front-end configuration and the track signal frequency.

A calibration procedure (which can be performed while the communication system is on-line) is needed to determine the value of the reference phase correction and the effective scan pattern size for each configuration. The calibration results should be stored in the ACU in a database that also logs RF path and tracking frequency. Calibrations are unique to each frequency/RF path configuration.

Synchronous demodulation of the signal level variations produced by the scanning of the synthetic beam is performed in the tracking receiver. This demodulation process not only provides the required two orthogonal error signals, it also performs a very effective filtering (signal variations with a frequency significantly different from the scan frequency will have little effect). The demodulation process is performed by software after application of the corrections described above for both net gains between the sum and difference channels and the loss variations from the phase shifter. After the demodulation, the coordinate rotation for reference phase and the secant correction of the AZ error signal is performed and the results are routed to the ACU for AZ and EL antenna corrections.

2.2.5.7 Monopulse Target Acquisition

Tracking a monopulse target consists of acquisition, peak detection, autophase adjustment, and tracking:

- Acquisition of a monopulse target can be performed using Move to Look Angles, Move to Longitude, TLE (SGP4, or IESS.
- Peak detection is performed using a cross scan to minimize the monopulse error vectors.
- Autophase adjustment is performed using the built-in feature of the monopulse tracking receiver, if equipped, or by adjusting receiver parameters to minimize phase errors that will degrade monopulse tracking performance.
- Tracking is performed by following the error vectors received from the tracking receiver to continually maintain a peaked condition on the target.

2.2.5.8 Monopulse Target Tracking

For all of the complexity that goes into receiving, transforming, acquiring, phase adjusting and calibrating the monopulse tracking signal – once it is complete the actual tracking is surprisingly simple. The tracking error signals represent the distance from the current angle on each axis to the peak location. Due to noise and other errors in the system this is only an estimate and requires filtering.

The 9000 monopulse position estimation function consists of two filters:

- Error Vector Filter
- Estimated Position Filter

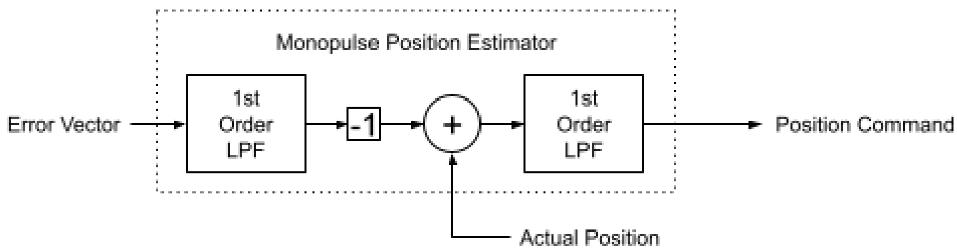


Figure 2-22 Monopulse position estimator

Filtering the error vector reduces noise but will increase pointing errors due to decorrelating the vector from the actual pointing angles in time. Note that the error vector filter is applied before the error vector is subtracted from the actual position. Due to this, a relatively high cutoff frequency is recommended, typically 1-2 Hz.

The estimated position filter is applied after the error vector is subtracted from the actual position so it is correlated to the position signal and does not cause the same pointing errors as the vector filter, however it will cause the estimated position to lag behind the actual target so it should be set with the expected target velocity in mind. Typically, 0.5-1.0 Hz is a good value.

These are both single order low pass filters of user selectable cutoff frequency. The cutoff frequency represents the frequency where the input signal is attenuated by 3dB. Frequencies above will be attenuated further. In time, the cutoff frequency (Fc) corresponds to what is called a time constant (Tc): Fc (Hz) = 1/(2πTc(s)). The time constant, in practical terms, is the time the output takes to rise to 63% of the input value in a step function. The output reaches 95% of the input value after three-time constants.

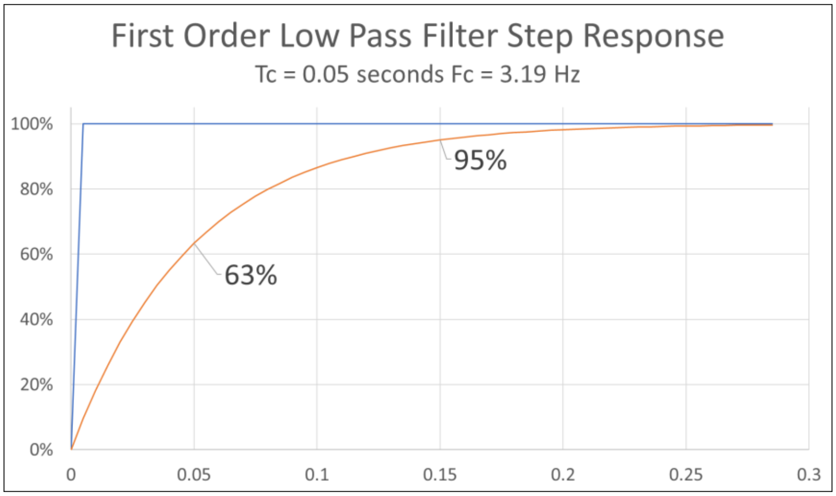


Figure 2-23 First order low pass filter step response

When setting the value of the estimated position filter the operator should consider how fast the target is moving and how much tracking error is acceptable. Often it is easiest to determine the optimal values by experimentation.

2.3 Operation

2.3.1 Overview

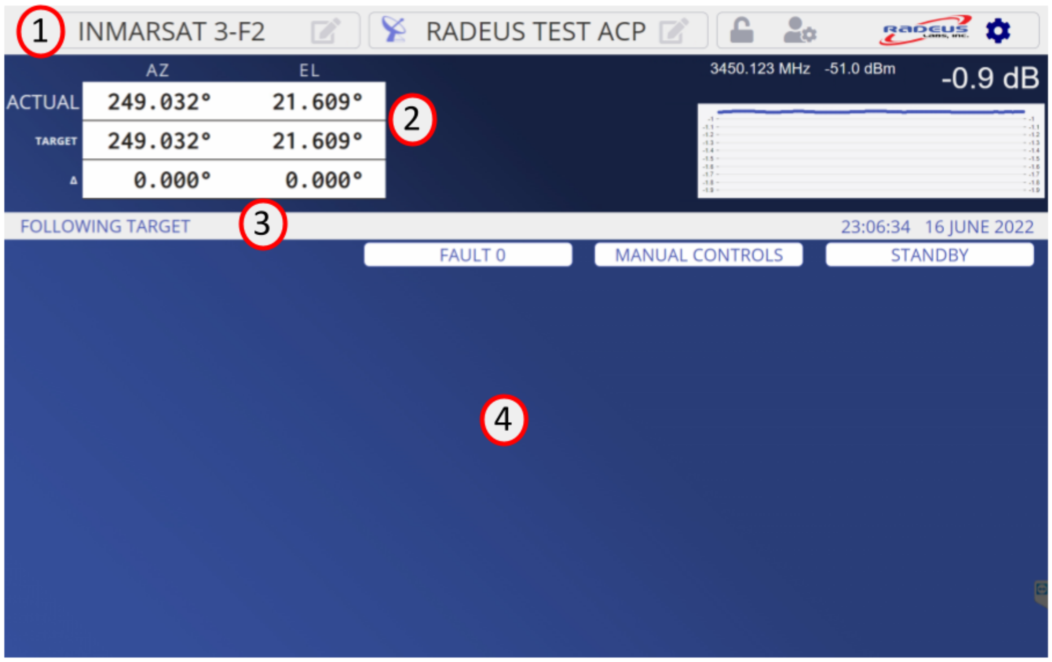


Figure 2-24 ACP screen

The 9000 ACP screen is divided into 4 zones:

(1) The menu bar

(2) The real-time display

(3) The status bar

(4) The operation and configuration zone

During periods of no interaction the system will go into a mode called FarView that makes the Actual angles and the Signal chart larger and easier to see at a glance.

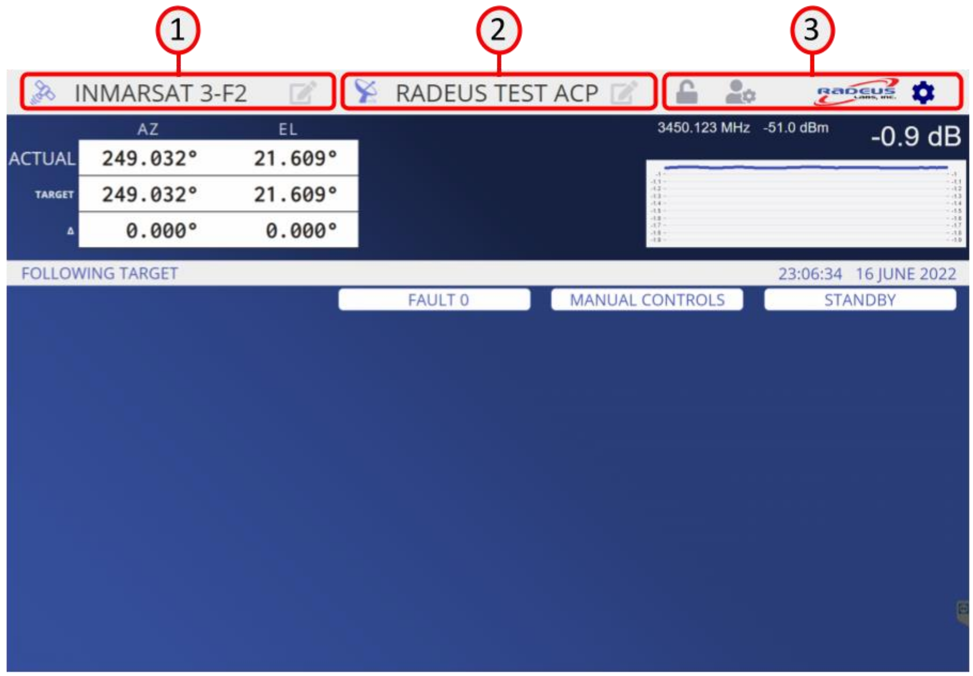


Figure 2-25 Web Interface - home screen

The menu bar of the display screen provides buttons to access to all of the system settings for (1) target menu, (2) antenna menu, and (3) ACP menu.

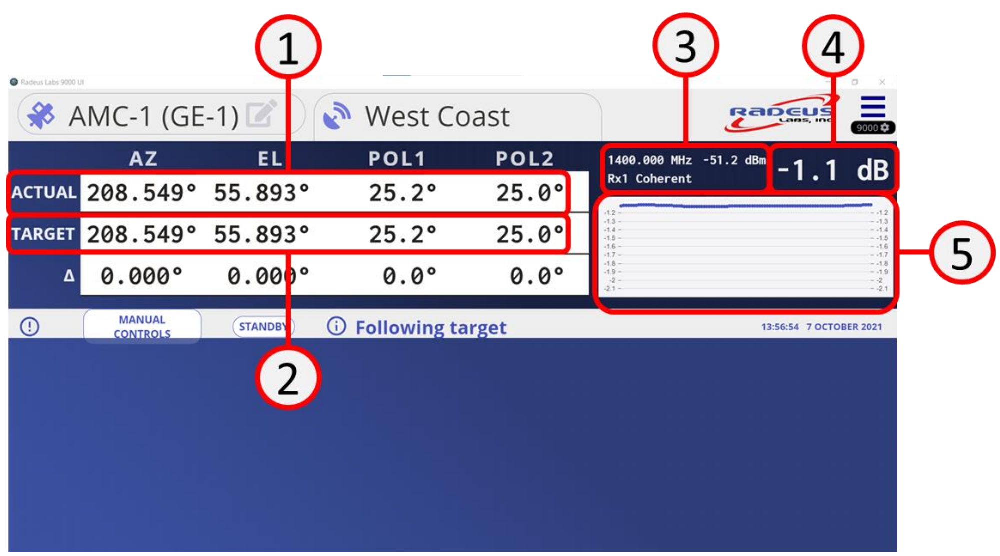


Figure 2-26 Web Interface -real-time display

While tracking, the real-time display will always show the current antenna position, the commanded position, and the difference between those 2 values. While the unit is in standby, the real-time display will always show the antenna position and the mechanical position.

1) The actual axis angles, (2) the mechanical angles or target angles depending on the operating mode, (3) the RF frequency, input selection and signal level, (4) the relative signal level and (5) a signal level history chart.

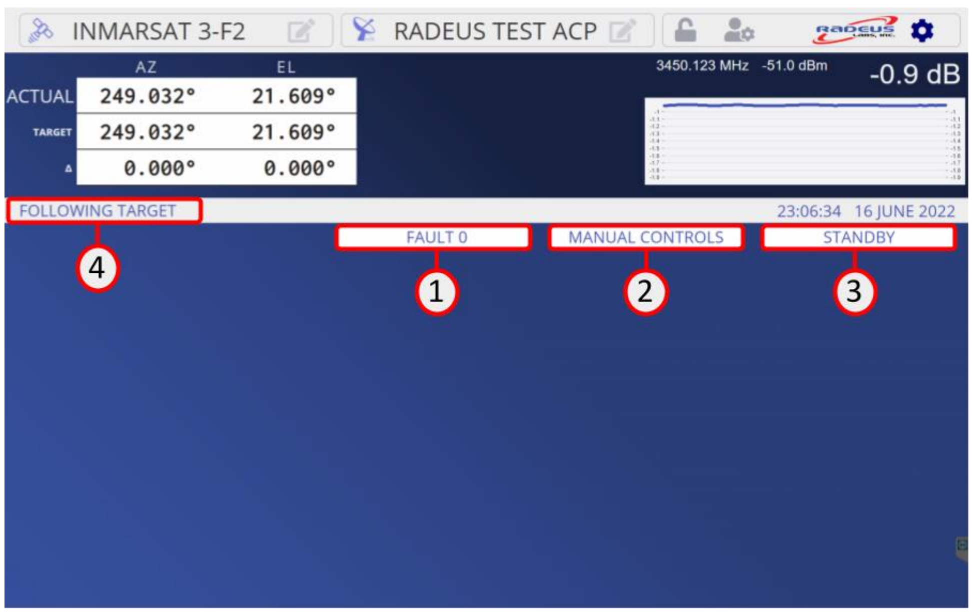


Figure 2-27 Web Interface - status bar

The status bar provides (1) a summary fault indicator, (2) a button for entering manual control mode, (3) a button for executing the standby command and (4) informational status messages.

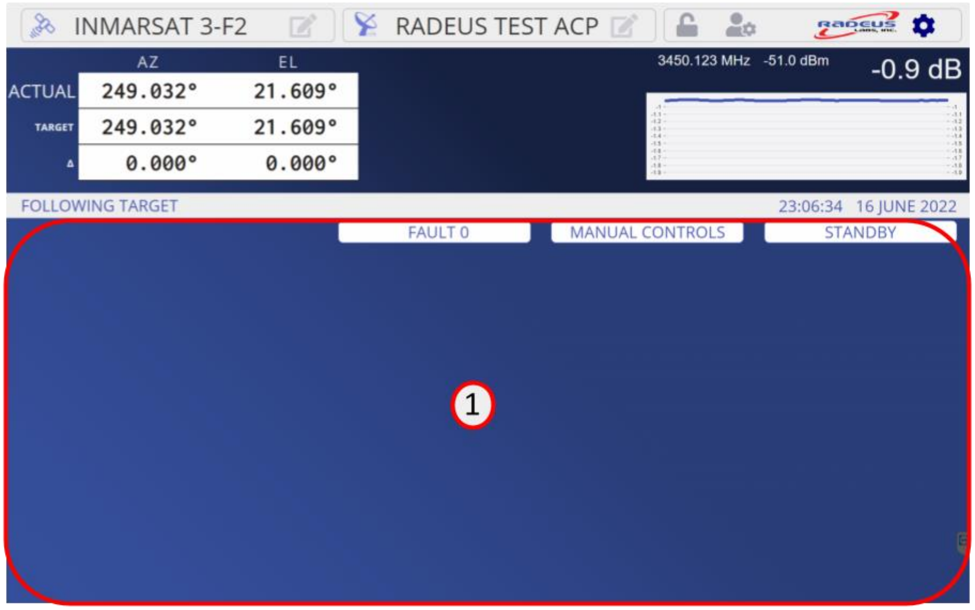


Figure 2-28 Web Interface - operation and configuration zone

The (1) operation and configuration zone shows various screens depending on what the operator is doing: Target setup, operation and diagnostics; Antenna setup and diagnostics; Utilities; Manual controls.

2.3.2 Antenna Settings

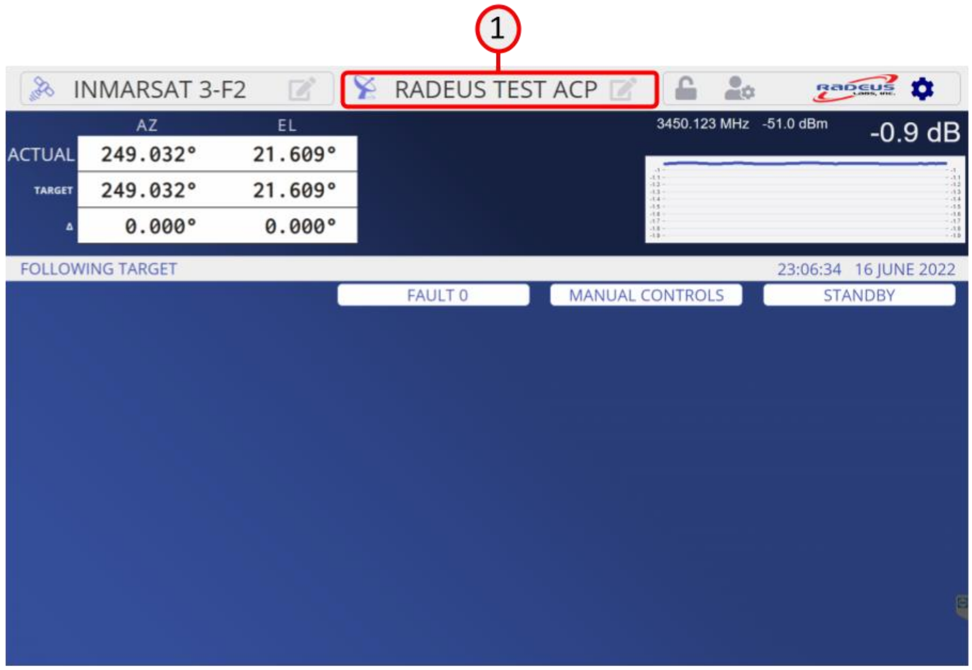


Figure 2-29 Web Interface - antenna settings

Figure 2-31

Press the (1) antenna button on the menu bar to set up the antenna settings.

2.3.2.1 Site tab

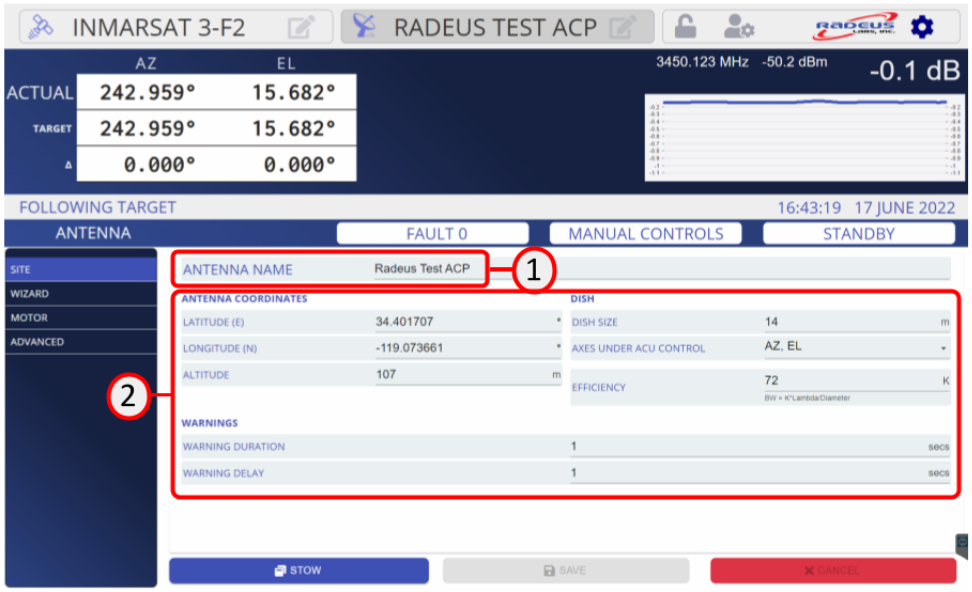


Figure 2-30 Antenna > Site
Setup for *required settings specific to the antenna.*

(1) Name the antenna to distinguish it from other nearby systems. This name will appear on the touchscreen display.
(2) On the Antenna Site tab:

- Enter the antenna's latitude (degrees north) and longitude (degrees east), using up to six decimal places.
- Enter the antenna's altitude (meters).

Enter the dish size (in meters, to the tenths).

Note
In this document, screenshots may illustrate a system with one, two, or no polarization axes.

- Enter the axes under control:
    - AZ, EL
    - AZ, EL, POL1
    - AZ, EL, POL1, POL2
- If a POL axis is selected, then enter the CP/LP Selection:

- None
- POL1
- POL1, POL2

- If a CP/LP control is used then enter the switching timeout. The switching timeout defines how long the SCU allows for the CP/LP controller to switch between settings before generating a fault.

2.3.2.1 Options tab

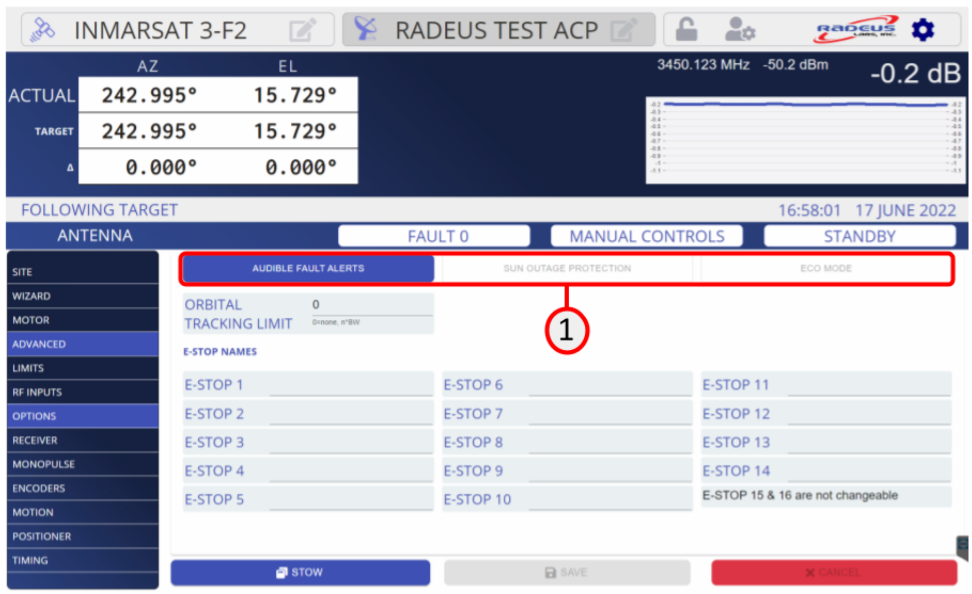


Figure 2-31 Web Interface - Alerts tab

(1) On the Antenna Options tab:

- *Audible fault alerts*
  Choose whether the ACP will emit audible alert tones, in addition to the visual alerts on its display, when a fault is detected.

- *Sun outage protection*
  Prevents steptrack operation if the beam width is pointing within 0.25° of the sun.

- *Orbital tracking limit*
  Constrains antenna control maneuvers to match the analemma trajectory of the target satellite (see **Figure 2-34**). When tracking a target whose trajectory brings it close to other satellites, orbital tracking limits can help avoid tracking nearby satellites unintentionally.

  The orbital tracking limit is measured in factors of the antenna 3dB receive beamwidth (n*BW). For example:

  - An orbital tracking limit of factor 2 and receive beamwidth of 0.27° would constrain tracking maneuvers to a maximum offset of 0.54° from the target trajectory.

    Orbital tracking limits is a system-wide option *and applies to all tracking modes*. These limits are disabled by default (factor 0); the maximum value is 9.

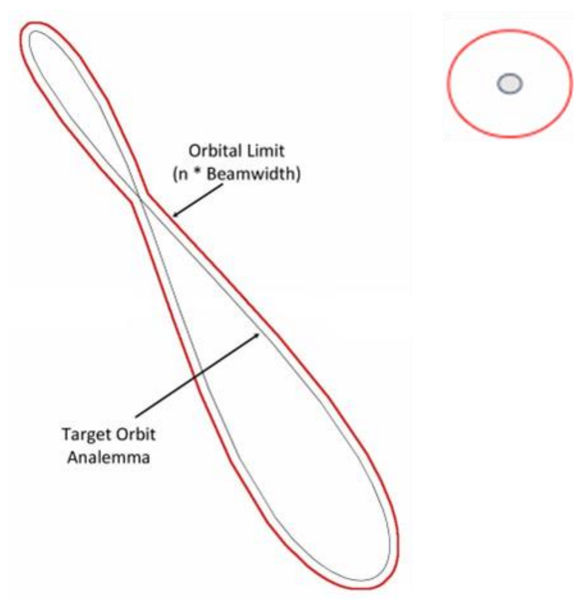


Figure 2-32 Orbital tracking limits constrain antenna maneuvers to the *analemma trajectory* of the GEO target satellite. This can help avoid accidentally tracking any other nearby satellites.

2.3.2.3 Receiver tab

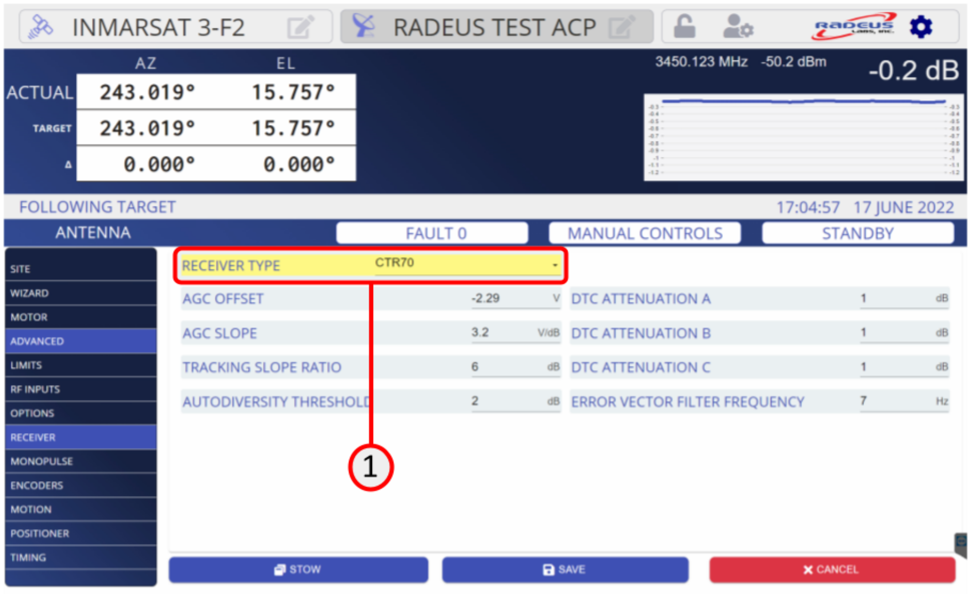


Figure 2-33 Setup > Receiver
For each axis, the *encoder angle* plus its *offset* equals the actual *look angle* (Encoder Angle + Offset = Look Angle the type of receiver being used, if any.

(1) On the Antenna Receiver tab select the type of receiver that is in use. Each receiver type has unique settings to configure which are explained in appendices at the end of this document.

2.3.2.4 Monopulse tab

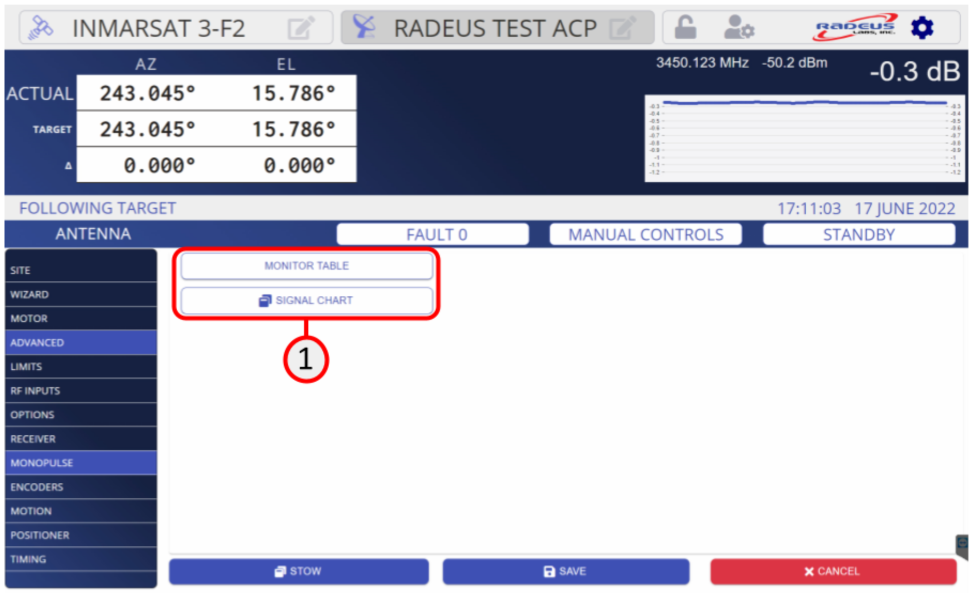


Figure 2-34 Setup > Receiver
Specify the type of receiver being used, if any.

(1) On the Antenna Monopulse tab there are functions for diagnostics. The available functions depend on the type of monopulse receiver that is selected and are explained in appendices at the end of this document.

2.3.2.1 Encoders tab

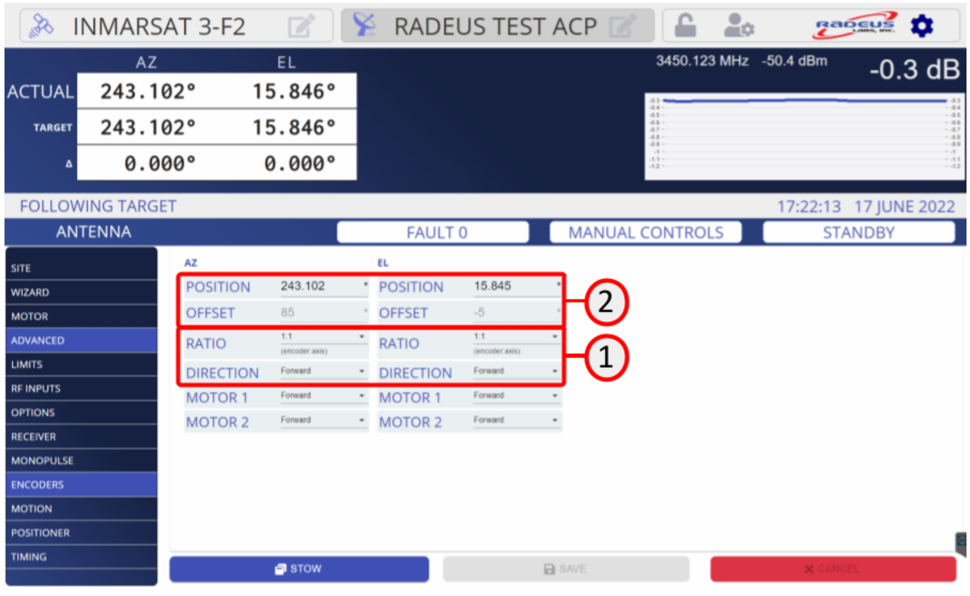


Figure 2-35 **Setup > Receiver**
For each axis, the *encoder angle* plus its *offset* equals the actual *look angle* (Encoder Angle + Offset = Look Angle **the type of receiver being used, if any.**

Required
A position and direction must be entered for each encoder or resolver.

Note: no position values can be entered unless resolvers or encoders are present.

On the Antenna Encoder tab there are fields for configuring the encoders for each axis.

(1) For each axis, select the encoder direction and ratio. The direction is Forward if a clockwise or up axis motion generates a clockwise turn of the encoder shaft. Encoder shaft direction is evaluated when looking at the face of the encoder, not at the rear of the encoder.

Radio defines the number of encoder/resolver-shaft revolutions for antenna movement along each axis:

- *Default ratio is 1:1*
- *Maximum ratio is 8:1*

(2) For each axis, the encoder offset must be generated.

1. Use the jog controls to point the antenna to a *known or referenced* look angle (e.g., a known satellites or star's position, true north, or the horizon).

2. If the angles are unknown and there's no reference, measure them with an inclinometer, tilt sensor, level (EL), or compass (AZ).

3. Enter the angles into the Encoders > Position (deg) fields. The ACU will populate the offset fields

2.3.2.2 Celestial Body mode

The ACU allows pointing and following a few predefined celestial targets as well as the option to point and follow a custom celestial body based on ephemeris data.

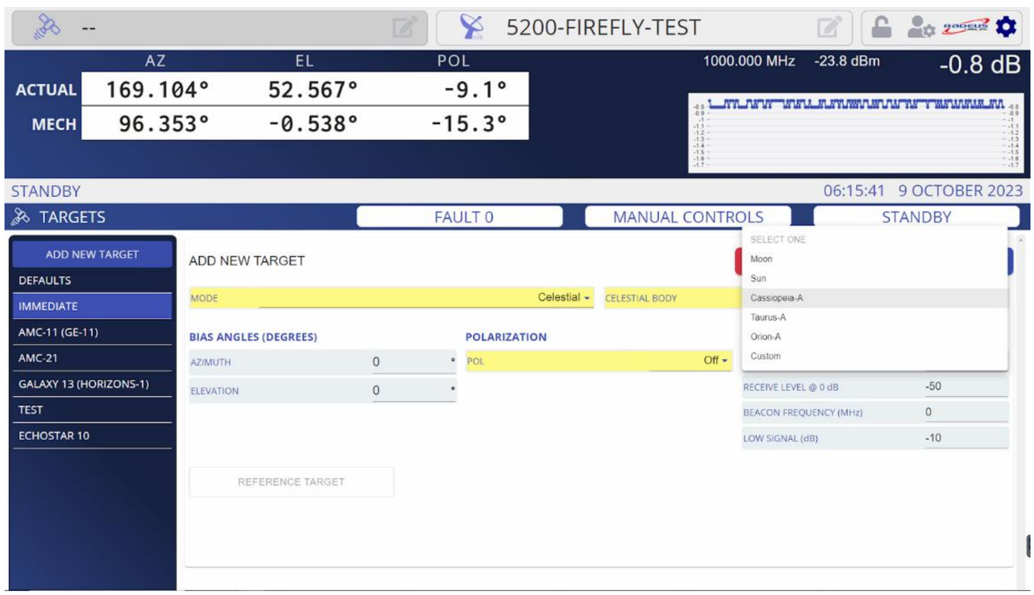


Figure 2-36 Predefined celestial targets

The custom option allows the user to define a custom target based on J2000.0 epoch right ascension and declination (RA/Dec). The target must be a deep-space object with a distance sufficiently far enough to not be a consideration (distance will be assumed to be infinite).

As with all targets, bias angles can be defined for the custom target. The target can disable the RF input or allow for the selected RF Input signal to be monitored during pointing/following.

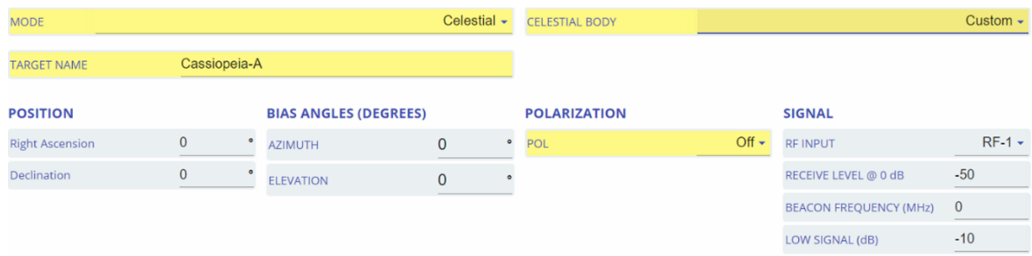


Figure 2-37 RF Input

2.3.2.3 Wizard tab

⚠ Warning
Do not run the Setup Wizard without working limit switches in place on every axis. *Otherwise, the antenna will drive into its hard stops and damage and/or injury may occur.*

⚠ Caution
While the wizard runs, the ACU drives the antenna to determine optimal operating parameters along each axis. The antenna will be in motion a number of times during this operation. *Even if it pauses, motions may resume until the Setup Wizard concludes.*

The Setup Wizard (see warning notes) can be used to perform the following tasks:

- Find the position of travel limits on each axis.
- Measure the gear ratio for the AZ and EL axes. This is used in the velocity control function of the controller.
- Measure the motion parameters to be used on the POL axes if present.

All settings determined by the Setup Wizard can be edited by the operator if needed to further optimize the system.

The Setup Wizard may be useful…

- after installing and connecting the ACS
- after significant changes to antenna or drive hardware
- to verify the integrity of a system experiencing issues

2.3.2.4 Requirements, before the Setup Wizard

- The Model 9000 must be installed and connected properly.
- BE SURE ALL LIMIT SWITCHES ARE TESTED AND WORKING CORRECTLY — ON EVERY AXIS.
- The antenna must not be tripping any limit switches.

- Encoder offsets must be established for each axis (see section 2.3.2.3 about Setup > Encoders).

2.3.2.5 How the wizard works

Setup details
To view or edit settings determined by the Setup Wizard, browse the 9000's Antenna tabs.

⚠ **Required:**
all limit switches must be in place before running the Setup Wizard.

The Setup Wizard will move the antenna through its full range of motion — in both directions, along each axis — until it has hit all the hardware limit switches.

When the system detects a pre-limit switch, it backs away from it by two degrees. That new position is the *default soft limit* for that direction on that axis. *Soft limits can be edited or even disabled on the Antenna Limits screen.*

After the Setup Wizard discovers hardware limit switch positions and establishes soft limits for each axis, it measures the axis deadband and gear ratio.

For the POL axis, it moves back to center to determine the angles and periods of the motion faults, and the threshold and deadband for the positioner parameters. It also will calibrate the bump and coast times.

2.3.2.6 Run the wizard

How long will it take?

Precise times are antenna-specific. Expect the Setup Wizard to take the time needed to exercise the antenna fully, along each axis, and to perform any other tasks as described.

First, complete the Setup screens for Site, Options, and Encoders, *and verify the wizard requirements,* above.

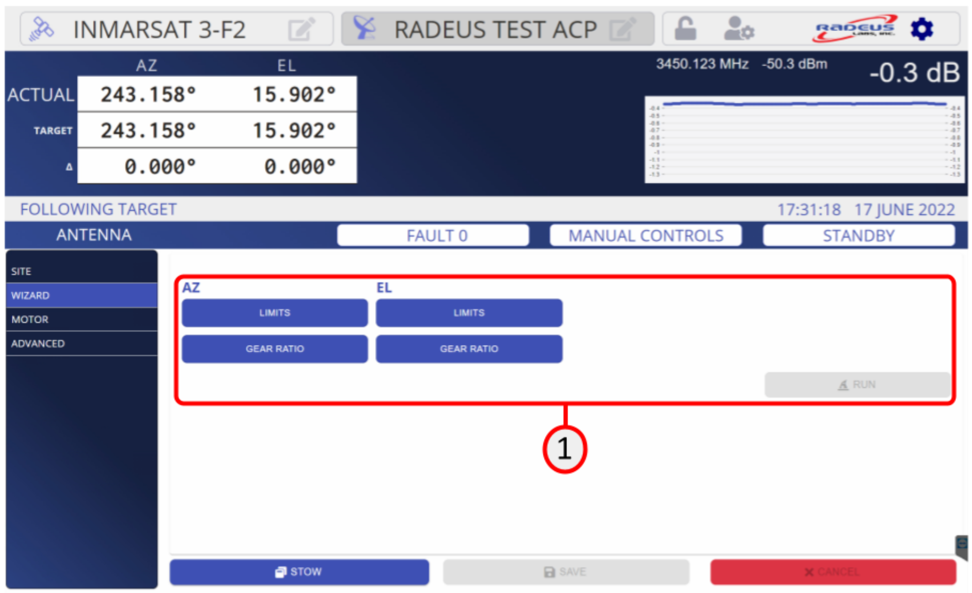


Figure 2-38 An ACU operator must confirm before the Setup Wizard will run.

(1) Select each function that you desire to run. For example, it is not necessary to run the POL limit detection if the POL axis limits are already known.

Select the RUN button.

The wizard will exercise the antenna's full range of motion along each axis, and more tasks, to detect vital characteristics. It will report in the blue status bar, for example:

> "Running setup wizard — Seeking AZ CW limit"

When the Setup Wizard has finished, the system will go into Standby.

2.3.2.7 Limits tab

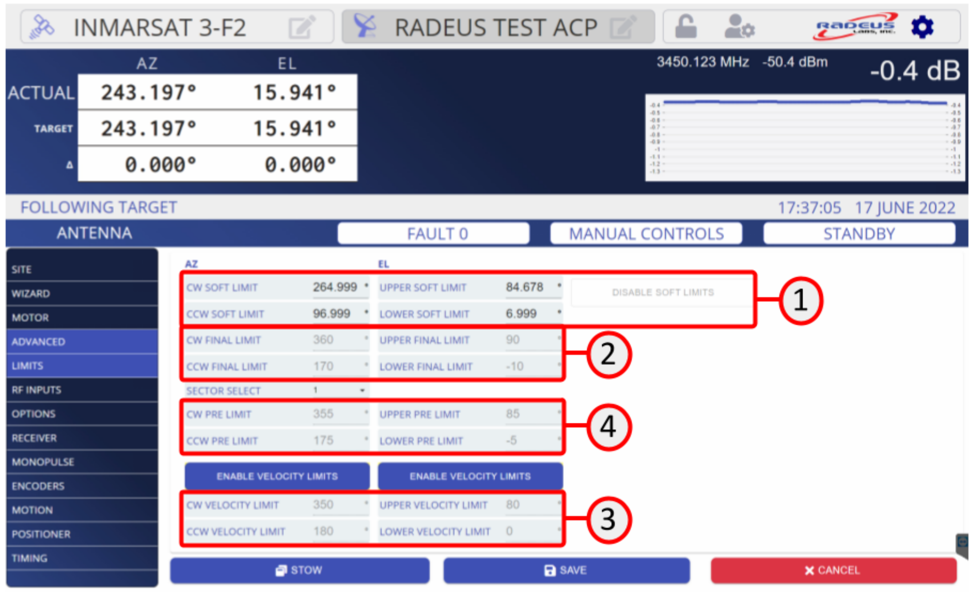


Figure 2-39 Setup > Limits, and the Setup Wizard. See below to add the field for setting up *sectors*.

The Setup Wizard finds the location of the final limits, pre limits and velocity limits. The values can be edited by the operator if needed, for example if the position of the hardware switch is changed, however, it is recommended to run the Setup Wizard again after any change to the limit switch positions.

⚠ Limit Switch Placement
Place the limit switches to ensure safe operation of the antenna.

Important:
It is the responsibility of the antenna system installer to ensure that the limit switches are placed in appropriate locations for safe operation of the antenna.

- The velocity limit should be far enough from the pre and final limits to allow the antenna to decelerate from full speed to the velocity limit speed before hitting the pre or final limit switch.
- The pre limit should be far enough from the final limit to ensure the antenna can decelerate to a stop without hitting the final limit.
- The final limit should be far enough from the antenna's end of travel to ensure that the antenna can stop before reaching the end of travel.

(1) The Setup Wizard sets a soft limit at 2° before the pre limit switch. The values can be edited by the operator based on the performance required for the application. The soft limits can also be disabled if their use is not required.

(2) The final limits use SS1 on the drives to stop motion in the direction of the limit switch. After the stop is complete, the antenna can be moved off of the limit using the manual jog function.

(3) The velocity limits use a PLC function to limit the velocity in the direction of the limit switch. Velocity limit switches are common on fast or high inertia antennas to ensure that the antenna can slow from max speed to a safe speed prior to hitting the pre or final limit switches. The velocity limit does not stop motion or otherwise inhibit operation, apart from limiting the maximum axis velocity while the switch is engaged.

(4) The pre limits use a software stop to stop motion in the direction of the limit switch. After the stop is complete, the antenna can be moved off of the limit using the manual jog function.

2.3.2.8 Motor tab

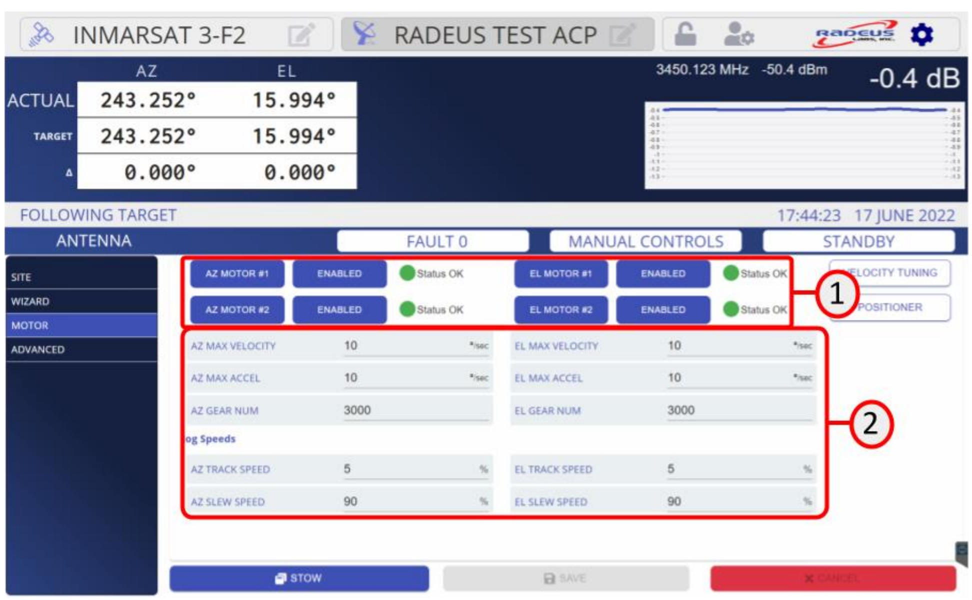


Figure 2-40 Setup > Limits, and the Setup Wizard. See below to add the field for setting up *sectors*.

(1) The motors tab provides status on each of the AZ and EL motors and the ability to disable individual motors for degraded performance.

(2) The motors tab provides inputs for setting the AZ and EL jog speed defaults for track and slew speeds. Track speed is not actually used to limit the speed of the system while tracking but the term is used for a slow jog speed because of common industry usage.

2.3.2.9 Motion tab

Settings on the Motion tab determine when certain key fault conditions are asserted by the ACU.

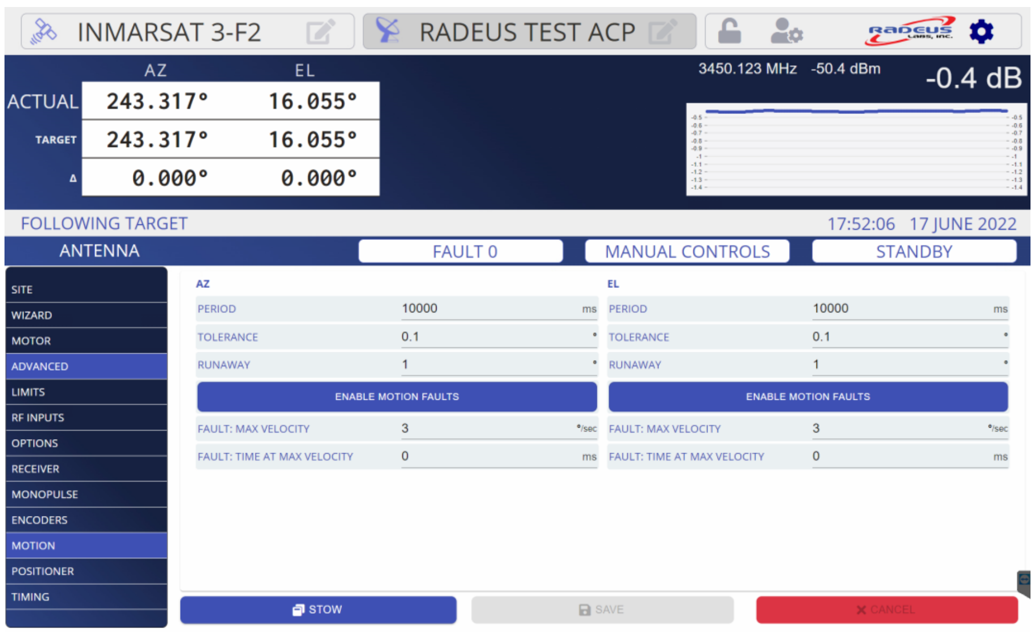


Figure 2-41 Setup > Motion Faults
Settings that influence when certain system faults will be asserted.

For each axis:

- *Period*
  How often, in milliseconds, measurements are checked for the two motion faults, which are:
- *Tolerance*
  If a motion is commanded and the measured angle does not change by at least the number of degrees entered here, the

axis-immobile fault is asserted. If motion is detected reverse to the

- commanded direction, by this amount, the *reversed* fault is asserted.

- *Runaway*
  If no motion is being commanded but the measured angle changes by this amount or greater, the *runaway* fault is asserted and the ACU cuts off the drive enable. (For details, see the runaway faults' descriptions at, for example, "Azimuth runaway".)

2.3.2.10 Positioner tab

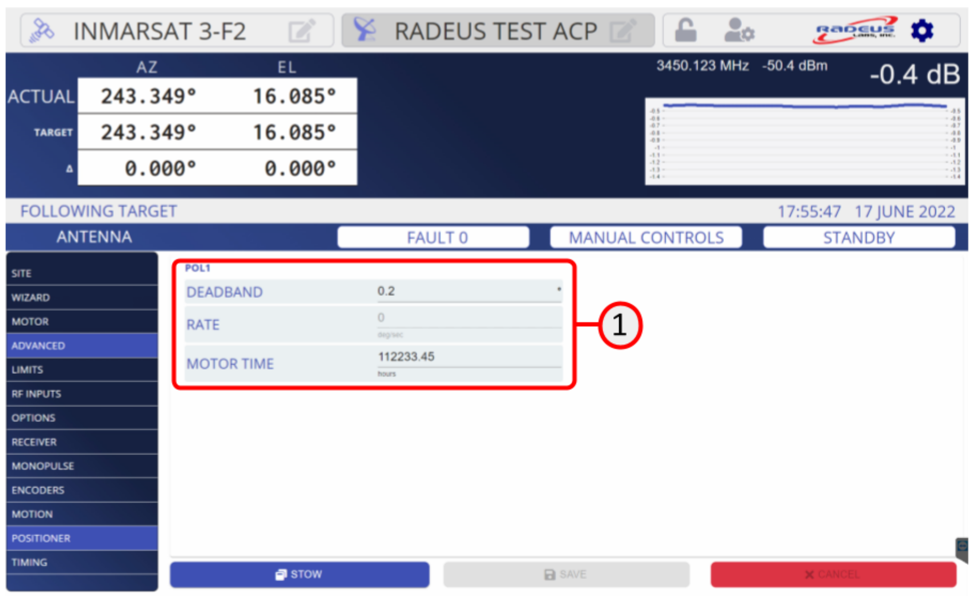


Figure 2-42 Setup > Positioner

(1) The positioner tab shows the settings to control the pol axis motors. These settings are set by the Setup Wizard but may be modified by the operator to optimize performance.

- *Deadband*
  The angle within which the controller will hold the axis. When the actual angle is within the deadband of a commanded position, the only antenna motions are momentary, "bump" adjustments.

- *Rate* — the track speed of the axis calculated by the Setup Wizard. If the Setup Wizard has not been run, these fields' values will be zero.

- *Motor time* — the number of operating hours each motor has logged. If a motor has been operated before the current setup, the ACU operator can enter the amount of pre-existing in-use time. The ACU will increment that as the system is used. (Motor time is recorded in milliseconds but is displayed as hours).

2.3.2.11 Timing tab

Figure 2-43 Setup > Timing

The timing tab provides settings related to timing for each antenna axis:

(1) Brake release time for Az and El – the amount of time, in milliseconds, the brakes require to physically disengage before movement can be commanded.

(2) Motion time for POL1 and POL2:

- *Bump duration* — the amount of time to take a very small, measurable step in position. The amount depends on the resolution of the position transducer (encoder or resolver).

- *Bump coast time* — the wait period to allow the antenna to "coast" to a stop, after a bump, before initiating another motion.

- *Track coast time* — the period to wait after running at track speed before moving again.

2.3.2 Standby

⚠ Caution:
Standby is not an emergency function! In case of an emergency press the E-Stop button!

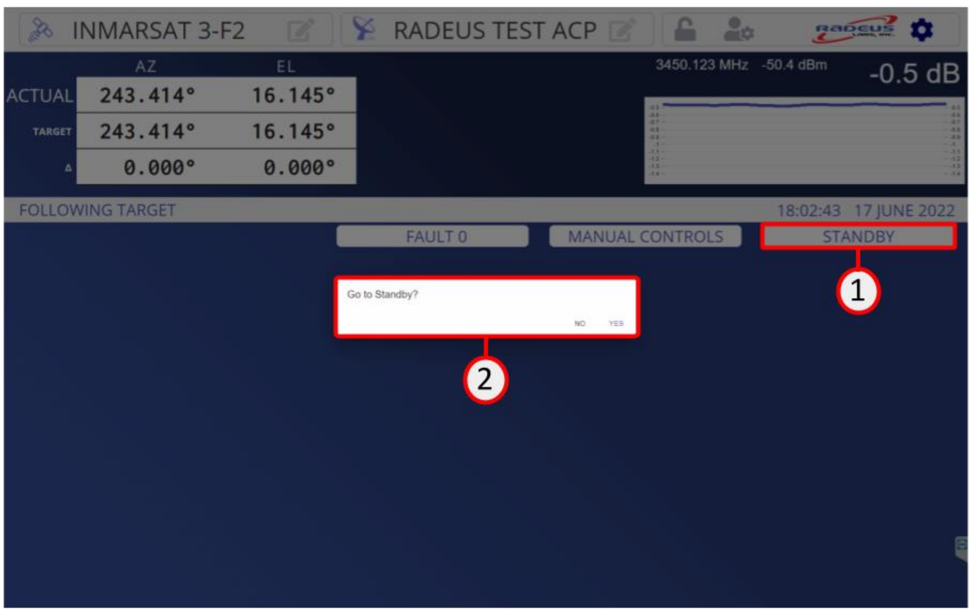


Figure 2-44 Web interface - Standby mode

Pressing the (1) Standby button on the status bar puts the ACU in Standby mode after (2) the user acknowledges the intention to prevent inadvertent interruption of tracking operations

While on standby, the ACU will not command the antenna to move. It will remain on standby until an operator's affirmative action takes it out of standby.

2.3.3 Manual jog

The ACP Manual Control screen provides user-configurable, manual jog controls:

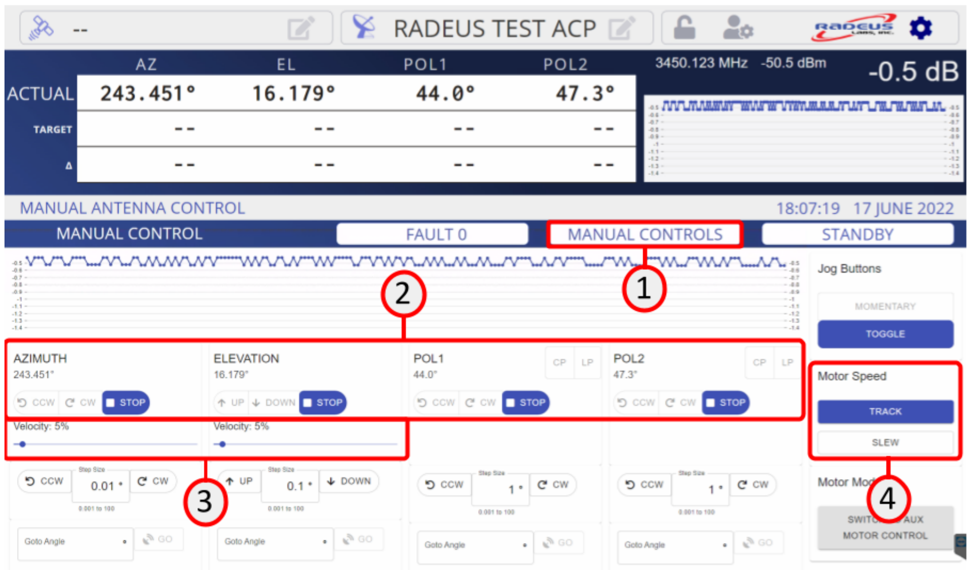


Figure 2-45 Web interface – manual job

> ⚠ **Caution**
> Only move the antenna while you are sure it is safe to do so.

Press the (1) manual controls button to see the screen for manual control of the antenna. It provides (2) buttons for jogging each axis in each direction as well as velocity control. Velocity control is variable by setting the (3) slide bars to the desired percentage of maximum axis velocity or by selecting the (4) track or slew speed presets.

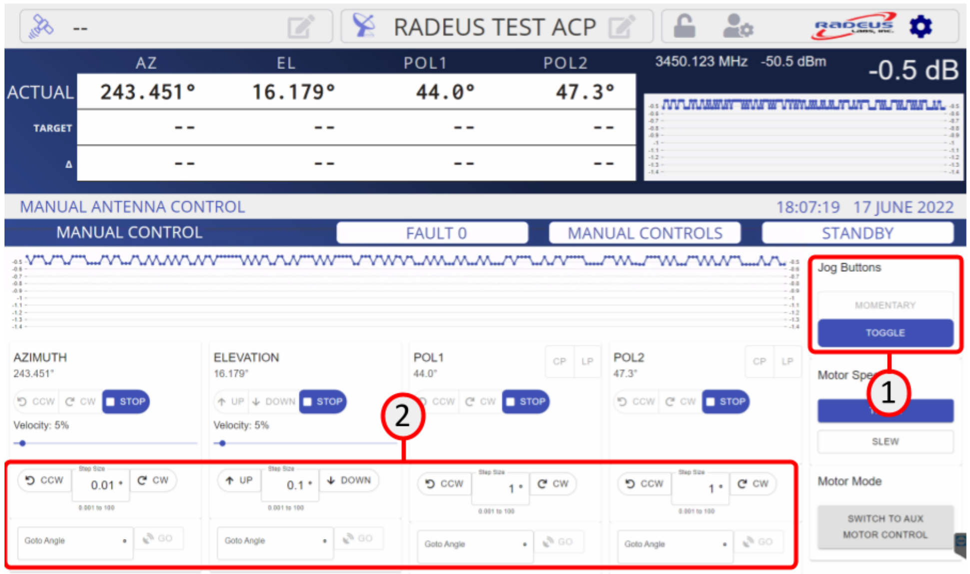


Figure 2-46 Web interface – manual antenna controls

The (1) Momentary/Toggle choice determines how the hardware buttons move the antenna.

- *Momentary:* the antenna will move only while the operator is actively pressing a button.
- *Toggle:* pressing a button once starts the antenna moving along that axis until the stop button is pressed.

⚠ CAUTION:
Never leave the antenna unattended when it's moving in Toggle mode.

⚠ CAUTION:
When moving the antenna with the GoTo function the velocity is controlled by the position and speed control loops, not by the manual control settings so full speed axis motion is possible.

Manual control also provides the ability to command a specific angle on each axis using the (2) GoTo Angle fields.

Soft limits when jogging: The ACU will not allow the antenna to move past its software-defined ("soft") travel limits (see section 2.3.2.10, "Limits"). If the antenna exceeds its limit along any axis, the ACU will allow the user to drive the antenna *back* only — *not further beyond the limit.*

Hard limits: The system should inhibit motion that drives the antenna past its hard limits, but if this happens the system sees the hard limit switch as a safety issue and stops all motion. While the system is in the limit the system will not drive and the system will need to be manually moved out of the limit using handcranks.

2.3.4 Targets

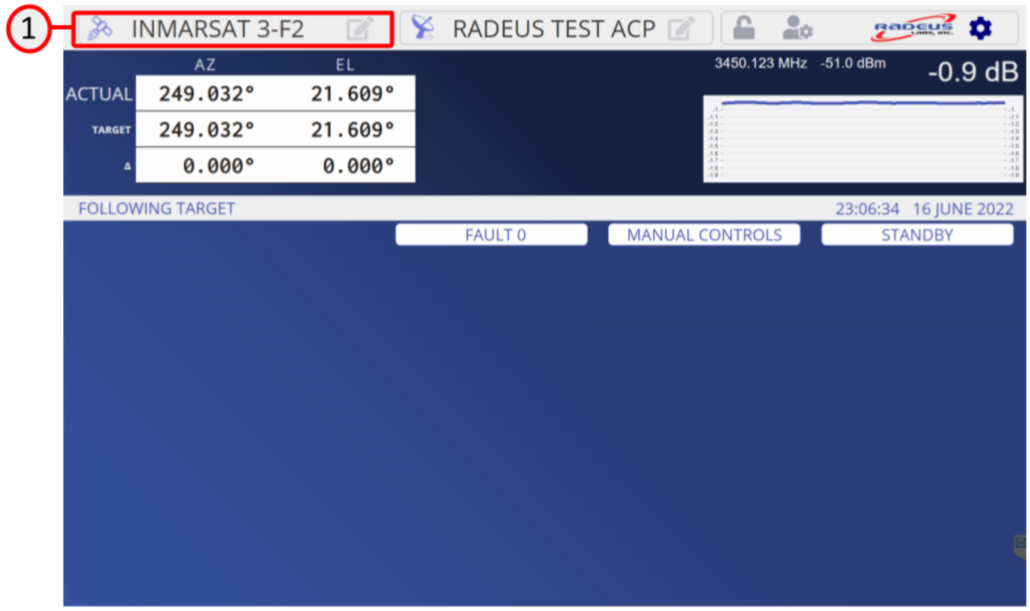


Figure 2-47 Web interface – target button

Press the (1) target button on the menu bar to set up and operate targets and tracking modes.

Creating a target in the 9000 system gives a set of editable parameters for possible pointing and tracking modes. All targets have the option to use all pointing and tracking modes. The parameters selected remain persistent across all pointing and tracking modes for the given target.

2.3.2.12 Default and Immediate Targets

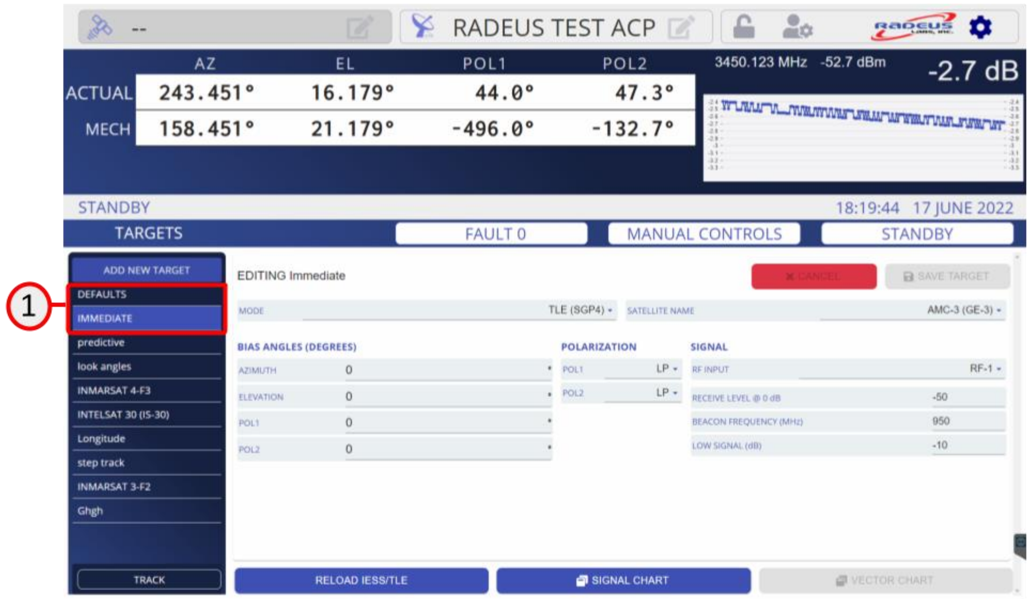


Figure 2-48 Web interface – special purpose items

Two special-purpose items are always at the top of the list of targets:

- **Defaults**
  When a user defines a new target, a copy of the Defaults values is used for its initial settings. To change those preset values, select this item and tap Edit.

  Edited defaults do not retroactively apply to targets already in the system. You may edit those individually, described in section 2.3.5.6.

  All of the default settings are copied to the new target, not only the settings currently displayed on the default for the selected tracking mode. Other tracking mode defaults are copied as well.

Immediate
Select this, then tap Track to begin tracking at the antenna's current position. If the signal level of the target is above the low signal threshold this target will skip the acquisition phase of tracking a target and immediately start tracking in whatever mode is currently selected.

Note: Immediate cannot be used with TLE or IESS pointing modes, because those associate the satellite name with the target profile name. But Immediate and Default profile names cannot be modified, so separate, new target profiles must be created instead.

2.3.2.13 Add a New Target

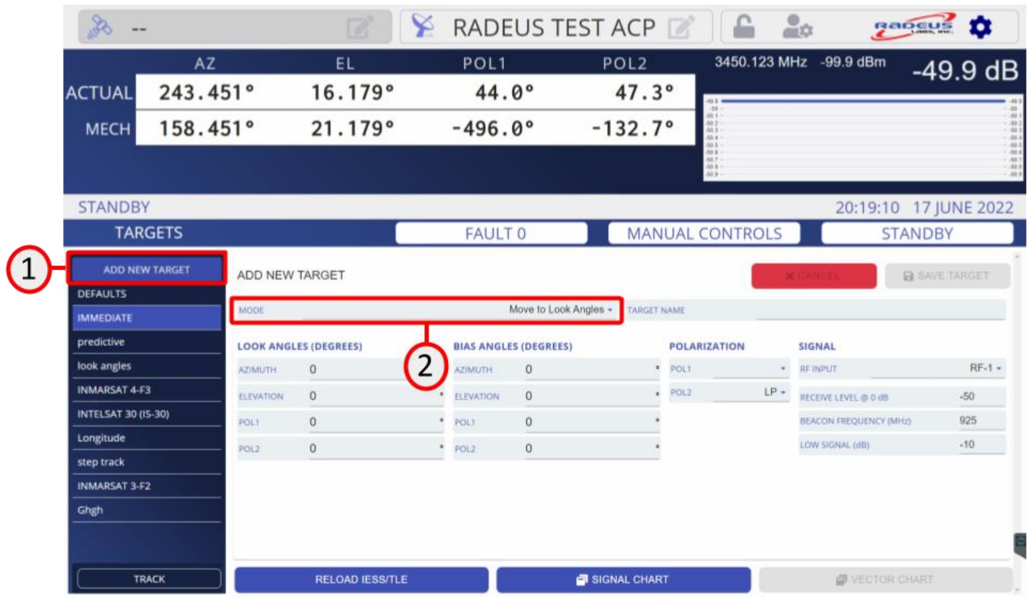


Figure 2-49 Web interface - add new targets

To add a new target, press the (1) new target button in the target menu. The first step is to select the (2) target mode. The details of each mode are explained in subsequent sections:

- Look angles
- Longitude
- Predictive
- Steptrack
- TLE (SGP4)
- IESS-412
- TLE/Steptrack
- IESS/Steptrack
- Monopulse
- Celestial Body

2.3.2.14 Edit a Target

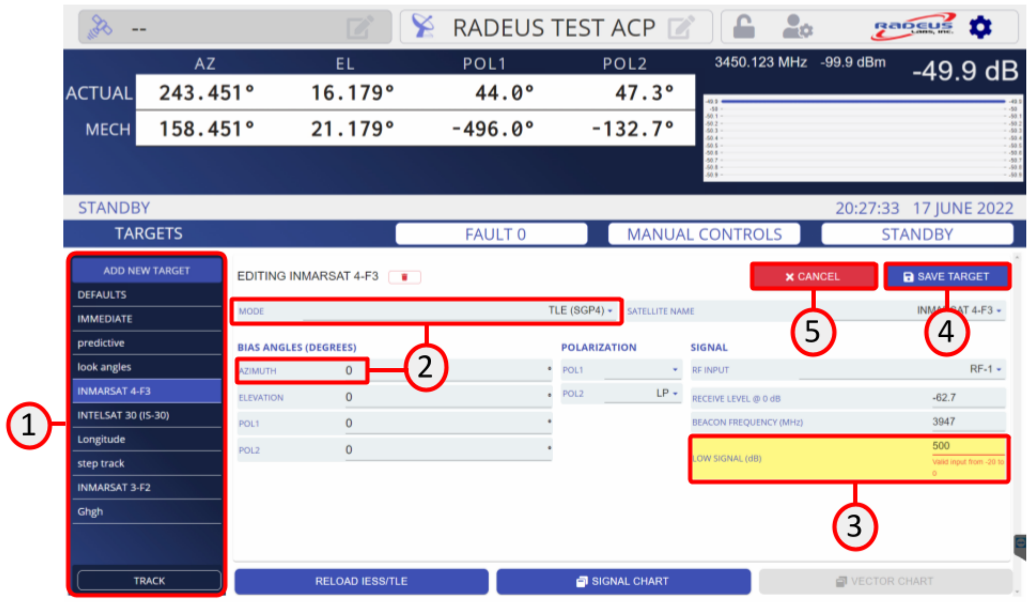


Figure 2-50 Web interface – edit a target

To edit a target (1) select the target in the target list. All of the target details appear in the configuration zone. When a field has been edited it is (2) highlighted so that the operator can clearly see what is being changed. If the edited value is not valid the field is (3) highlighted in red text with a description of the problem. When all errors have been resolved, the operator must save the changes by pressing the (4) save target button. To discard changes and not save them press the (5) red x button.

2.3.2.15 Delete a Target

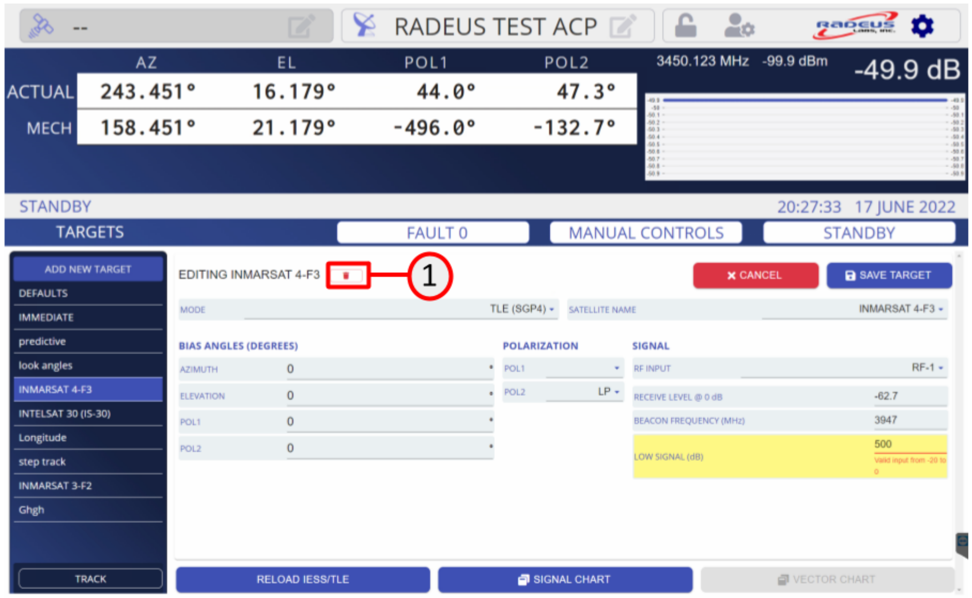


Figure 2-51 Web interface – delete target (1)

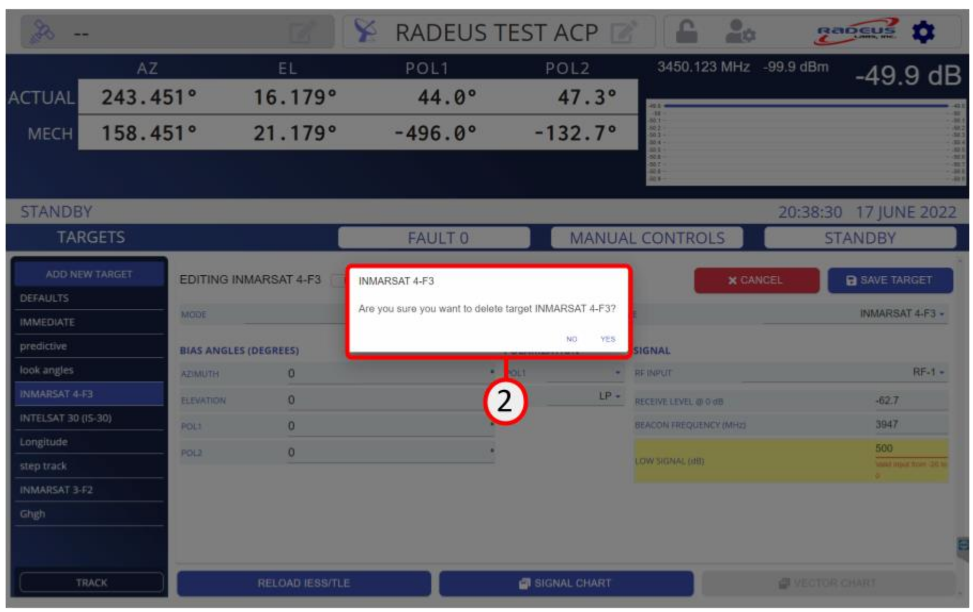


Figure 2-52 Web interface -delete target (2)

To delete a target (1) select the target in the target list and press the waste can delete button. A (2) confirmation dialog window will appear.

Deleted targets cannot be un-deleted. They are permanently lost and must be recreated from scratch after deletion.

2.3.2.16 Track a Target

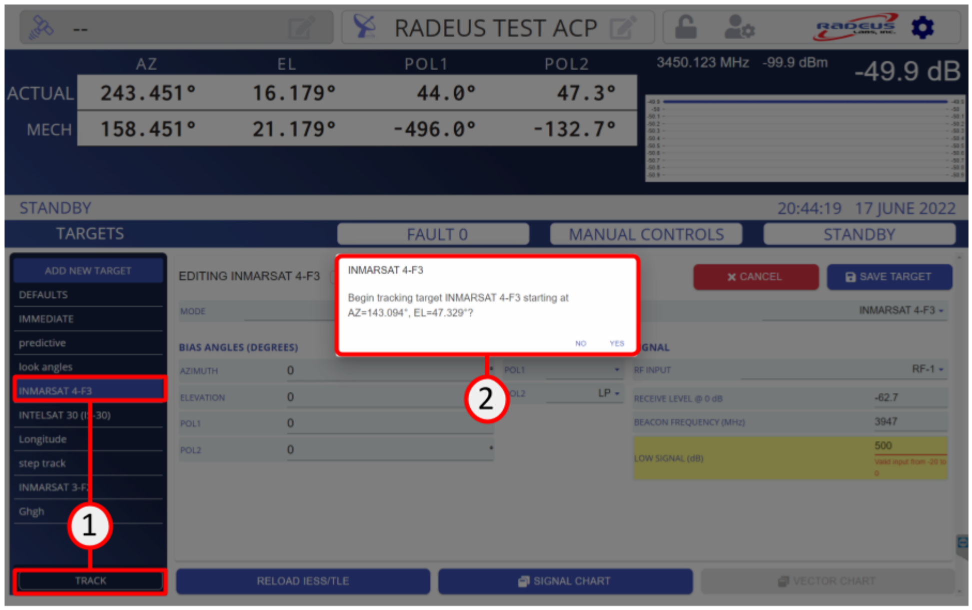


Figure 2-53 Web interface -track a target

To track a target (1) select the target in the target list and press the track button. A (2) confirmation dialog window will appear and also provides information about where the antenna will be moving to.

2.3.5 Target Pointing Modes

A *pointing mode* directs the antenna to the target location as determined by either fixed angles or ephemeris models and actively holds that position or follows the model.

2.3.2.17 Look angles mode

Move the antenna to the *look angles* entered for the target, then actively hold.

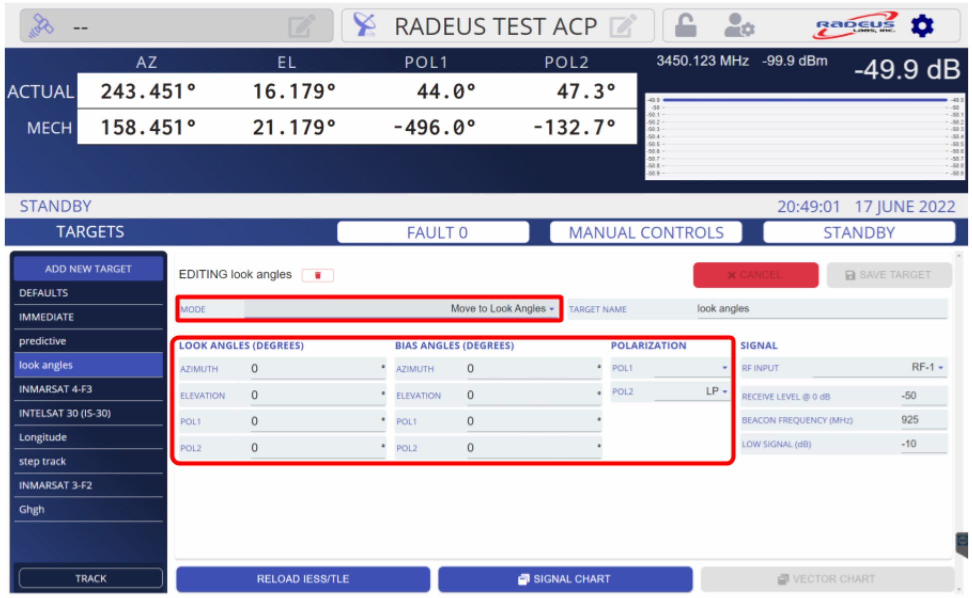


Figure 2-54 look angle modes

Settings for Look Angles targets:

- Look angles (AZ, EL, POL1, POL2) (degrees)
- Bias angles (AZ, EL, POL1, POL2) (degrees)
- Polarization Select (LP, CP)

2.3.2.18 Longitude mode

Much like look angles, except the initial angles are computed from antenna data and the satellite's box center longitude.

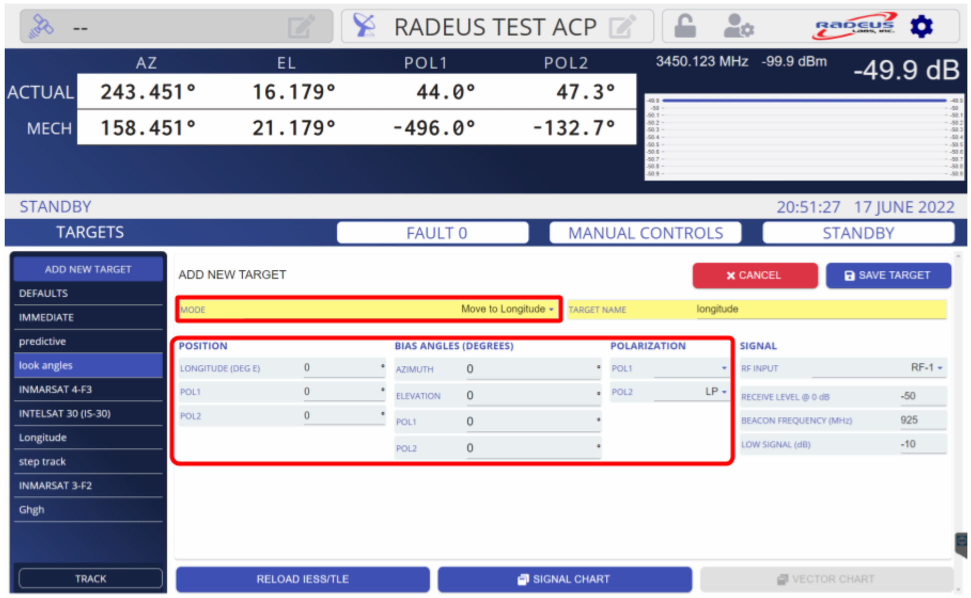


Figure 2-55 Web interface -longitude mode

Settings for Longitude targets:

- Longitude (degrees East)
- POL1 and POL2 angles (degrees)
- Bias angles (AZ, EL, POL1, POL2)
- Polarization Select (LP, CP)

2.3.2.19 TLE (SGP4)

The Series 9000 ACS supports the TLE (NORAD two-line element) data format for locating a target by using the SPG4 simplified perturbation model.

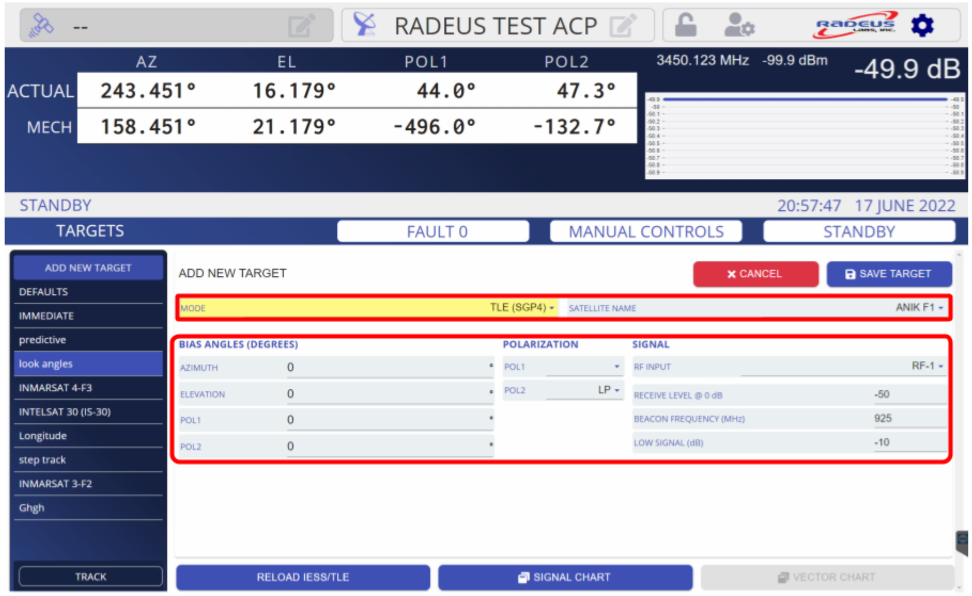


Figure 2-56 Web interface -TLE setup

To set up a TLE target select the satellite name from the (1) drop-down list. The list shows all satellites from the current TLE file that are visible given the antenna's location and its soft limit settings.

Next set up the remaining parameters (if applicable) :

- Bias angles (AZ, EL, POL1, POL2)
- Polarization Select (LP, CP)
- Receive Level (dB)
- Beacon frequency (MHz)
- Low Signal (dB)
- RF Input

2.3.2.20 Requirements for TLE and IESS–412

The ACU auto-updates its TLE and IESS–412 data daily if it has web access.

- Internet connection to the SCU network connector.

  If no internet connection is available:

  - *The data may be updated over internal LAN.* Click the ACP Menu > System > Quit App to access Windows and ensure the directory at

C:\Radeus Labs is shared with write permission. Copy geo.txt (for TLE) or satlist.csv (for IESS-412) into it, from wherever it's located on the LAN.

- *The data may be transferred via USB drive.*
  Insert a USB drive containing the data file into the USB interface on the ACU's front panel. Use the ACU's Windows interface (Click the ACP Menu Choose Setup > System > Quit App) to copy the data into C:\Radeus Labs.

- *IESS-412 and TLE (SGP4) modes are not available for Default or Immediate targets.* To use either of those modes, first choose Target > New or edit an existing target.
- Encoder offsets must be non-zero values.
- The antenna's coordinates must be set.

⚠ When providing custom TLE or IESS data, the ACU should be configured to disable automatic TLE download. Otherwise, any custom TLE data will be overwritten. To do this please create a file named **acu.ini** in the C:\Radeus Labs directory and add the following line:
[EPHEMERIS]
TLEPATH=0
IESSPATH=0

The ACU checks the C:\Radeus Labs directory every second for sources of TLE or IESS data. To force the ACU to use new data, delete geo-local.txt and supply new TLE data using one of the above methods.

Whenever any limit changes, the lists of available TLE and IESS-412 targets will update to include only potential targets within the antenna's range.

2.3.6 Tracking Modes

A *tracking mode* directs the antenna to the target location as determined by either fixed angles or ephemeris models and then uses the RF signal to track or automatically peak the antenna.

2.3.2.21 Steptrack

Also see section 2.2.4 for the theory of operation

Steptrack is a basic but flexible and robust tracking mode used when a geosynchronous target requires frequent re-peaking of the antenna to optimize signal level during the day. Predictive track uses the same steptrack tracking process but further optimizes it by modeling the target's path to reduce the signal loss both between steptrack cycles and by allowing fewer steptrack cycles to achieve improved pointing accuracy. *Therefore, predictive track is the preferred method for tracking geosynchronous targets over steptrack.*

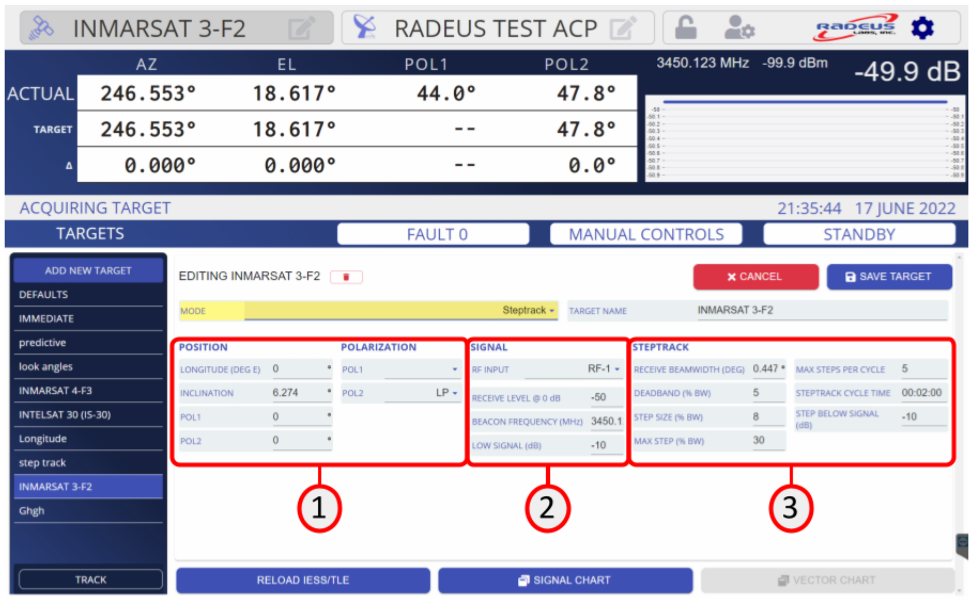


Figure 2-57 Web interface – steptrack mode

The steptrack mode consists of two steps: acquisition and tracking.

Steptrack acquisition uses (1) the satellite's longitude and inclination as well as pol angles if using linear polarization (LP) to initially point to the target. Inclination is used to perform a scan of the predicted path of the target if needed to find the signal.

The (2) signal parameters are used to initially acquire and then to track the target:

- Receive level @ 0 dB – an offset to the actual signal level to make the tracking signal relative to 0 dB at its highest point.
- Beacon frequency (MHz) – the RF frequency of the signal prior to any down-conversion.
- Low Signal (dB) – a threshold that prevents tracking if the signal has fallen too far, for example due to heavy weather. This is relative to the Receive @ 0 dB setting and is limited to 0 to -20dB.
- RF Input – selection of the active RF input for the target.

Once acquired, the (3) steptrack parameters are used to track the target. The following definitions are important to understanding the step track parameters:

Measurement Step – A position step taken to measure the signal level for determining the estimated peak location.

Correction Step – A position step taken toward the measured peak location as a result of the *measurement steps*.

Steptrack Cycle – A *measurement step* in both directions and a *correction step* performed on both AZ and EL.

Tracking Cycle – A sequence of one or more *steptrack cycles* performed to peak the antenna.

- Receive beamwidth (deg) – the calculated full 3dB beamwidth of the signal. This is based on the antenna diameter and K-factor set in the antenna settings and the beacon frequency. This can also be manually changed if a more precise beamwidth is known.
- Deadband (% BW) – the threshold for successfully ending a *tracking cycle*. When the steptrack algorithm determines that the antenna is pointing within the deadband percentage of the peak the *steptrack cycle* is said to have "converged", the *tracking cycle* is stopped, and the antenna remains pointed at the position of the last correction movement. A smaller deadband will force the tracking to attempt to be more accurate however it will also require more *steptrack cycles* to achieve the accuracy. Usually, a larger deadband is preferred since the signal loss due to excessive stepping can degrade the signal level more than a moderately less accurate peak detection.
- Step size (% BW) – the size of *measurement steps* the steptrack algorithm uses to measure signal level during tracking. Larger steps will make the tracking results more accurate in the presence of higher signal noise. However, similarly to setting a small deadband, this will increase the signal loss due to the tracking motion. The step size should be increased as much as the RF loss tolerance allows to allow the *steptrack*

cycles to converge in the presence of noise, this makes the tracking more robust.

- Max step (% BW) – the limit to the size of *correction steps*. When the steptrack algorithm determines the peak position, the antenna is moved toward the peak, but the motion is limited by the max step parameter. This prevents erroneous calculations (due to noise) from causing very large movements in the wrong direction.
- Max steps per cycle – the limit to how many *steptrack cycles* will be taken in a given *tracking cycle*. Setting this low will ensure the antenna is not allowed to "hunt" for the peak for very long in the presence of high signal noise. However, it can also cause the *tracking cycle* to stop before converging. If the max steps per cycle limit is reached, then the *tracking cycle* aborts and the antenna points back to the original angles.
- Tracking cycle time – the time between *tracking cycles*. When in the tracking cycle time waiting period, the antenna is parked at the estimated peak location. Setting this low will cause increased tracking signal loss due to frequent step motions but will also allow the system to follow faster moving targets with less loss in-between *tracking cycles* when the antenna is not moving. This should be set to the highest interval that still ensures that the tracking will keep up with the motion of the satellite.
- Step below signal (dB) – the signal threshold that will trigger a *tracking cycle* during the waiting period set by the tracking cycle time. Use of the step below signal threshold allows the tracking cycle time to be increased. In this way *tracking cycles* will be initiated "on-demand" when the signal level drops below the threshold. The step below threshold is a dynamic threshold meaning that it compares against the highest signal measured since the convergence of the last *tracking cycle*. If the signal rises due to clearing weather or RF gain adjustments, then the threshold rises with it. However, if the signal drops due to weather or other influences then a lower threshold will be set at the conclusion of a *tracking cycle*.

2.3.2.22 Predictive track

Predictive tracking is preferred over steptrack for geosynchronous satellites that require periodic re-peaking during the day. It reduces the frequency of *tracking cycles* required to keep the antenna satisfactorily peaked at all times.

Predictive track is a complex tracking mode consisting of acquisition, model building and model tracking.

Predictive track acquisition uses longitude, inclination and POL1/POL2 angles to initially point to the target.

Once the target is acquired it begins building a predictive model using steptrack to follow the target until one full day's data is stored.

After the model is complete it is used to point to the target— and adjusted periodically with fresh steptrack data — to predict the target position.

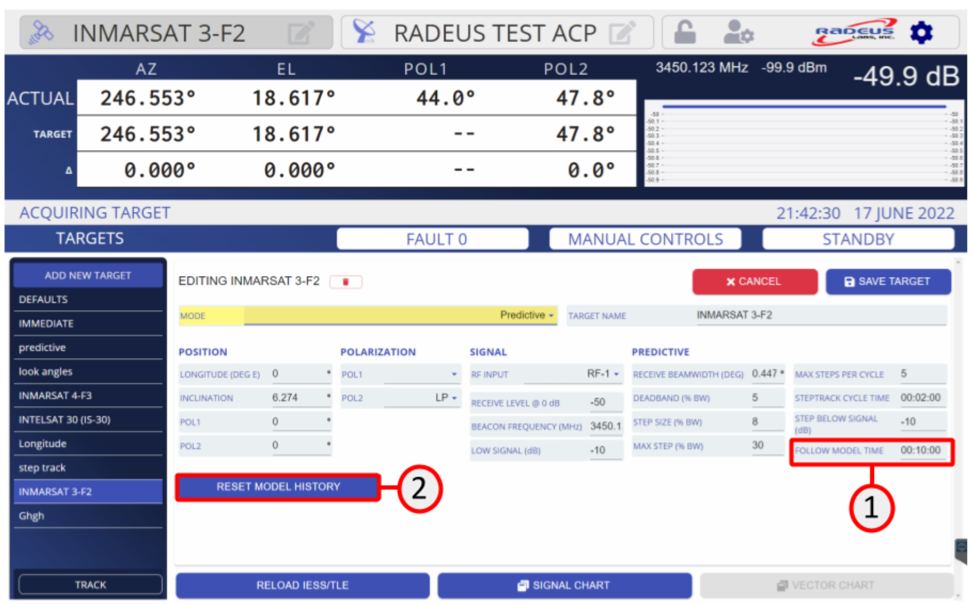


Figure 2-58 Web interface –predictive track

The setup parameters for predictive track are identical to those of a steptrack target with two additions (1) follow model time which sets the interval between *tracking cycles* once a model has been developed and is in use; (2) reset model history which is used to clear the model if it is no longer relevant, for example if the satellite has experienced significant station keeping maneuvers.

2.3.2.23 Monopulse

The Monopulse tracking mode is the most complex as well as the most accurate of tracking modes. It is suitable for use on high-dynamic or well station-kept targets and minimizes the tracking loss by not taking steps to determine the peak position. See the Theory of Operation section for information on how the monopulse system works.

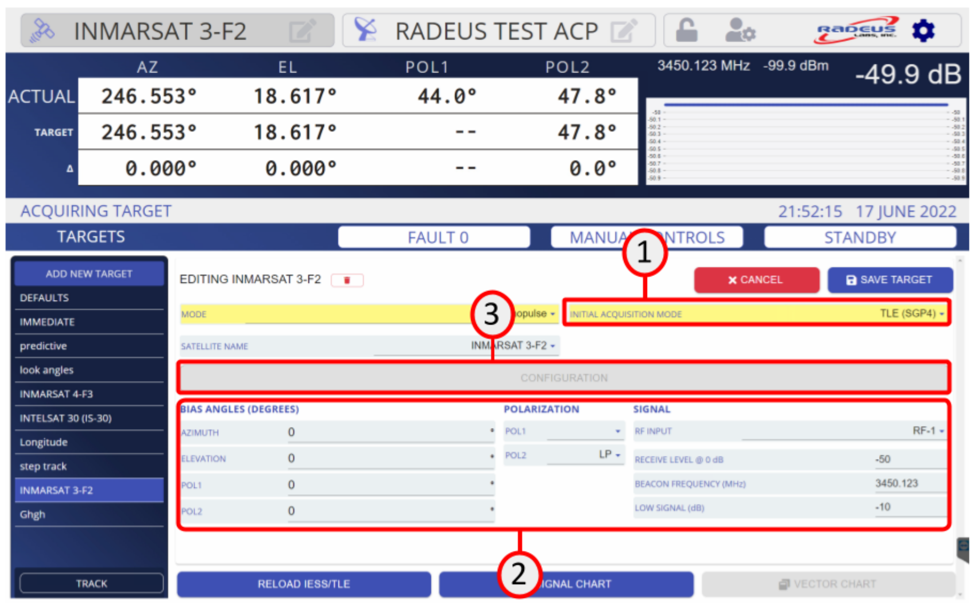


Figure 2-59 Web interface – monopulse target setup

To set up a monopulse target, first select the (1) initial acquisition mode. Then adjust the (2) acquisition mode specific parameters. Finally, select the (3) configuration button to setup the monopulse specific parameters. Monopulse configuration setup is specific to the type of monopulse receiver that is used.

2.3.2.24 CTR-70 Configuration

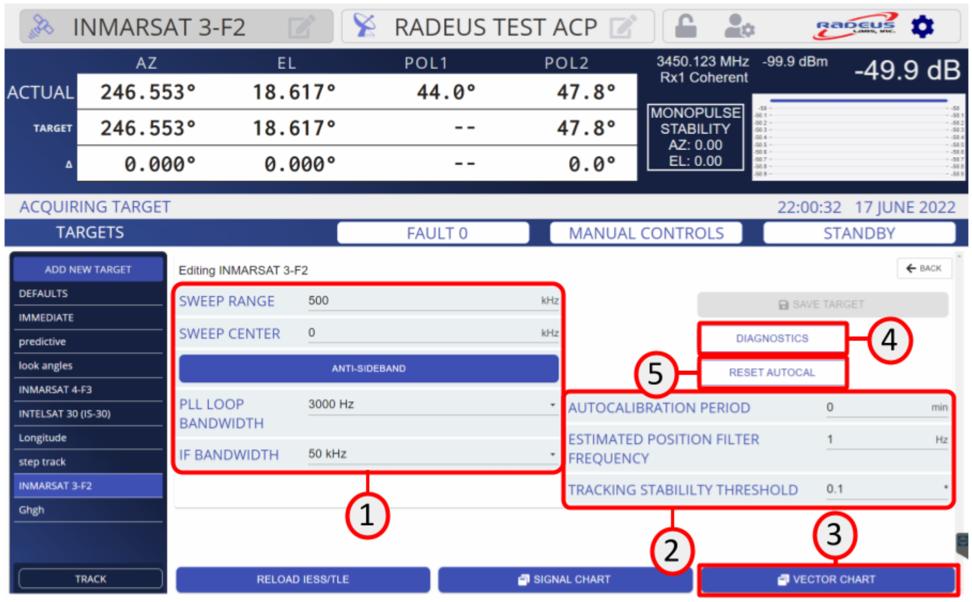


Figure 2-60 Web interface –CTR 70 monopulse configration

The CTR-70 monopulse configuration consists of (1) signal acquisition parameters and (2) monopulse tracking parameters. Additionally, a (3) vector chart and (4) additional diagnostics are provided. The user also has the option to (5) reset the receiver's autocal data on demand.

(1) Signal acquisition parameters:

- Sweep range (kHz) – the frequency range the receiver will use to search for the signal.
- Sweep center (kHz) – an offset to where the receiver will search for the signal (typically 0kHz)
- Anti-sideband – a feature to prevent locking on the sideband of a modulated beacon.
- PLL loop bandwidth – the bandwidth used in the receiver's PLL to lock to the beacon signal. Smaller bandwidths result in more accurate and stable signals at the cost of longer acquisition times meaning possibly higher chance of missing a signal when scanning the antenna. Typically, the largest value should be used.

- IF bandwidth – the limit of the bandwidth of the signal passed from the Tracking Down Converter (TDC) box in the antenna hub to the CTR-70 tracking receiver. This will limit the bandwidth of signals that can be tracked using non-coherent mode.

(2) Monopulse tracking parameters:

- Autocalibration period – the time between CTR-70 autocalibrations. Autocalibration compensates for phase and gain changes in the cables between the TDC and the CTR-70 that may occur due to varying temperature during the day. Setting to 0 disables autocalibration.
- Estimated position filter frequency – the cut off frequency that filters the monopulse position estimate. Typically, 0.5-1.0 Hz is a good value.
- Tracking threshold – the limit to position variability that causes the monopulse tracking to stop. If the standard deviation of the estimated position rises above this threshold, then the tracking is disabled and the system goes into the fall back tracking mode.

2.3.2.25 CTR-70 Diagnostics

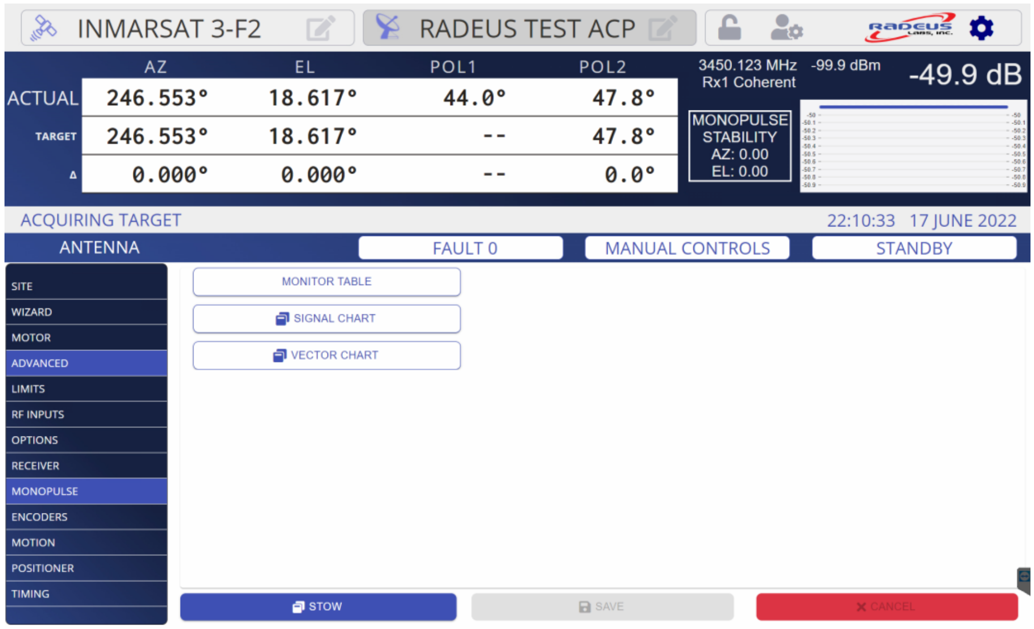


Figure 2-61 Web interface – CTP-70 diagnostics

Pressing the (4) diagnostics button on the monopulse configuration screen gives options for optimizing monopulse tracking performance and diagnosing monopulse tracking problems.

2.3.2.26 CTR-70 Monitor Table

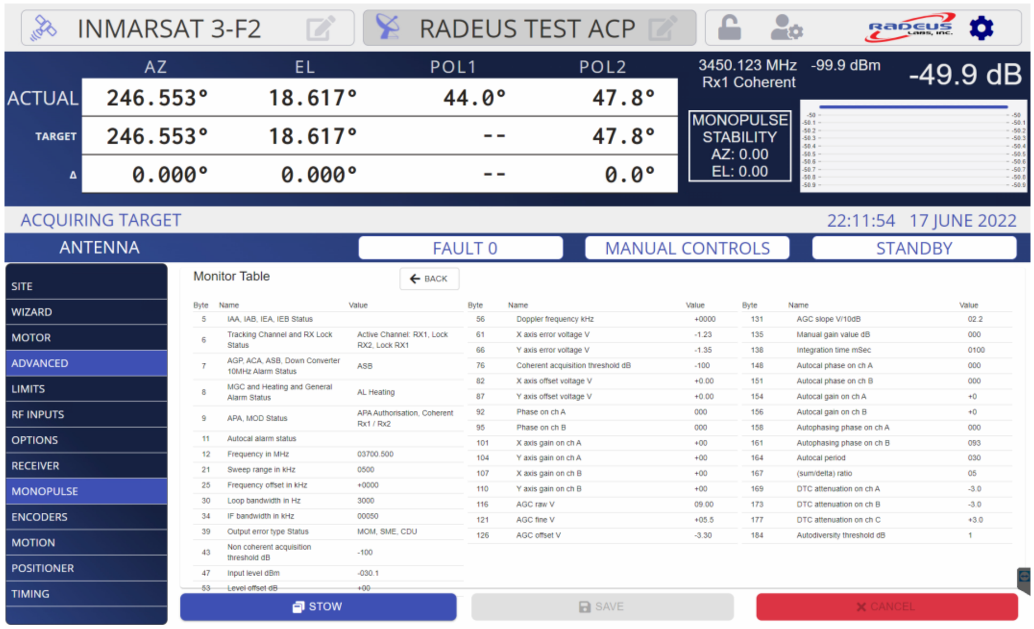


Figure 2-62 Web interface – CTP-70 monitor table

The monitor table shows all of the parameters that the CTR-70 maintains for diagnostic purposes. Most of these are not needed most of the time however they are made available in case of complex troubleshooting scenarios.

2.3.2.27 CTR-70 Signal Chart

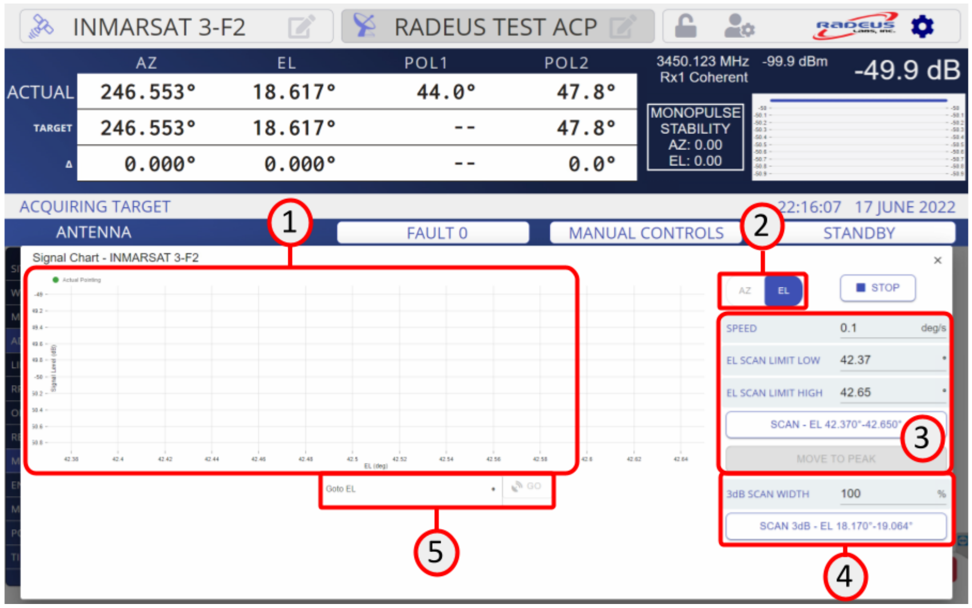


Figure 2-63 Web interface –CTR70 signal chart

The signal chart is useful for diagnosing problems peaking the antenna, for example possible peaking on a sidelobe which will prevent accurate tracking. As the position changes the chart will show a line curve depicting the highest signal level measured at a given position.

The signal chart provides (1) a large chart of signal level and monopulse error vs. axis position. The axis used on the chart can be (2) switched between AZ and EL.

Automatic scanning functions are available to scan either (3) a custom range of positions or (4) a selectable percentage of the 3dB beamwidth. The (5) speed of the scan can be adjusted to make the scan more accurate (slower) or faster (less accurate).

Once a scan is complete an automatic function is available to (3) move to the detected peak. Or the operator can manually input positions in the goto box and command manually control of the position.

2.3.2.28 CTR-70 Vector Chart

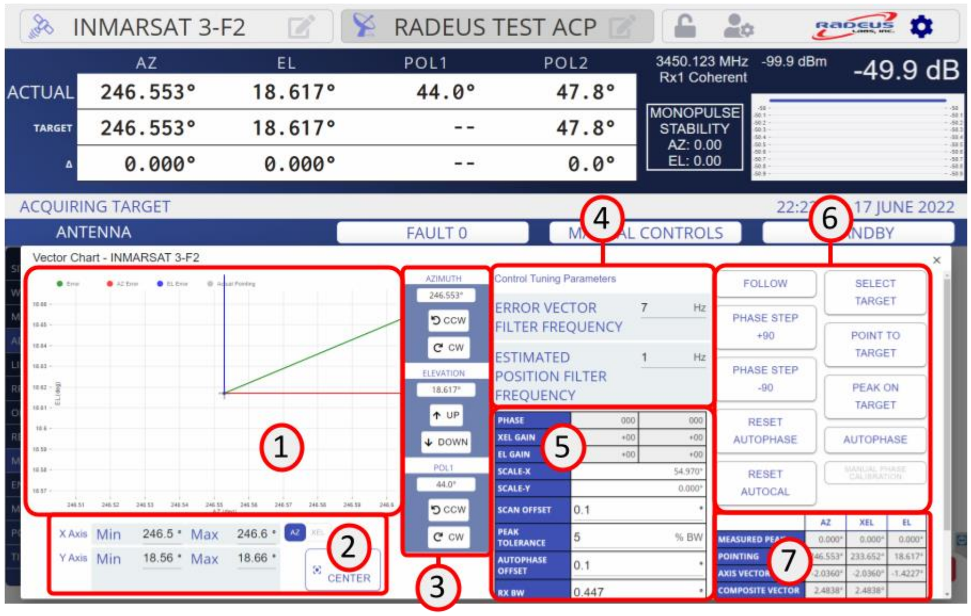


Figure 2-64 Web interface –CTR70 vector chart

The vector chart is used to verify monopulse tracking performance and diagnose problems.

The (1) vector chart displays the EL axis plotted against the AZ or XEL axes. The vectors plotted on the chart are the EL (blue), AZ (or XEL) (red) and composite or beam radial (green) error vectors. The vectors all originate at the current pointing angle of the antenna and terminate at the location of the estimated target peak for the axis represented. The information on the chart is also represented by (7) a table showing the numeric values.

Controls for the vector chart are (2) minimum and maximum angles represented for each axis, selection of AZ or XEL for the horizontal axis and a button to automatically center the chart on the current pointing angles.

(3) Manual jog buttons are available so that the operator can move the antenna and observe how the vectors respond.

(4) Filter cutoff frequencies are available for both the error vector and estimated position.

(5) A table is provided with other parameters that affect the monopulse tracking:

- Phase – the phase correction applied by the autophase process to align the receiver's error vectors with the antenna axes. Channel A is for RX1 and Channel B is for RX2.
- XEL Gain / EL Gain – the gain correction applied by the autocal process to correct the magnitude of the vectors. Channel A is for RX1 and Channel B is for RX2.
- SCALE-X / SCALE-Y – the scale factor that transforms the error vector from units of voltage to units of degrees in the XEL (X) and EL (Y) axes.
- Scan Offset – the angular distance that the monopulse acquisition process uses to scan for the peak. Smaller values will make the autophasing less accurate, but larger values may saturate the receiver.
- Peak Tolerance – the constraint for how close the scan gets to the peak before performing autophase.
- Autophase Offset – the angular distance that the autophase process uses to move away from the peak for performing the phase alignment. Smaller values will make the autophasing less accurate, but larger values may saturate the receiver.
- Rx BW – display of the beamwidth value for the current target.
- Autocalibration period – the time between CTR-70 autocalibrations. Autocalibration compensates for phase and gain changes in the cables between the TDC and the CTR-70 that may occur due to varying temperature during the day. Setting to 0 disables autocalibration.

Several (6) diagnostic buttons are available to perform various functions to help optimize the monopulse tracking performance:

- Track – turns on and off the control loop for following the monopulse error vectors. This is useful for performing a "snap on" test: 1) turn off track; 2) manually offset from the peak in one or both axes; 3) verify that the vectors point generally toward the target; 4) turn on track and observe the path the antenna takes to get to the peak location. If it significantly overshoots, then the gain may need to be decreased; if it spirals up to the peak then the phase adjustment may be poor and should be redone; if does not track to the peak at all then autophase may not have been performed or may have been interrupted by a signal anomaly or some other disruption and should be repeated.

- Phase Step +/- 90 – apply either +90- or -90-degree offsets to the receivers phase adjustment. When a 90-degree offset is applied the vectors should rotate by approximately 90 degrees. A complete circle of the vectors back to their original location should be observed with 4 presses of the +90 button. This verifies proper configuration of the monopulse RF system. If the vector rotation is not close to 90 for each press of the button, then it is likely that the RF feed, amplifier, conversion, or phase adjustment circuit is not configured or operating properly.
- Reset Autophase / Autocal – set the automatically calculated phase and gain values to zero. This can be useful to put the system back to a known state but will not result in a system that is ready to track.
- Select Target – choose a new target to diagnose.
- Point to Target – move to the look angles of the chosen target.
- Peak on Target – perform an automatic cross scan to peak on the target.
- Autophase – move to the autophase offset and adjust the phase alignment. When autophase is complete, the EL error vector should be approximately 0.

2.4 System-Fault Conditions

See safety information in "Important Precautions" before proceeding.

WARNING
Disconnect power in case of any emergency.

The Series 9000 ACP notifies users visually and with an optional audio tone if it detects a fault condition.

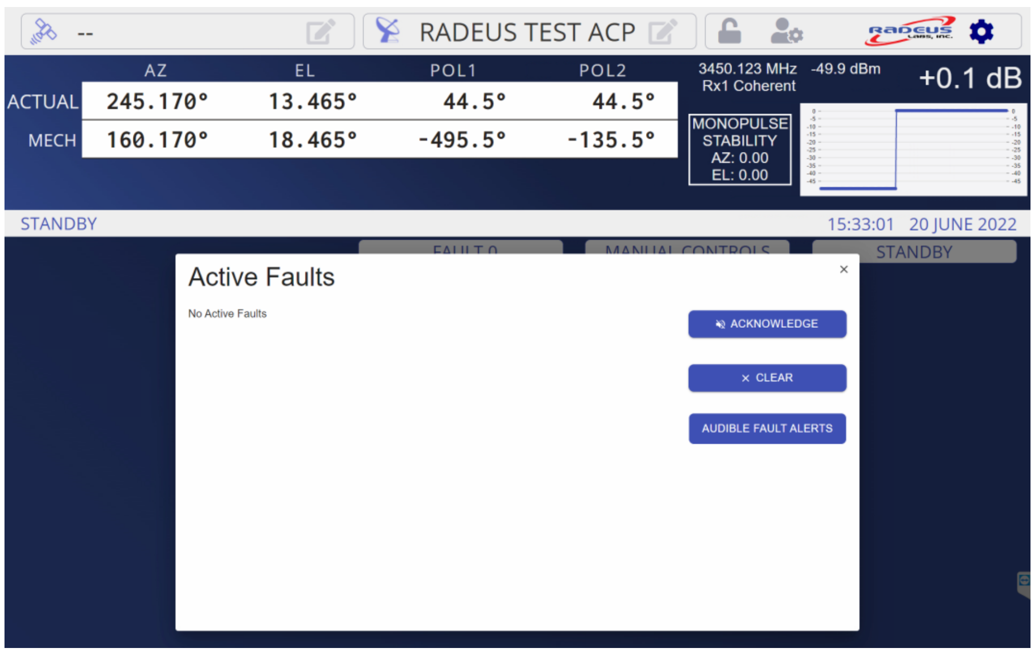


Figure 2-65 A warning and fault description(s) are displayed, and an optional warning tone issued, if the ACU detects a fault condition.

2.4.1 Faults and System Standby

If any of the following fault conditions lasts two seconds or longer,[1] it may force the ACU into standby:[2]

[1] This delay can prevent some transient conditions from halting otherwise normal operations.

[2] I.e., it cuts power to the motors.

Azimuth runaway (pg. 110)
Azimuth immobile (pg. 111)
Azimuth reversed (pg. 111)
Azimuth encoder fault (pg. 111)
Azimuth CCW soft travel limit (pg. 112)
Azimuth CW soft travel limit (pg. 112)
Azimuth motor controller fault (pg. 112)
Azimuth travel limit switch tripped (pg. 112)
Azimuth/Elevation brake fault (pg. 112)
Elevation encoder fault (pg. 112)
Elevation runaway (pg. 112)
Elevation immobile (pg. 113)
Elevation reversed (pg. 113)
Elevation encoder fault (pg. 113)
Elevation lower soft travel limit (pg. 113)
Elevation upper soft travel limit (pg. 113)
Elevation motor controller fault (pg. 113)
Elevation travel limit switch tripped (pg. 113)
Polarization runaway (pg. 113)
Polarization immobile (pg. 113)
Polarization reversed (pg. 114)
Polarization encoder fault (pg. 114)
Polarization select in wrong position (pg. 114)
Polarization CCW soft travel limit (pg. 114)
Polarization CW soft travel limit (pg. 114)
Polarization travel limit switch tripped (pg. 115)
Emergency stop pressed (pg. 115)
Maintenance override at drive cabinet (pg. 115)
Soft travel limit disabled (pg.115)
Travel limit switch tripped (pg. 115)
No power at drive cabinet (pg. 115)
Halted at PMCU (pg. 115)

Contact Radeus Support if you have one of the following faults

- Azimuth CCW velocity limit
- Azimuth CW velocity limit
- Azimuth CCW prelimit
- Azimuth CW prelimit
- Azimuth motor communication failure
- Azimuth not zeroed
- Azimuth motor program downloading
- Azimuth stow pin
- Azimuth max velocity error exceeded
- Azimuth controller initialization abort
- Azimuth hand crank engaged
- Elevation motor controller fault

Elevation down velocity limit
Elevation up velocity limit
Elevation down prelimit
Elevation up prelimit
Elevation not zeroed
Elevation motor program downloading
Elevation stow pin
Elevation max velocity error exceeded
Elevation controller initialization abort
Elevation hand crank engaged
Polarization motor communication failure
Polarization not zeroed
Polarization motor program downloading
Polarization encoder fault
Polarization 2 CCW limit
Polarization 2 CW limit
Drive disabled at control panel
No power at drive cabinet
Drive cabinet door open
JPB communication failure
JPB firmware update failed
Can't access settings file
Can't access tracking history file
Polarization select in wrong position
TLE ephemeris data file needs update
IESS ephemeris data file needs update
SCU communication failure
Steptrack inhibited for ranging
Error in IESS ephemeris data

2.4.2 Respond to a Fault Condition

When the system reports a fault, you may:

1. *Mute the fault alert:*
   On the Home screen, tap Fault once to mute the alert.

2. *Investigate and resolve:*
   Resolve any issue indicated by a fault message. The meaning of each fault message is discussed in section 2.4.3.

3. *Clear the fault(s) and resume:*
   Press the Fault button again to clear the fault status.

   If a fault condition is still detected, the system will re-assert the alert message.

2.4.3 Fault Messages & Causes

System fault messages are described below, with some potential causes and remedies. (Also see "Faults and System Standby.")

2.4.3.1 "Azimuth runaway"

The ACU has detected that the axis is moving but the ACU is not commanding it to move. The ACU responds by de-asserting the drive-enable line to the drive cabinet. May put system in standby.

Common causes:

- Stuck drive command relay
- Malfunctioning position transducer

2.4.3.2 "Azimuth immobile"

The axis is being commanded to move, but it is not moving. May put system in standby.

Common causes:

- Motor and/or motor controller is not producing enough torque to move the axis.

- Position transducer has become decoupled from the structure.

2.4.3.3 "Azimuth reversed"

The axis is reporting movement in the opposite direction to which it is being commanded to move. May put system in standby.

Possible causes:

- On the Setup > Encoders screen, the direction value needs to be reversed.
- Motor is wired incorrectly.

2.4.3.4 "Azimuth encoder fault"

The encoder is reporting invalid values. May put system in standby.

Possible causes:

- Electrical noise corrupting the encoder signals
- Encoder hardware malfunction

Verify that the encoder is connected and that the pinouts are correct

2.4.3.5 "Azimuth CCW soft travel limit"

The axis drove past a software-defined travel limit. It may be driven only in a direction that brings it back within its soft limits.

2.4.3.6 "Azimuth CW soft travel limit"

See preceding.

2.4.3.7 "Azimuth motor controller fault"

The motor controller has faulted and must be reset to resume operations. May put system in standby.

Common cause:

- Misconfiguration of the motor controller, resulting in exceeding its operational limits.

2.4.3.8 "Azimuth travel limit switch tripped"

The travel-limit switch has been engaged. The drive cabinet interface does not tell *which* limit was exceeded; however, that should be obvious from observing the antenna's position. Because the ACU doesn't know which limit was exceeded, it does not inhibit motion in either direction as a result of this error. May put system in standby.

This shouldn't happen after the ACU is properly configured, because a soft limit should be reached before the limit switch is engaged.

2.4.3.9 "Azimuth/Elevation brake fault"

This fault means that the status of the brake and the command coming from the system do not match. May put system in standby.

2.4.3.10 "Elevation runaway"

See section 2.4.3.1, "Azimuth runaway". May put system in standby.

2.4.3.11 "Elevation immobile"

See section 2.4.3.2, "Azimuth immobile". May put system in standby.

2.4.3.12 "Elevation reversed"

See section 2.4.3.3, "Azimuth reversed". May put system in standby.

2.4.3.13 "Elevation encoder fault"

See section 2.4.3.4, "Azimuth encoder fault". May put system in standby.

Verify that the encoder is connected and that the pinouts are correct (see Appendix **Error! Reference source not found.**).

2.4.3.14 "Elevation lower soft travel limit"

The axis drove past its software-defined tracking limits. Now it may be driven only in the direction that brings it within its limits.

2.4.3.15 "Elevation upper soft travel limit"

See preceding.

2.4.3.16 "Elevation motor controller fault"

See section 2.4.3.7, "Azimuth motor controller fault". May put system in standby.

2.4.3.17 "Elevation travel limit switch tripped"

See section 2.4.3.8, "Azimuth travel limit switch tripped". May put system in standby.

2.4.3.18 "Polarization runaway"

See section 2.4.3.1, "Azimuth runaway". May put system in standby.

2.4.3.19 "Polarization immobile"

See section 2.4.3.2, "Azimuth immobile". May put system in standby.

2.4.3.20 "Polarization reversed"

See section 2.4.3.3, "Azimuth reversed". May put system in standby.

2.4.3.21 "Polarization encoder fault"

See section 2.4.3.4, "Azimuth encoder fault".

Verify that the encoder is connected and that the pinouts are correct

2.4.3.22 "Polarization select in wrong position"

If the system detects the CP/LP (circular POL/linear POL) setting is incorrect — based on POL-3 and POL-4 limits[3] CIB 110–112 and CIB 100–102 — it will attempt *up to five times* to move the feed to the correct position, after which this fault will be asserted, and no further movement will be attempted until an operator clears the fault.

To restore proper operation, the CP/LP feed must be repositioned:

1. Manually position the feed at the antenna to CP or LP.
2. At the ACU, select Home > Manual and choose the position (CP or LP) that corresponds to the feed.

---

[3] POL3 and POL4 are labeled on the IOC board in the drive cabinet.

3. Back at the Home screen, double tap the Fault button.
4. Verify that the fault clears.

2.4.3.23 "Polarization CCW soft travel limit"

See section 2.4.3.5, "Azimuth CCW soft travel limit".

2.4.3.24 "Polarization CW soft travel limit"

See section 2.4.3.6, "Azimuth CW soft travel limit".

2.4.3.25 "Polarization travel limit switch tripped”

See section 2.4.3.8, "Azimuth travel limit switch tripped". May put system in standby.

2.4.3.26 "Emergency stop pressed"

The emergency stop has been engaged. May put system in standby.

2.4.3.27 "Maintenance override at drive cabinet"

Someone engaged local mode on the PMCU. The ACP cannot command the antenna until local mode has been de-asserted. May put system in standby.

2.4.3.28 "Soft travel limit disabled"

The system’s soft travel limits are disabled, which is normal only during testing and setup. This fault will persist until the soft limits are re-enabled on the Setup > Travel Limits” screen (**Figure 2-39**).

2.4.3.29 "Travel limit switch tripped"

In systems with a single summary travel-limit switch status line, this indicates that one or more axes engaged a travel-limit switch. The ACU has no way of knowing which limit was exceeded and it does not inhibit motion. May put system in standby.

2.4.3.30 "No power at drive cabinet"

This fault condition is inferred when all drive cabinet faults occur simultaneously. May put system in standby.

2.4.3.31 "Halted at PMCU"

The system was halted via a Portable Maintenance Control Unit.

2.4.3.32 "Low tracking signal level"

The tracking-signal level is too low to perform steptrack operations.

Common causes:

- Not beginning tracking on the target signal main lobe.
- Incorrect tracking receiver frequency.
- Incorrect tracking receiver source selected.

2.4.3.33 "Unstable tracking signal level"

The tracking signal is varying too rapidly to steptrack.

2.4.3.34 "IOC communication failure"

The link between the touch-panel computer's I/O controller and the drive cabinet has been severed. The system will de-assert the drive-enable line.

2.4.3.35 "IOC firmware update failed"

The automatic installation of new firmware on the I/O controller did not complete successfully. Contact supplier for service or support.

Troubleshooting:

1. Clear the fault and verify system is operating normally.
2. If not, cycle power at the drive cabinet.
3. If issues persist, contact support.

2.4.3.36 "ENC communication failure"

The SCU cannot communicate with the encoder board.

Troubleshooting:

1. Verify the drive cabinet is turned on.

2. Verify power supplies in drive cabinet are turned on, check the Ethernet connection(s).
3. Verify IFL from the drive cabinet is connected to the ACU
4. Verify the appropriate position feedback is selected in Setup > Encoders > Type

2.4.3.37 "ENC firmware update failed"

The automatic installation of new firmware on the encoder did not complete successfully.

Troubleshooting:

1. Clear the fault and verify system is operating normally.
2. If not, cycle power at the drive cabinet.
3. If issues persist, contact support.

2.4.3.38 "RDC communication failure"

The SCU cannot communicate with the resolver board.

Troubleshooting:

1. Verify the drive cabinet is turned on.
2. Verify power supplies in drive cabinet are turned on, check the Ethernet connection(s).
3. Verify IFL from drive cabinet is connected to the SCU.
4. Verify the appropriate position feedback is selected in Setup > Encoders > Type.

2.4.3.39 "RDC firmware update failed"

Automatic installation of new firmware on the resolver-to-digital converter did not complete.

Troubleshooting:

1. Clear the fault and verify system is operating normally.
2. If not, cycle power at the drive cabinet.
3. If issues persist, contact support.

2.4.3.40 "Ephemeris data file needs update" "TLE ephemeris data file needs update" "IESS ephemeris data file needs update"

The ephemeris data for the selected target is older than 170 hours. This happens if the SCU loses its internet connection or if ephemeris data for a target is no longer reliable. To clear the fault:

- Restore the network connection, which will cause the SCU to update the data. *Or…*
- Double-tap the Home > Fault button to clear the *alert* — if the issue isn't addressed, the system may report the fault again.

2.4.3.41 "Fault condition forced standby"

Standby mode was asserted by the system in response to a detected fault. Clear the fault condition and resume operation. If the fault condition still exists, the fault will be re-asserted.

2.4.3.42 "Receiver communication failure"

The SCU application cannot communicate with the tracking receiver.

Possible remedies:

- Check all internal connections.
- It might be necessary to restart the receiver with a power cycle.

2.4.3.43 "Receiver not running"

The beacon receiver has not entered run state after being commanded to do so.

Possible remedy:

- It may be necessary to restart the receiver with a power cycle.

2.4.3.44 "Receiver not locked"

The signal level is too low. Move the antenna closer to beam center.

2.4.3.45 "Beacon frequency out of range"

The beacon frequency specified for the selected target is not within the range of the beacon receiver. Check the beacon frequency and the LO settings (via Home > Setup > Receiver).

2.4.3.46 "Drive cabinet network interface misconfigured"

The IP address of the SCU, on the NIC that connects to the drive cabinet network, is wrong. 192.168.244.1 is the correct address.

2.4.3.47 "Orbital tracking limit"

The SCU is attempting to track the target along a path bound by the orbital tracking limit option.

The SCU may partially or completely lose the target's signal during this fault condition.

Troubleshooting:

1. Increase the orbital tracking limit.
2. Verify the tracking beamwidth.
3. Disable orbital track by setting the Setup > Options > Orbital tracking limit to 0.

2.4.3.48 "Sun outage"

The SCU has detected that a sun outage event will occur or is currently occurring. It will prevent further steptrack cycles until the sun outage event has passed.

2.4.3.49 "PMCU firmware update failed"

Troubleshooting:

1. Clear the fault and verify system is operating normally.

2. If not, cycle power at the drive cabinet.
3. If issues persist, contact suppor

SECTION

3

3 Maintenance

⚠ **CAUTION:**
Maintenance of the 9000 system must only be performed by qualified personnel. Improper maintenance can result in hazard to equipment and personnel.

3.1 Cabinet Maintenance

The following maintenance should be performed at least annually:

- The cabinet is equipped with one or more air filters which should be checked and replaced or cleaned as needed.
- Check to ensure that the cabinet fans are operational.

⚠

- *Power off the cabinet first!* Inspect the wiring connections to ensure the wiring connections are secure, no corrosion or damage has occurred.

⚠

- *Power off the cabinet first!* Inspect the mechanical connections to ensure all hardware is tight.

3.2 Drive Unit Maintenance

The following maintenance should be performed at least annually:

- *Power off the cabinet first!* Check system for loose screws and plugs and tighten if necessary.
- *Power off the cabinet first!* Clean drive converter from dirt and dust deposits. Pay attention especially to cooling fins and protective grid of the fans.
- *Power off the 3-phase power first!* Check the function of the fans of the drive converter. The fan must be replaced in case of audible vibrations or squeak.

3.3 PLC Maintenance

C6 SMART PLC has a battery for storing settings during power off phases. For a stock temperature of 25°C the lifetime of the battery is >10 years. If the battery requires replacement refer to the C6 SMART manufacturer's instructions in document KEB: 20130559

SECTION

4

4 Service

Caution: Service of the 9000 system must only be performed by qualified personnel. The 9000 system has no user serviceable parts. Contact Radeus Labs support for service if needed.

SECTION

A

Appendix

Appendix 1: Model 9000 ACS Specifications

Subject to change. *Details may vary between units. Always refer to specs current at the time the unit being used was manufactured. Also see the documentation for any specific system or custom configuration.*

Antenna Control Panel (ACP)

Ethernet:	Connect to the drive unit's internal or external network connections
USB:	Connect the keyboard and mouse
Power:	Connect the power supply

Tracking Accuracy

Better than 10% receive 3dB beamwidth RMS in steptrack.
Nominally 5% receive 3dB beamwidth RMS with predictive track.
Nominally 3% receive 3dB beamwidth RMS with monopulse track.

Environmental	
Temperature:	0–40° C
Humidity:	95% non-condensing

Electrical	
Electronics Power:	100–240 VAC Single Phase
	47–63 Hz
	100 W typical

Appendix 2: Model 9000 Drive Cabinet

4.1 Operating Environment, Power

Temperature:	0 to 40°C
Humidity:	95% non-condensing
Electrical:	200- and 400-Volt Class, 50–60 Hz, 5-wire WYE Electrical-current requirements determined by motor horsepower.

A-2.1 Mechanical (Cabinet Config)

Height: 72”
Width: 48”
Depth: 18”
Weight: 500 lbs.
Motor size: 1–15 HP standard. Larger sizes available.

A-2.2 Mechanical (Rack Config)

Height: 80” (42RU Cabinet)
Width: 48” (2 Racks Wide)
Depth: 39”
Weight: 250 lbs.
Motor size: 1–15 HP standard. Larger sizes available.

Appendix 3: Setup: GD Model 253

Instructions for the General Dynamics tracking receiver:

1. Power-off the Model 253 and set its internal switch S1 to position 1.
2. Power-on the 253.
3. Set the 253 to REMOTE mode — on the Summary screen, CONTROL: REMOTE will be indicated.
4. Set the 253's SERIAL PORT 1 settings to:
   a) BAUD: 19200
   b) PARITY: NONE
   c) DATA: 8
   d) STOP: 1
5. Connect the Model 253's port J1 DATA LINK 1 to the 9000's port J4 RS-232.
6. If replacing an existing 7200 unit, use the supplied null modem and the existing wiring.
7. If installing a new 9000, use a straight-through serial cable (i.e., no null modem required).
8. On the 9000 ACU, ensure that 253 is selected as the Setup > Receiver > Receiver type.
9. Verify that the frequency set at the 253 is shown on the 9000's data display.

Appendix 4: Setup: DTR

1. Set the DTR to its remote mode using SHIFT+HELP
2. Set DTR settings for PORT 1 as follows:
   a) BPS: 57600
   b) NEWLINE: DISABLED
   c) ECHO: DISABLED
   d) SHELL: M&C SHELL
3. Select RESET PORT on DTR
4. Connect the DTR's PORT 1 RS-232 to the 9000's port J4 RS-232
   a) If replacing an existing 7200, use the supplied null modem and the existing wiring.
   b) If installing a new 9000, use a straight-through serial cable (no null modem).
5. On the 9000 ACU, ensure that DTR is selected as the Setup > Receiver > Receiver type.

Verify that the frequency set at the DTR is shown on the 9000's data display.

Appendix 5: Setup: Radeus SSC Model 3430

For use with the Model 3430 beacon-tracking receiver.

⚠ *See the Model 3430 manual for details and important safety notes.*

Figure A-1 For serial communication:

1. Configure the RL9000 to use the 3430 Serial receiver

Figure A-2 Configure RL9000 with thew 3430 Serial Receiver

2. Connect the BTR's J2 M&C port to the 9000's port RS-232.
3. On the 3430 itself use the L/R button to enter *local mode*.
4. Press the > (right-arrow) button.
5. Press the + button to select RS-232.
6. Press the + button to select 19200 baud.
7. Press the CUR button to exit the menu.
8. Use the L/R button to enter *remote mode*.

For Ethernet communication:

1. Configure the RL9000 to use the 3430 Ethernet receiver
2. Input the IP address for the SSC 3430 that you will connect to

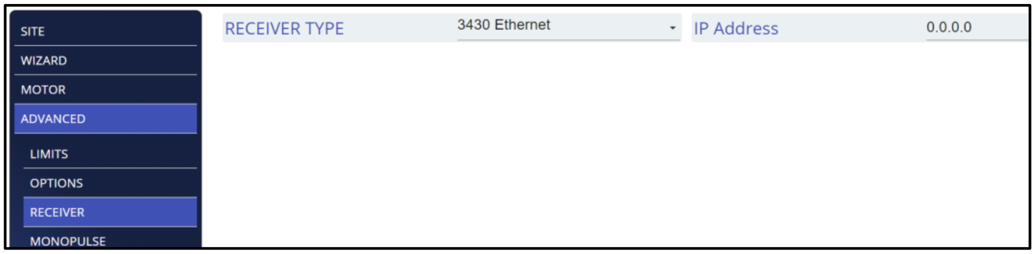


Figure A-3 SSC3430 Advanced options

3. On the 3430 itself use the L/R button to enter *local mode*.
4. Press the > (right-arrow) button.
5. Press the > button to select Ethernet
6. Press the CUR button to exit the menu.
7. Use the L/R button to enter *remote mode*.

Appendix 6: Setup: IRIG

Important
Connect the IRIG source *before* powering-up the ACU.

If the Model 9000 ACU is configured for IRIG-B,[4] it supports IRIG-B sources that output *one of the following:*

IRIG–B122/B123

B002/B003

B126/B127

B006/B007

If local time is needed, set it through the Windows time manager.

1. To do so, first quit the ACU application, or minimize it, to access OS functions — use Setup > About > Quit or Desktop.

   Note: If the time does not update within the first five minutes of using the ACU, follow the instructions below.

2. Open the IRIG monitoring software, “MbgMon v3.06.99.13,” via the Start menu.

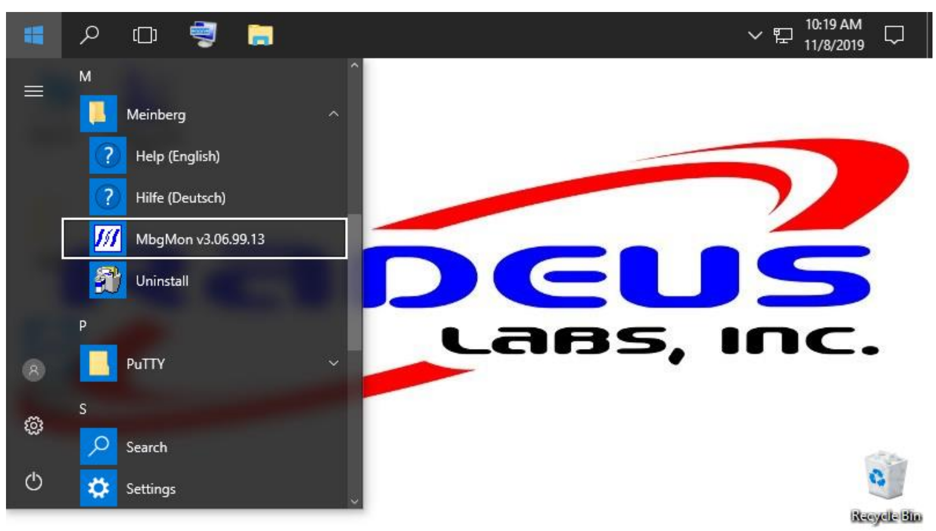
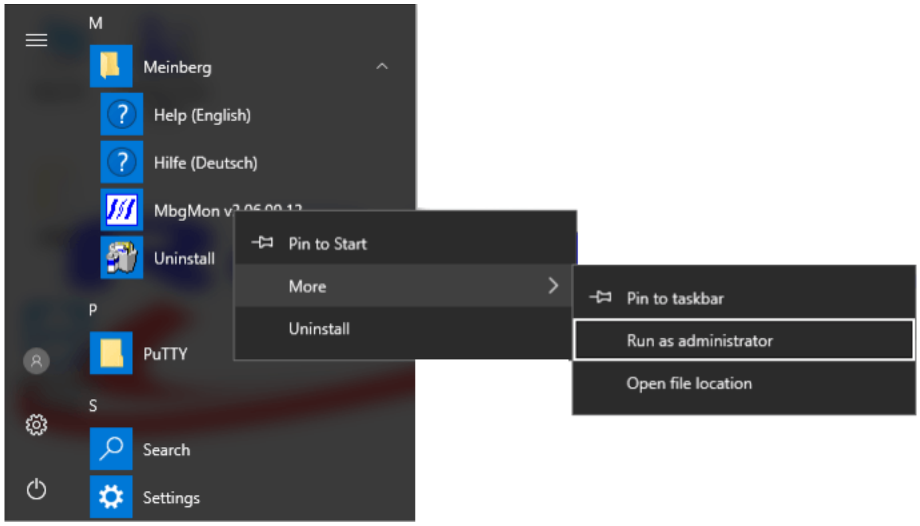


Figure A-4 This and the following figures demonstrate changing local time if the Windows time manager is not successful.

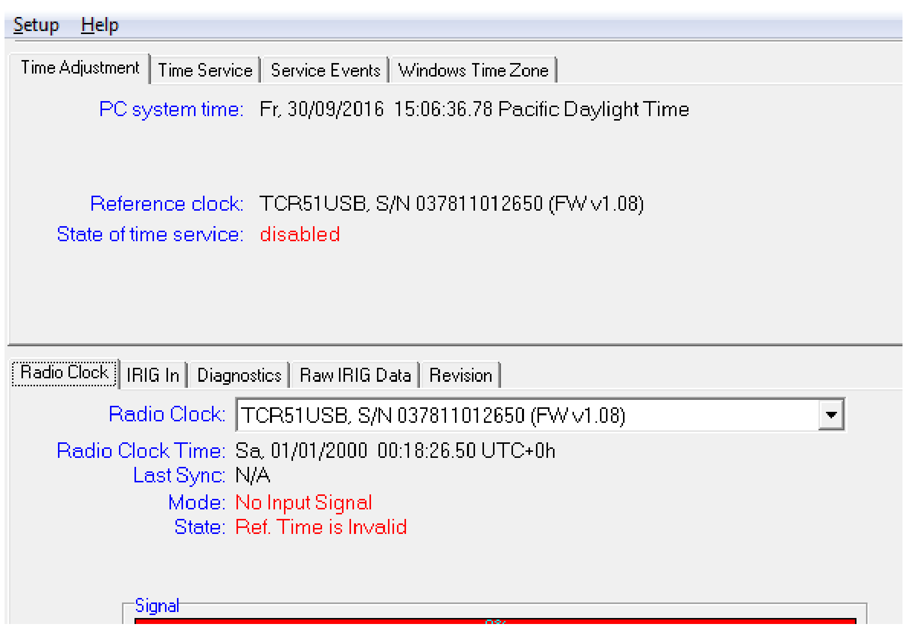
[4] IRIG-A is an option but must be configured before shipment. Inquire with Radeus Labs.

3. Right-click on the program and choose to "Run as administrator":

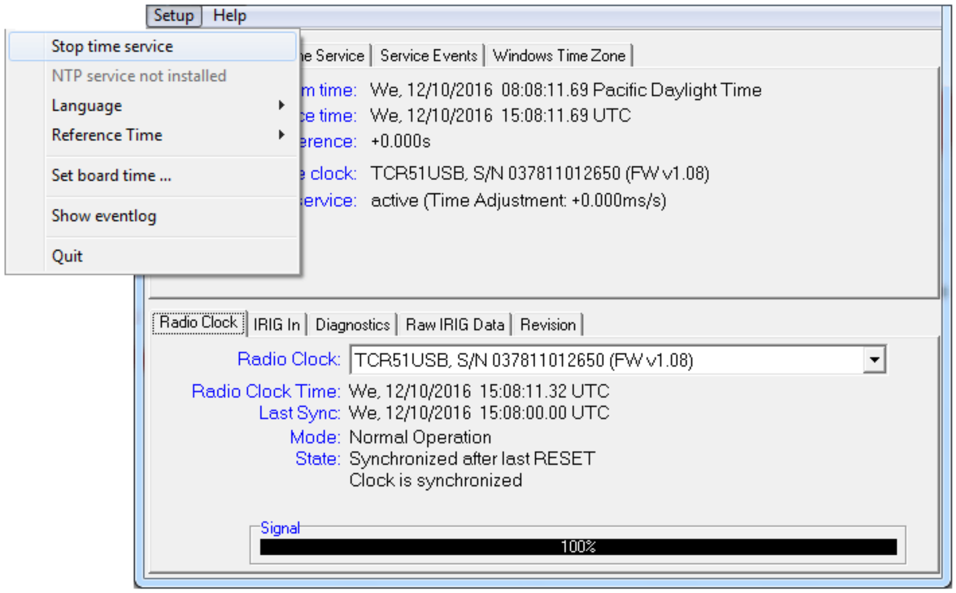


4. When the program opens:

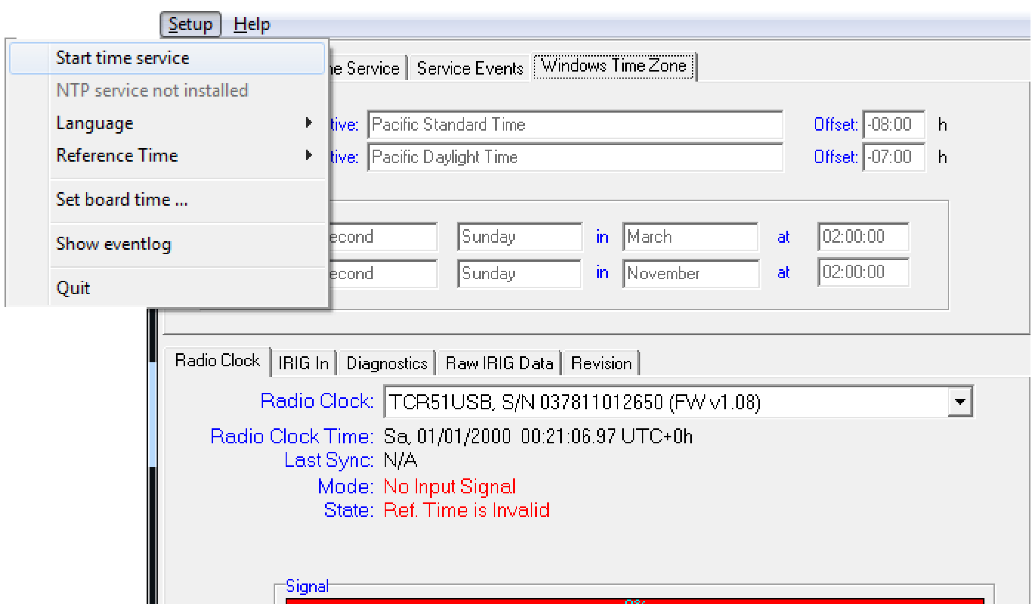
   - Make sure the signal is 100%.
   - Check that the clock is synchronized.
   - Verify that the Reference time is correct.



5. If those three are correct, choose Setup > Stop time service.



6. Then choose Setup > Start time service and the system time should update:



Appendix 7: IESS-412 file format

An IESS-412 data file consists of comma-separated values (CSV) for 11 ephemeris parameters and additional parameters supported by Intelsat Earth Station Standards.[5]

Example records:

sat name	Satellite name	
	Type:	string, unquoted
nom cob	Nominal Center-of-Box position, nominal orbital location	
	Type:	decimal number
	Range:	0.00 – 360.00
Epoch	Epoch expressed as a Julian day number	
	Type:	decimal number
	Range:	0 – 1.7E308
lm0	Mean longitude (deg. east of Greenwich)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
lm1	Drift rate (deg/day)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
lm2	Drift Acceleration (deg/day/day)	
	Type:	decimal number

5 https://www.celestrak.com/NORAD/elements/supplemental/IESS_412_Rev_2.pdf

	Range:	-1.7E308 – 1.7E308
lonc	Longitude Oscillation-amplitude (deg)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
lonc1	lonc rate of change, cosine term (deg/day)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
lons	Longitude Oscillation-amplitude (deg)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
lons1	lons rate of change, sine term (deg/day)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
latc	Latitude Oscillation-amplitude (deg)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308
latc1	latc rate of change, cosine term (deg/day)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308

lats	Latitude Oscillation-amplitude (deg)	
	Type:	decimal number
	Range:	-1.7E308 – 1.7E308

lats1	lats rate of change, sine term (deg/day) *Type:* decimal number *Range:* -1.7E308 – 1.7E308
verify_lon	Predicated satellite longitude 170 hours after epoch *Type:* decimal number *Range:* 0.00000 – 360.000
verify_lat	Predicated satellite latitude 170 hours after epoch *Type:* decimal number *Range:* -90.000 – 90.000
norad_num	NORAD catalog number, NORAD ID, satellite catalog number *Type:* integer *Range:* 0 – 99999

A-7.1 Example IESS-412 data

Authorized users of related Radeus Labs equipment have access to our comprehensive IESS-412 data file, which is updated regularly.

Two example records from such a file:

sat_name	nom_cob	epoch	lm0	lm1	lm2	lonc	lonc1 …
IS-21	302.00	2458451.50000000	302.0018	0.0034	-0.000586	0.0218	-0.0007…
IS-34	304.50	2458451.50000000	304.4936	-0.0025	-0.000586	0.0118	-0.0007…

…lons	lons1	latc	latc1	lats	lats1	verify_lon	verify_lat	norad_num
…-0.0120	0.0005	0.0265	-0.0018	0.0094	0.0010	302.0048	0.0209	38749
…0.0299	0.0005	-0.0283	-0.0018	0.0157	0.0011	304.4721	-0.0187	40874

Figure 4-3 Sample data records in IESS-412 format (split onto two lines here).

Appendix 8: Portable Maintenance Control Unit (PMCU)

Figure A-5 Portable Maintenance Control Unit (PMCU)

A-8.1 Introduction

The handheld Portable Maintenance Control Unit (PMCU) provides a means for moving an antenna manually by a user who is around or near the antenna or its drive cabinet. It can be used to maintain the antenna and associated systems.

A-8.2 PMCU in the Series 9000 ACS

Power

The PMCU device operates at 48VDC~52VDC delivered over its Ethernet connection to the drive cabinet.

Dependency

PMCU buttons except Halt or Local will be ignored if the ACS is in standby, manual, or tracking mode, or if there is no ACU and the drive cabinet is in remote mode.

Unplugging

If the PMCU is *unplugged after it was in local mode,* the DC goes into remote mode and the ACU is in standby.

Testing

Test mode 1: Press and hold Toggle and AZ CCW (the two upper-left buttons) while powering up. It sequences through all the LEDs – press any of those buttons and the LED by it will remain illuminated while you depress the button. The 7-segment display steps through all the displays continuously and lights up all the segment.

Test mode 2: Press the two upper-right buttons (SLEW and AZ CW) Lights up all the LEDs to show all LEDs and segments function.

To exit a test mode, the PMCU must be powered off and back on (unplugged, then plugged in).

A-8.3 PMCU Controls

LOCAL

The PMCU must be in Local mode in order to function.[6] When Local mode is active, the word LOCAL at the top of the device is illuminated in green.

- Entering Local mode also changes the drive cabinet to Local mode.

HALT — while in HALT mode…

…the drive cabinet's Local LED blinks and no axis movement can happen (power is removed from the motors).

…the ACU displays a PMCU fault and a maintenance override fault.

Halt mode can be canceled by pressing the PMCU's Halt button again or by pressing drive cabinet's Local button twice. (Pressing the drive cabinet's Local button puts the system into Remote mode; one more push puts it back into Local mode.)

TOG ("toggle")

The movement buttons normally cause the antenna to move only while they are depressed. Toggle mode changes that, so pressing a direction button starts *motion that will continue until the button is pressed again*.

GO TO ANGLE

⚠ *Warning:* soft limits will not be respected in this mode.

Press and hold the Toggle ("TOG") button for one second to activate *go-to-angle mode*. The blue LED under it will light and all valid directional LEDs will blink.

Press the jog buttons to change the commanded display angles — no motion will take place until…

---

[6] The exception is the Halt button, which works whenever the PMCU is connected to the drive cabinet.

…pressing the toggle button starts the commanded movement.

Change your mind? When in go-to mode, press and hold toggle for one second, then release, to cancel and start over. If no change has been made to the angles and you tap toggle, it exits go-to mode. Returning to remote mode (pressing Local) or entering halt mode (pressing Halt) cancels go-to mode and discards any changes to the angles.

This uses the slew threshold and deadband settings specified in Setup > Positioner.

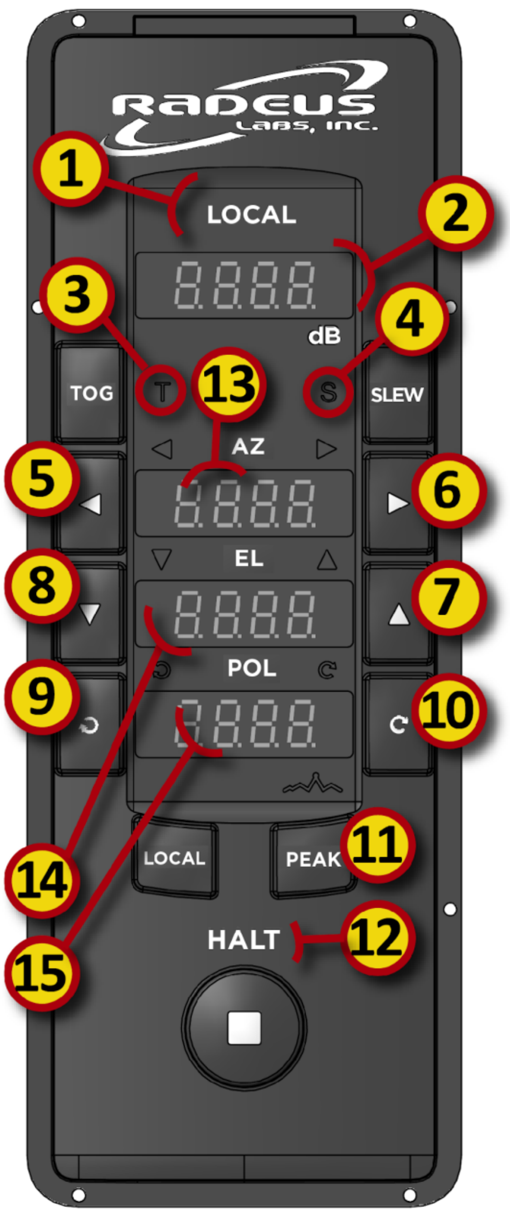
- The Slew button doesn't respond in this mode.

PEAK

Reserved for future use.

Will require an ACU signal level.

A-8.4 Indicators & Displays



1. Local LED — on when drive cabinet (DC) is in local mode

2. Signal Level — when connected to ACU, display relative signal level

3. Toggle LED —
off: system is in momentary (DC or PMCU)
green on: system is in toggle mode (DC or PMCU)
blue blinking: waiting for user to choose move-to angles
blue on: moving to look angle
red blinking: movement interrupted by fault

4. Slew LED —
on: system is in slew mode (DC or PMCU)
off: system is in track mode (DC or PMCU)

5. AZ CCW — on: AZ motor is moving CCW
6. AZ CW — on: AZ motor is moving CW

7. EL UP — on: EL motor is moving UP
8. EL Down — on: EL motor is moving Down

9. POL CCW — on: POL motor is moving CCW
10. POL CW — on: POL motor is moving CW

11. Peak —
blue LED on: performing peaking function
blue LED blinking: waiting for user to choose direction/axis to peak
red LED on: peak pressed in unsupported function
red LED blinking: movement interrupted by a fault

12. HALT — on: system is in Halt mode

13. AZ
14. EL
15. POL
] if ACU is present, show offset angles

Figure A-6 PMCU labeled buttons

Appendix 9: ACU Remote Control Methods

The following remote-control methods are supported:

A-9.1 TeamViewer

TeamViewer software enables remote access to the ACU. It supports both Internet and private network connection.

This remote-control method provides access to the functions available on the ACU touch panel. Additionally, files can be transferred between the ACU and the device running TeamViewer.

This software is loaded on all Radeus Labs ACUs.

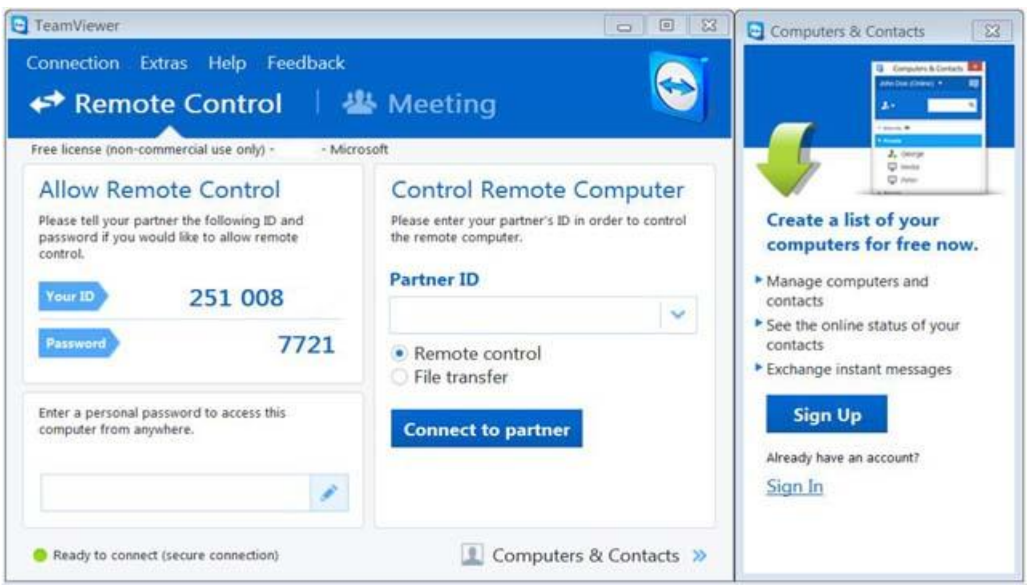


Figure A-7 TeamViewer provides remote access to Radeus Labs ACUs.

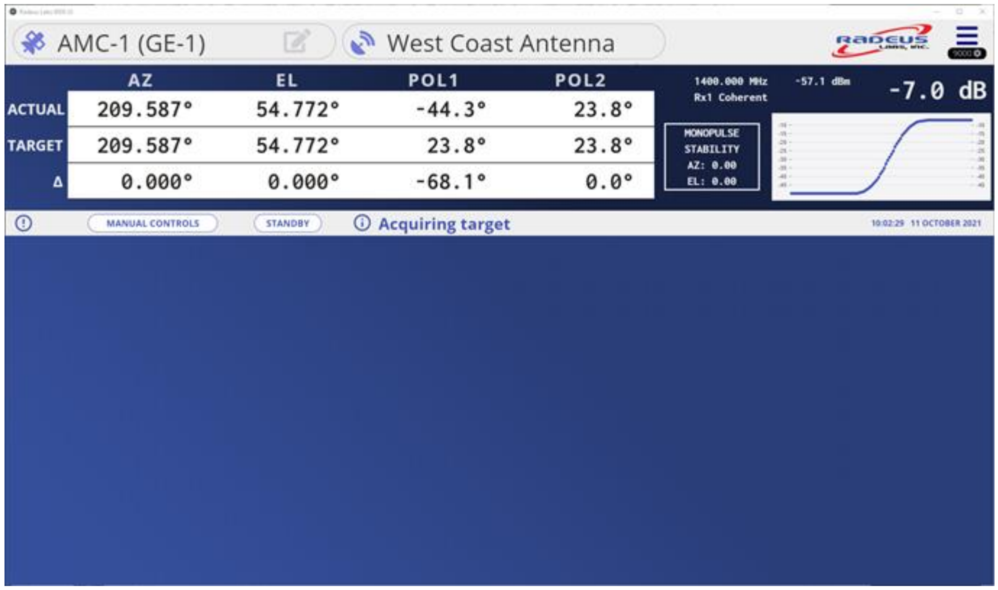


Figure A-8 TeamViewer's remote view of the ACU's display.

If permission is granted, Radeus Labs Support can connect to an ACU using TeamViewer in order to update software and provide troubleshooting. By downloading logs and system parameters, Radeus Labs Support can deliver tracking performance and diagnostics.

For instructions on how to connect to an ACU using TeamViewer, refer to TeamViewer - Spontaneous Support instructions.

A-9.2 SNMP

The Simple Network Management Protocol (SNMP) allows extensive ACU control and diagnostics via network connection. It consists of GET and SET commands to retrieve and configure parameters and to command actions. Radeus Labs ACUs support SNMP v1,v2c, and v3.

SNMP typically is used for integrating the ACU into Monitor-and-Control (M&C) systems that provide real-time system information, fault detection, target scheduling, etc.

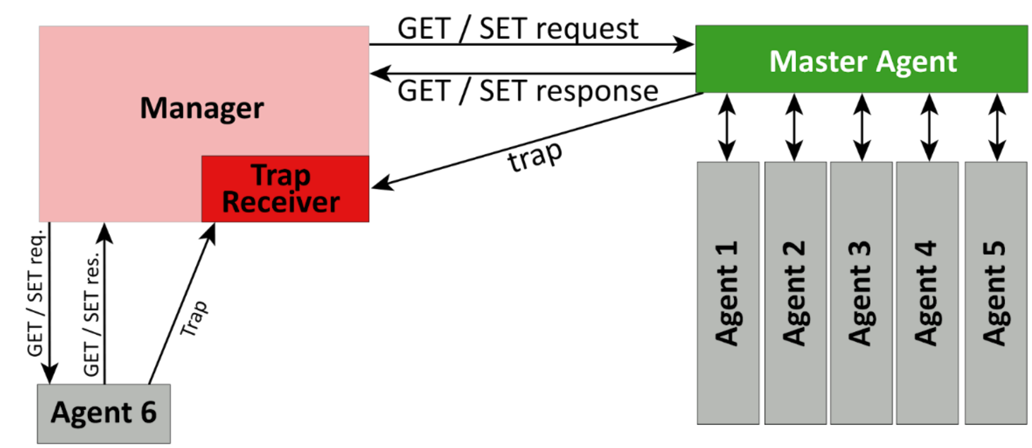


Figure A-9 The SNMP option for remote control uses GET/SET commands.

Management Information Base (MIB) files define the SNMP calls that can be issued to the ACU for remote control. A copy of these files is located on the ACU Windows Desktop (see **Figure 5-13**):

C:\Users\Public\Desktop\MIBS

Updated MIB files are available for download from:

https://www.radeuslabs.com/

Please contact support@radeuslabs.com for access.

To use SNMPv3 the system needs to have the authentication password and privacy password populated in the INI file. When these fields are populated the system disables SNMPv1 and v2. When configuring the a device to use SNMPv3 in communication with the ACU use the Security User Name "RadeusLabs" the Authentication Protocol of SHA, and the Privacy Protocol of AES128.

If you want to control the ACU remotely, you can use SNMP calls defined in the Management Information Base (MIB) files. These files are saved on the ACU Windows Desktop:

C:\Users\Public\Desktop\MIBS

Updated MIB files are available for download from:

- https://www.radeuslabs.com/

  Please contact support@radeuslabs.com *for access.*

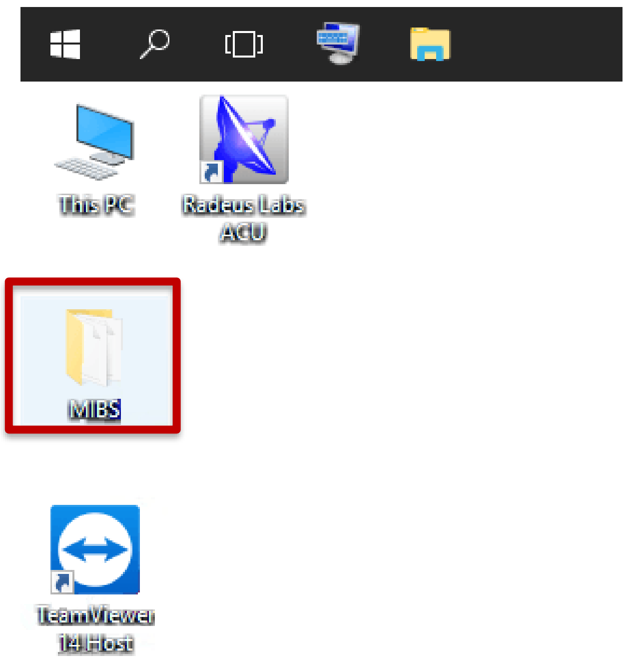


Figure A-10 MIBS Files on the ACU Desktop

To use SNMPv3, you must include the authentication and privacy passwords in the INI files. If you populate these fields, SNMPv1 and v2 will be disabled. When you configure a device to use SNMPv3 to communicate with the ACU use the following:

Security User Name: RadeusLabs

Authentication Protocol: SHA

Privacy Protocol: AES128.

A-9.3 SNMP Requirements

An Ethernet connection to the ACU rear panel port "E1 NETWORK" is required for SNMP communication.

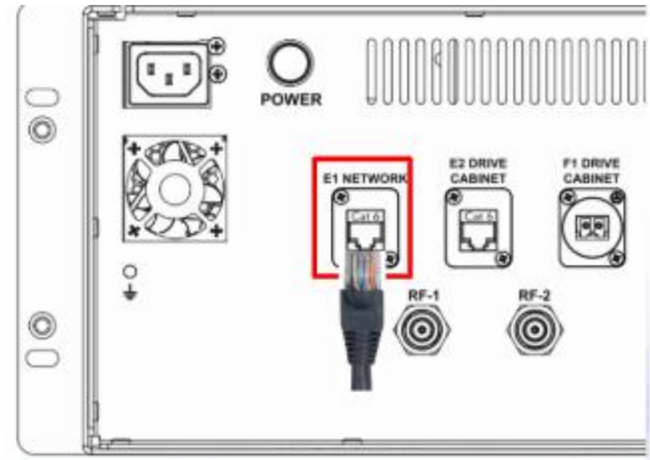


Figure A-11 Ethernet connection back of the ACU

A-9.4 Commercial M&C software with Radeus Labs ACU support

The following commercial M&C (Monitor and Control) software offer M&C solutions for Radeus Labs ACUs:

- Dataminer
- Kratos Compass
- SED Mon-A-Co

A-9.5 Open source M&C software

The following software is freely available for M&C use:

- Cacti
- Zabbix

A-9.6 SNMP Tools

The following can help test SNMP communication with an ACU:

- net-snmp — Unix-based command-line utility for walking the tree, setting and getting values via SNMP.
- SnmpB — GUI-based utility for SNMP communication.

A-9.7 Serial M&C (7200 Request / Command M&C Protocol)

As a drop-in replacement for the GD 7200 ACU, the Radeus Labs ACU supports serial remote control. The simple protocol provides limited ACU control useful in supporting legacy systems or transitioning from 7200 to Radeus Labs 8000 or 2000 series ACUs.

For more information refer to CG-6042 (Rev. L, Nov. 2005).

A-9.8 Requirements for serial M&C

- A straight-through serial cable must be connected to the ACU rear panel port J5 RS-232 (DB25F). If using legacy 7200 serial cables, a null modem is required (one ships with Radeus Labs 8200 ACU Legacy configurations).

For pinout information, please see Appendix A-2.1.

A-9.9 Web Interface

If the system is connected to a LAN the interface can be connected to using a web browser of a computer on the same network. The ip address to connect will be the ip address assigned to the SCU.

- The system supports a web interface after version 9k-RC152, which allows users to access an ACP-like interface from any computer on the same network. This makes it more convenient to control the unit or operate it remotely in unmanned locations.

A-9.10 REST API

This document is for developers who want to use the Radeus Labs Antenna Control Unit (ACU) RESTful API. It assumes the reader is familiar with web programming concepts and web data formats.

A-9.11 Before you start

- Obtain the API key for your ACU. This is contained in the file:

  C:\Radeus Labs REST\api-key.txt

  The key is unique to each unit and cannot be reused elsewhere.

- Be familiar with the ACU. The REST API provides a subset of the capabilities offered by both the ACU itself and the SNMP management-and-control interface.

The full OpenAPI specification for the ACU RESTful API is contained in the acu_openapi.yaml file provided by Radeus Labs.

A-9.12 API key

The API key needs to be supplied in the request header for each API call. The key is placed in the api-key field.

A-9.13 Testing API operation

You will need the IP address of your ACU in order to test proper operation.

Options for confirming that the API is properly deployed and working include Postman, curl, and PowerShell's Invoke-RestMethod but other tools and methods may be utilized:

Postman — https://www.postman.com/

Curl — https://curl.haxx.se/

Invoke-RestMethod — https://docs.microsoft.com/en-us/powershell/module/microsoft.powershell.utility/invoke-restmethod

A-9.14 Get API version

The /version command can be used to verify that the REST API has been correctly installed and is accessible in your environment. The following section provides details on how to do this with the most commonly used tools.

A-9.14.1 Postman

Postman is a full GUI desktop application that can be used for exploring REST APIs. Installation and operation is beyond the scope of this document, but this article…

https://learning.postman.com/docs/getting-started/importing-and-exporting-data/

…describes how you can import the OpenAPI specification into Postman to streamline the process. Alternatively, you can just issue the /version request and go from there.

curl

The following command can be used to test with curl:

curl -X GET https://acu.radeuslabs.com/version

If the domain name entry has not been created or the CA certificate hasn't been installed, you can use the following command, substituting <ipaddress> with the IP address of your ACU:

curl -k -X GET https://<ipaddress>/version

A-9.14.2 Invoke-RestMethod

The following command can be used to test with the Windows Powershell Invoke-RestMethod command:

Invoke-RestMethod https://acu.radeuslabs.com/version

If the domain name entry has not been created or the CA certificate hasn't been installed, you can use the following command[7], substituting <ipaddress> with the IP address of your unit:

Invoke-RestMethod -SkipCertificateCheck https://<ipaddress>/version

All commands, including the script can be run in a non-administrative session.

A-9.14.3 SSL CA certificate

The API can be used to retrieve the public CA certificate that was used to sign the SSL certificate used by the ACU. This certificate can be installed on your local machine to ensure the identity of the ACU.

It can be requested at the following endpoint:

https://acu.radeuslabs.com/certificate

[7] The -SkipCertificateCheck parameter was added in PowerShell 6.0.0. If you are using an earlier version, you can use the Invoke-RestMethod-SkipCertCheck.ps1 script provided by Radeus Labs.

A-9.14.4 ACU domain name entry

In order for the certificate to work, a local DNS entry is needed in either your /etc/hosts file or C:\Windows\System32\drivers\etc\hosts file, depending upon your operating system.

Appendix 10: Advanced Configuration - acu.ini

The text file acu.ini consists of key-value pairs. It is used to configure ACU options not exposed by the system's GUI.

A-10.1 File location

In the ACU's host OS, the file is located at:

C:\Radeus Labs\acu.ini

A-10.2 Default acu.ini

Caution: Use extreme caution when making any change to this file. Its default contents when shipped:

[EPHEMERIS]
;TLEPATH=
;IESSPATH=

[SNMP]
;READ_COMMUNITY=
;WRITE_COMMUNITY

TLEPATH

Used to specify an alternate web location for the ACU to request TLE ephemeris data.

· The web server must not be password protected and must be accessible by the ACU over HTTP (not HTTPS).

· The file must follow the NORAD Two-Line Element Set Format.

The ACU checks this location every 24 hours for updated ephemeris data, making a local copy. The ephemeris file served does not need to be named geo.txt.

Type: string, unquoted

Example IESS path (any space character must be encoded as %20 as shown below):
TLEPATH=http://the.domain.com/file%20repository/ … [more path] … /geo.txt

IESSPATH

Used to specify an alternate web location for the ACU to request IESS-412 ephemeris data. An Ethernet cable must be connected to the rear-panel port labeled:

- The web server must not be password protected and must be accessible by the ACU over HTTP (not HTTPS).

- The file must conform to spec; see “Appendix 11: IESS-412 file format.”

The ACU will check this location every 24 hours for updated ephemeris data, making a local copy. The ephemeris file served does not need to be named satlist.csv.

Type: string, unquoted

Example IESS path (any space character must be encoded as %20 as shown below):

IESSPATH=http://the.domain.com/file%20repository/ … [more path] … /geo.txt

A-10.3 Disable automatic TLE download

When providing custom TLE files by means such as LAN or USB (see section 2.6.3.1), the ACU can be instructed to disable download-ing TLE so the custom TLE files are not overwritten. The following entry should be used for this purpose:

TLEPATH=0
IESSPATH=0

[SNMP]

READ_COMMUNITY

Specify a read community string for SNMP (v1 & v2c) GET requests. If this is not specified, the ACU will accept any community string for GET requests.

Example:

READ_COMMUNITY=public

WRITE_COMMUNITY

Specify a write community string for SNMP (v1 & v2c) SET requests. If this is not specified, the ACU will accept any community string for SET requests.

Example:

WRITE_COMMUNITY=private

Appendix 11: Web Interface Installation

A-11.1 Download and Install

- Visit the Radeus Labs website to access the Web Interface download:
- https://www.radeuslabs.com/.
- If you encounter any issues with access, contact Support@radeuslabs.com for assistance.
- Download the file and make a note of the download location.
- Locate the downloaded file and double-click it to initiate the installation process.

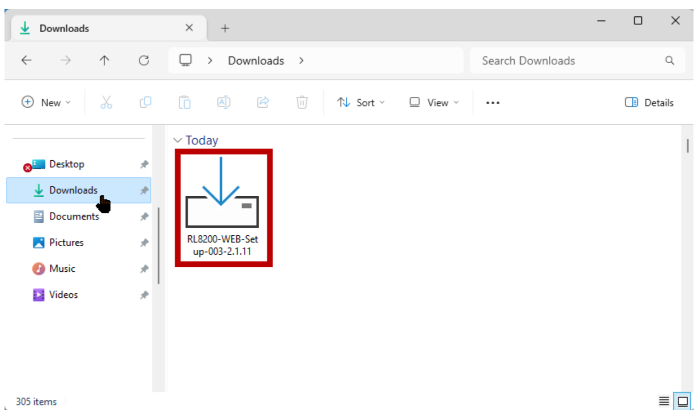


Figure A-12 Open the Web Interface Download

- During the installation, you may encounter prompts asking for your consent to install the interface. Be sure to accept these prompts if you want to proceed.

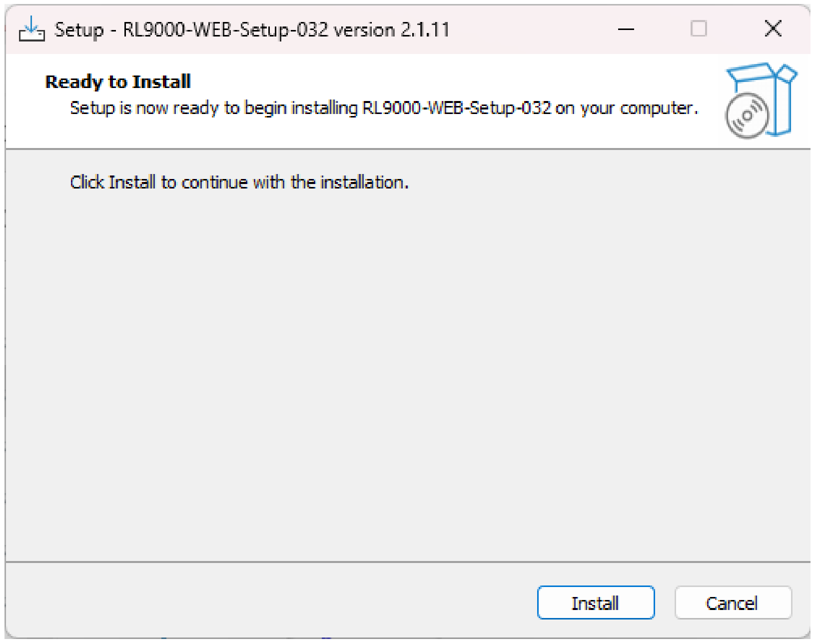


Figure A-13 Installation Prompt

- Click the "Install" button, and the necessary files will be installed on your computer.

NOTE: Part of this installation includes a blue dialog box. Once this box closes, you can proceed with your work.

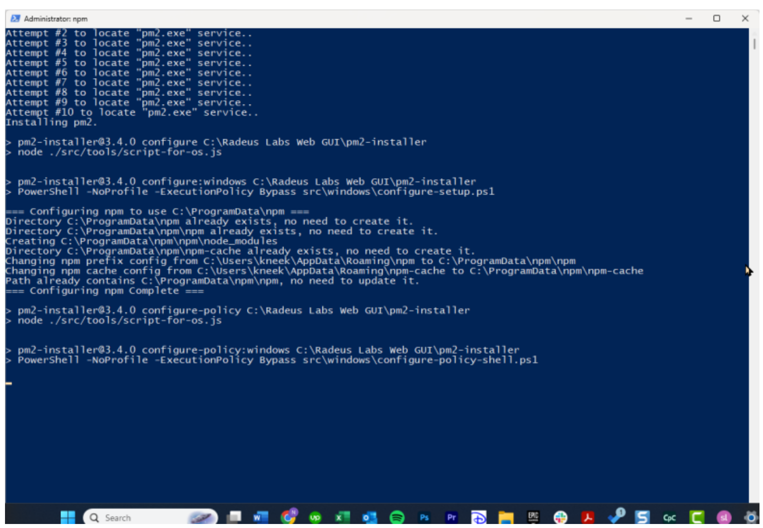


Figure A-14 Blue dialog box when installing the Web Interface

- Click Finish to complete the installation.

A-11.2 Opening the Web Interface

NOTE: Make sure the Radeus Labs ACU software is running on your computer. If it's not running, start it using the instruction found in.

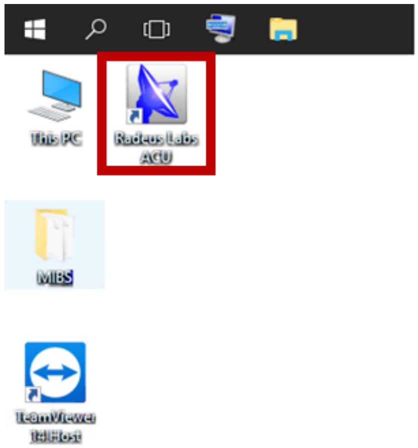


Figure A-15 Radeus Labs ACU Software Icon on Desktop

Open your computer's Network & Internet settings and select either Wi-Fi or Ethernet, depending on your internet connection method.

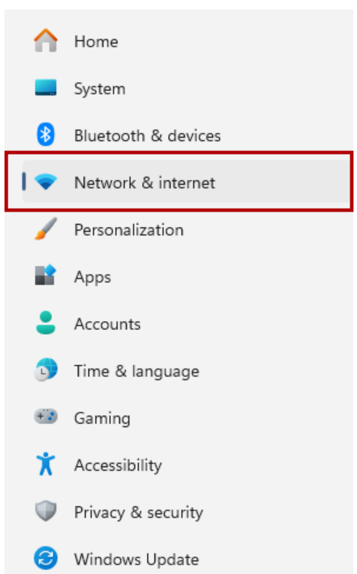


Figure A-16 Network & Internet Settings

- Access the properties of your selected Wi-Fi or Ethernet connection and copy the IP address.

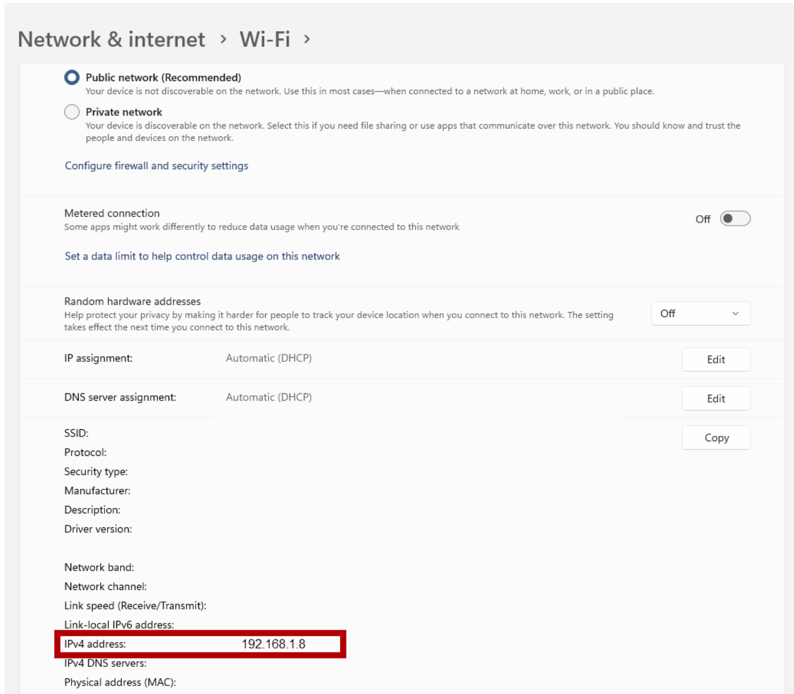


Figure A-17 Find your IP address

- Open your web browser and paste the copied IP address into the address bar. Then, press "Enter."

Figure A-18 Paste IP address in the address bar

- Before it will open, you may receive a dialog box warning that you are about to open a non-secure website. Follow these steps to proceed:
- Click "Advanced."
- Click "Proceed to (IP address) (unsafe)."

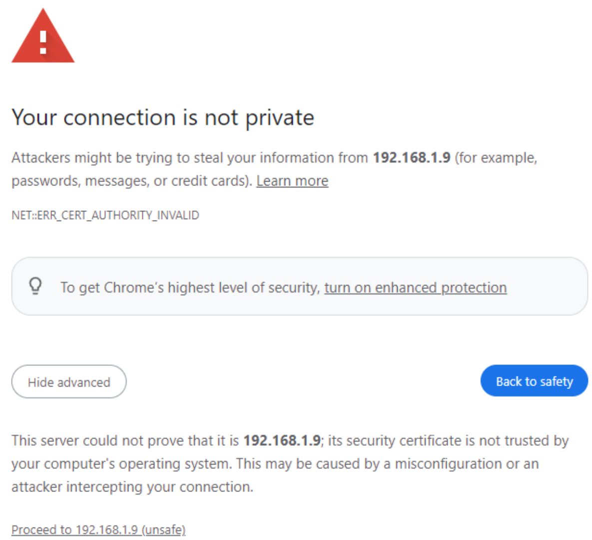


Figure A-19 Proceed with unsafe Network

- The Web Interface will open and be ready for use.

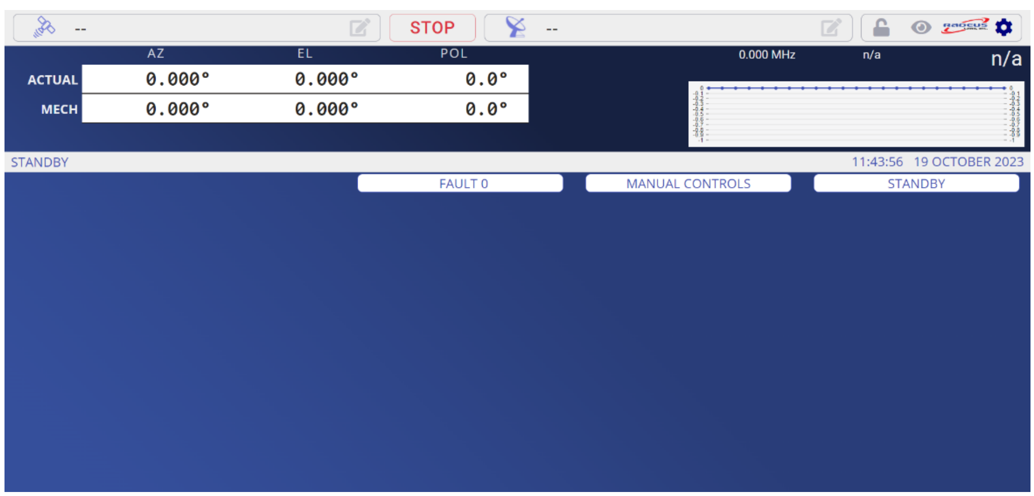


Figure A-20 Web Interface Home Page

Appendix 12: List of Figures

Appendix 13: Description of CE Symbols

Certain symbols important to the European Union CE mark are used in this manual and may be placed on equipment.

General Warning or Caution:

The Exclamation Symbol designates an area where personal injury or damage to equipment is possible.

Electrical Shock:

The Electrical Shock Symbol indicates a hazard arising from dangerous voltage. Any mishandling could result in irreparable damage to equipment, and personal injury or death.

European Union CE Mark:

The presence of the CE Mark on our equipment indicates it has been designed, tested, and certified as complying with all applicable European Union (CE) regulations and recommendations.

Waste Electrical and Electronic Equipment (WEEE):

Indicates it is the user's responsibility to dispose of waste according to local laws. The separate collection and recycling of waste equipment at the time of disposal will help conserve natural resources and ensure it is recycled in a manner that protects human health and the environment.