Antenna Controller

sat-nms ACU2-ODU-DC

User Manual

Version 3.3.1

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Table Of Contents

Table Of Contents 1
sat-nms ACU2-ODU DC Version User Manual 2
5.3 Target Memory 23
5.3.1 How to make a new target 25
5.9.2 I11 Dataset Editor 52
7.5 One line read via TCP/IP 81
7.6 SNMP Remote Control 82
8.5 Program Tracking 95
8.6 Memory Tracking 96
8.7 Prediction Tracking with Ephemeris Data 96
8.7.1 Intelsat eleven Parameter Prediction (I11) 97
8.7.2 Two Line Elements Prediction (TLE) 97
8.8 Polarization Prediction 98
8.9 Faults and Tracking 99

sat-nms ACU2-ODU DC Version User Manual

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Abstract

> The ***sat-nms*** ACU-ODU is a full featured antenna positioner and as an option antenna tracking system. The electronics of the ***sat-nms*** ACU-ODU is build into an outdoor cabinet. The protection class of the cabinet is IP66 if no optional air ventilation is installed. So it is no problem to install it outside without any additional roof.
>
> This document describes how to install, setup and operate this antenna controller.

Table Of Contents

- 1 Introduction
- 2 Safety Instructions
- 3 The ***sat-nms*** ACU-ODU DC
  - 3.1 ***sat-nms*** ACU-ODM
  - 3.2 Power supplies for ***sat-nms*** ACU-ODM
  - 3.3 Power supply for motor drivers
  - 3.4 Motor drivers
  - 3.5 Circuit breakers
  - 3.6 Contactor
  - 3.7 Terminals
  - 3.8 Heater
  - 3.9 Optional air ventilation
- 4 Installation
  - 4.1 Mechanical installation
  - 4.2 Interfaces to the Antenna, Pin descriptions
    - 4.2.1 Angle encoder connection
    - 4.2.2 Limit switch and emergency switch connection
    - 4.2.3 Motors connection
    - 4.2.4 Mains connection
    - 4.2.5 Ethernet connection
  - 4.3 Start-up
    - 4.3.1 Setting the IP Address
    - 4.3.2 Limit switches
    - 4.3.3 Angle detectors
    - 4.3.4 Motors
    - 4.3.5 Pointing/ Tracking
    - 4.3.6 Backup of ACU settings
- 5 Operation
  - 5.1 The Web-based User Interface
  - 5.2 Antenna Pointing
  - 5.3 Target Memory
    - 5.3.1 How to make a new target
  - 5.4 Tracking Parameters
  - 5.5 Test Page

    - 5.6 Setup
    - 5.7 Handheld/ Frontpanel Operation
        - 5.7.1 LCPH (Local Maintenance Controller)
        - 5.7.2 LCPHD-PT (Local Maintenance Controller with Display)
        - 5.7.3 RCPH (ACU Handheld Controller)
        - 5.7.4 RCPH19 (ACU Handheld Controller 19��?)
        - 5.7.5 Handheld Terminal
    - 5.8 Target Editor
    - 5.9 Orbital Data Editor
        - 5.9.1 TLE Dataset Editor
        - 5.9.2 I11 Dataset Editor
- 6 Frontpanel operation
- 7 Remote Control
    - 7.1 General command syntax
    - 7.2 The TCP/IP remote control interface
    - 7.3 The RS232 remote control interface
    - 7.4 Parameter list
    - 7.5 One line read via TCP/IP
    - 7.6 SNMP Remote Control
- 8 Theory of Operation
    - 8.1 Angle Measurement
    - 8.2 Pointing / Motor Control
    - 8.3 Steptrack
        - 8.3.1 The ***sat-nms*** Steptrack Algorithm
        - 8.3.2 ACU and Beacon Receiver
        - 8.3.3 Smoothing
        - 8.3.4 Steptrack Parameters
    - 8.4 Adaptive Tracking
        - 8.4.1 The ***sat-nms*** Adaptive Tracking Algorithm
        - 8.4.2 The Tracking Memory
        - 8.4.3 Adaptive Tracking Parameters
        - 8.4.4 Hardware Protective Mode (Spindle Save Mode)
    - 8.5 Program Tracking
        - 8.5.1 Practical Usage
        - 8.5.2 File Format
    - 8.6 Memory Tracking
    - 8.7 Prediction Tracking with Ephemeris Data
        - 8.7.1 Intelsat eleven Parameter Prediction (I11)
        - 8.7.2 Two Line Elements Prediction (TLE)
    - 8.8 Polarization Prediction
    - 8.9 Faults and Tracking
- 9 Specifications

1 Introduction

The ***sat-nms*** Antenna Control Unit is an antenna controller / positioner with optional satellite tracking support. It may be operated as a standalone unit or in conjunction of the ***sat-nms*** ACU-IDU, a PC based indoor unit which offers extended tracking capabilities and a full featured visualization interface.

The ***sat-nms*** ACU is available as:

- ***sat-nms*** ACU2-ODM: only the core-module integrated in a compact case prepared for mounting on a 35mm DIN rail
- ***sat-nms*** ACU2-ODU: complete antenna controller system for AC- or DC-Motors integrated in an outdoor cabinet that could be mounted directly to the antenna. By mounting a ***sat-nms*** LBRX beacon receiver into this cabinet, you have a complete antenna tracking system in a compact cabinet directly at your antenna.
- ***sat-nms*** ACU2-RMU: complete antenna controller system for AC-Motors integrated in a 6RU 19inch rack mount case for indoor use
- ***sat-nms*** ACU2-19: complete antenna controller system for DC-Motors integrated in a 1RU 19inch rack mount case for indoor use
- ***sat-nms*** ACU2-19V2: antenna controller pincompatible to former Vertex 7200 ACU. It directly controls existing Vertex 7150 outdoor cabinet together with Vertex PMCU handheld.

For detailed description please refer to the ***sat-nms*** documentation CD or www.satnms.com

Main benefits of the ***sat-nms*** ACU are:

- The ACU outdoor unit is able to act as a standalone antenna control and tracking system without an indoor unit required.
- The ACU provides an Ethernet interface using the TCP/IP and HTTP Internet protocols. It can be controlled using any PC providing an Ethernet interface and a web browser like the Microsoft Internet Explorer. The ACU runs a web server which acts as a user interface to the antenna controller.
- The ACU is prepared to read the receive level of a ***sat-nms*** beacon receiver through the TCP/IP interface.
- The flexible interface design of the ACU enables it to control most types of motor driving antennas for geostationary satellites. Supported motor controllers are (configurable in the field):
- **Power relays:** This simple solution is suitable for antennas using 2-speed AC motors.
- **Frequency inverters:** Speed and acceleration/deceleration ramps are programmed into the inverter module with this solution.
- **Servo controllers:** Used for DC motors at small antennas or AC servos for big Antennas, especially with countertorque drives.

Supported position sensors are (separate hardware interface modules for each axis):

- **Resolver Interface:** The resolver interface module contains a resolver to digital chip which does the decoding of the resolver sin/cos signals.
- **SSI Interface:** SSI is a high speed serial interface used by modern digital position encoders.
- **DC Voltage Interface:** The third position encoder interface module contains an A/D converter which is suited to measure the DC voltages produced by simple inductive angle encoders. This application is for small antennas especially in the SNG business.

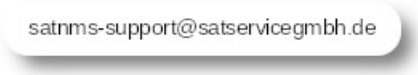
The paragraphs below give a short overview to the contents of the documentation. A subset of this documentation is stored on the device itself, the complete documentation is available on the ***sat-nms*** documentation CD and at www.satnms.com .

- Safety Instructions: This chapter gives an overview about the safety precautions that have to be observed during installation, operation and maintenance.

- Unit Overview : The installation chapter gives informations about the different modules that are integrated in the ACU (not ACU2-ODM and ACU2-19).
- Installation/Start-up : The installation chapter guides through the installation and setup of the ACU outdoor module. It describes the mechanical concept of the ACU and the assignment of the ACU's connectors. It gives you informations about the starting up procedure. Finally you learn in this chapter how to set the ACU's IP address, which is a essential precondition to operate the ACU by means of a web browser.
- Operation : The ***sat-nms*** ACU is operated using a standard web browser like the Microsoft Edge on MS Windows based computers. The user interface design is straight forward and clearly structured. Operating the ACU is mostly self-explanatory. Nevertheless, the 'Operation' chapter outlines the map of web pages which make up the ACU user interface and elaborately describe the meaning of each alterable parameter.
- Frontpanel Operation : The ***sat-nms*** ACU2-19, ***sat-nms*** ACU2-19V2 and the ***sat-nms*** ACU2-RMU optionally are equipped with a frontpanel Human-Machine-Interface. This Keyboard/ Display combination is also available as remote 19��? controller (***sat-nms*** RCP19) for units without frontpanel or also as local handheld-controller (***sat-nms*** RCPH). This chapter describes how to use this interface.
- Remote Control : The ACU outdoor module provides a versatile remote control interface. A monitoring & control software may fully operate the ACU either through a TCP/IP network connection or through the RS232 interface of the ACU. This chapter describes the communication protocol used for remote control and lists all parameters accessible through the remote interface.
- Theory of Operation : This chapter gives a short overview how the ACU works. It also describes the different tracking algorithms and their parameters. The interaction with a beacon receiver is described as well. Knowing about the theory regarding this functions helps to find the best parameter settings for a given application.
- Specifications : At the end of the document, the specifications applicable to the ***sat-nms*** ACU are summarized in this chapter.

Support and Assistance

If you need any assistance regarding our ACU, don't hesitate to contact us. We would be pleased to help you by answering your questions.



helpmail.png

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2 Safety Instructions

Safety

The mains shall only be connected provided with a protective earth wire. Any interruption of the protective wire, inside or outside the ***sat-nms*** ACU, is likely to make the unit dangerous. Intentional interruption is prohibited.

The unit described in this manual is designed to be used by properly-trained personnel only.

Adjustment, maintenance and repair of the exposed equipment shall be carried out only by qualified personnel who are aware of hazards involved.

Refer servicing to qualified personnel.

To prevent electrical shock, do not remove covers.

For the correct and safe use of the instrument, it is essential that both operating and servicing personnel follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

Whenever it is likely that safety protection is impaired, the unit must be made in-operative and secured against unintended operation. The appropriate servicing authority must be informed. For example, safety is likely to be impaired if the unit fails to perform the intended measurements or shows visible damage.

Ensure that the cabinet is proper connected to the protective earth conductor.

The circuit breaker, that fuses the mains for the ***sat-nms*** ACU has to switch off all phases AND the neutral wire as well.

Installation of any electrical kind have to carried out by electrial skilled specialits only!

WARNINGS

- The outside of the equipment may be cleaned using a lightly dampened cloth. Do not use any cleaning liquids containing alcohol, methylated spirit or ammonia etc.
- Follow standard Electrostatic Discharge (ESD) procedures when handling the Unit.
- Apply the appropriate voltage according to the attached schematic.
- Only use shielded cable to connect the AZ- and EL-Motor. The other components in the cabinet might be jammed through the harmonic waves the frequency inverters inject into the motor wires.
- Use only double shielded twisted pair cables (e.g. CAT7 Ethernet cable) to connect the resolvers to the ***sat-nms*** ACU

Additional warnings only ACU2-ODU :

- If the Unit is equipped with an optional air ventilation, avoid direct contact with jets of water, normal rain is no problem.
- In case of switching off all the circuit breakers in the ACU2-ODU, there is still voltage available at the mains terminals! Install an external mains/feeder switch if you like to disconnect the whole cabinet from power. If UPS mains is connected, use a switch that disconnects mains power as well as UPS power at once!

3 The ***sat-nms*** ACU-ODU DC

The ***sat-nms*** ACU-ODU is a full featured antenna positioner and as an option antenna tracking system. The electronics of the ***sat-nms*** ACU-ODU is build into an outdoor cabinet. The protection class of the cabinet is IP66 if no optional air ventilation is installed. So it is no problem to install it outside without any additional roof.

The unit consists from the components listed in the following table. All of these components are described in the next chapters. As the unit is available in different versions (optional LNA power

supply, with or without Polarisation drive ect.) the following picture shows one standard cabinet. The look and the arrangement of the units may vary depending on your demand.

ACU-ODU-DC_num.gif

No.	*component*	*No.*	*component*
(1)	***sat-nms*** ACU-ODM	(5)	Circuit breakers
(2)	Power supplies for ***sat-nms*** ACU-ODM	(6)	Contactor
(3)	Power supply for motor drivers	(7)	Terminals
(3a)	Capacitor for motor driver power supply	(8)	Thermostat for heater
(4)	Motor drivers	(n.a.)	Optional air ventilation

3.1 ***sat-nms*** ACU-ODM

The ***sat-nms*** ACU-ODM is the core module of the ***sat-nms*** ACU-ODU. For the detailed operation of the antenna controller please refer to chapter 5 Operation . Another interesting chapter is belonging the ACU-ODM is 4.3 Startup here you find also the description how to change the IP

address of the unit in order to integrate the antenna controller in your sub-net. A short version of the documentation could also be found on the internal website of the ***sat-nms*** ACU-ODU. Just enter the IP-address of the unit (standard-IP is: 192.168.2.69) into the Web-browser of a connected computer and press the **HELP** button on the left side.

3.2 Power supplies for ***sat-nms*** ACU-ODM

In the ACU-ODU you find 2 power supplies: one is for the core processor of the ACU-ODM, it is labelled with PS ODM. The other one supplies the external contacts of the ACU e.g. the control signals for the POL drivers relais. This one is labelled with 'PS EXT'. By this, the core processor of the ***sat-nms*** ACU-ODM will not break down if something externally happens (e.g. overload/ short circuit)

3.3 Power supply for motor drivers

As standard type a 24VDC/10A power supply is installed for the motor drivers. On demand versions with up to 48VDC/15A are available. To provide enough power for starting up the motors, there is an additionally 15000uF capacitor integrated (3a).

3.4 Motor drivers

Depending on your requirements up to 3 motor drivers are integrated into the ACU-ODU. These are DC power drivers with power rating of 15A. The standard version has a voltage rating of 35VDC, an extended version for 48VDC is available on demand. The standard power supply integrated into the ***sat-nms*** ACU-ODU is 24VDC/10A, so this is the limiting value. On demand, the ***sat-nms*** ACU-ODU is available with a power supply that provide higher current.

The following picture shows a DC driver

DC-Treiber_freigestellt_kl.gif

On the upper side, you see the control inputs, on the lower side the power input and motor output terminals are located. Between three trimmers are located, where the maximum current, high and low speed could be adjusted. When using a 24VDC power supply, the adjustable range is:

trimmer	*range*
Current Adj.	0.5A…15A
Low Speed	6.5VRMS…11.7VRMS
High Speed	10.5VRMS…22.4VRMS

All interfaces are realized with altogether 4 Phoenix combicon connectors, type MSTBT 2,5/ 3-ST. By this an easy replacement of the unit is possible. Use 24VDC as control signal.

ATTENTION: As a PWM (puls width modulation) is used to realize the speed control, it is **absolutely necessary to use shielded cables for connecting the motors** in order to prevent disturbance due to harmonic waves. Take care that the shielding of the cable is connected only on **one** side of the cable: **either** on driver **or** on motor side. This is to prevent ground loops. We recommend to connect the shield to 'PE'-Pin of the DC-driver and isolate shield on motor side.

The following table shows the pin description of the motor drivers:

pin	*signal*	*description*	*type*
SP	speed	speed selection, connect 24VDC for low speed, 0V or floating selects high speed	IN
COM	COM control	GND for control voltage	IN
ER	error	in 'OK' condition, this pin is connected to COM by an optocoupler. In case of fault state is high Z	OUT
R	right	apply 24VDC here to drive motor right	IN
COM	COM control	GND for control voltage	IN
L	left	apply 24VDC here to drive motor right	IN
+	power input	DC power input + (15…35VDC)	IN
-	power input	DC power input GND	IN

-	power input	DC power input GND	IN
M1	motor-	Motor power output +	OUT
PE	protective ground	connect cable shield here	OUT
M+	motor+	Motor power output -	OUT

3.5 Circuit breakers

The circuit breakers disconnect the mains from the units build to the control cabinet. Every circuit breaker is labeled with the unit it is connected to.

Warning: In case of switching off all the circuit breakers it is still voltage available at the mains terminals!

3.6 Contactor

The contactor disconnects the motor's mains when the emergency stop contact is open. Please refer to the schematics shipped together with the ***sat-nms*** ACU-ODU to see how to connect the emergency stop switch.

3.7 Terminals

Here the mains and emergency switch and are connected. Please refer to the schematics shipped together with the ***sat-nms*** ACU-ODU to see how to connect them. The limit switches and angle encoders are connected directly to the ACU-ODM (1), the motors have to be connected directly to the motor drivers (4).

3.8 Heater

The ***sat-nms*** ACU-ODU is equipped with a temperature controlled heater. In delivery state the thermostat is set to 10°C, that means as soon as the temperature in the cabinet falls below 10°C the heater switches to on state.

3.9 Optional air ventilation

For using the ***sat-nms*** ACU-ODU in very hot regions, it is possible to equip the ***sat-nms*** ACU-ODU with an optional temperature controlled fan. By this way it is possible to ensure the availability of the ***sat-nms*** ACU-ODU in hot ambients.

ATTENTION: If the unit is equipped with an optional air ventilation, avoid contact with jets of water, rain is no problem. Through the build-in ventilator the protection class is only IP54. The thermostat for the fan is normally set to 40°C, that means the fan switches on as soon as the temperature of the cabinet raises above 40°C. We strongly recommend not to set this threshold below 40°C. The reason for this is, that in the winter the heater and the fan work against each other. In worst case the fan and the heater run parallel over a longer time. This behavior is avoided through setting the fan threshold to 40°C.

4 Installation

The following chapter describes how to install the ACU-ODU mechanically and electrically.

Additional a detailed start-up procedure is given in this chapter.

4.1 Mechanical installation

The ***sat-nms*** ACU-ODU is integrated into an outdoor cabinet that could be mounted outside directly at the antenna. There are 2 possibilities to mount the ***sat-nms*** ACU-ODU:

- If you mount the ***sat-nms*** ACU-ODU to a plain wall, make sure that the cabinet has a minimum distance of 5mm to the wall to ensure that the rain-roof will not be damaged through mounting the cabinet.
- If you mount the ***sat-nms*** ACU-ODU to an antenna mast, first fix 2 strong metal bars (e.g. C-Bars) in horizontal direction to the mast. After that, fix the ***sat-nms*** ACU-ODU to these metal bars Use at least M8 or comparable screws to fix the ***sat-nms*** ACU-ODU. On the following picture you can see an example where the ***sat-nms*** ACU-ODU is fixed to the antenna mast with C-Bars and according special nuts. These C-Bars can optionally be ordered at SatService.

mounting.gif

4.2 Interfaces to the Antenna, Pin descriptions

ATTENTION! Electrical installation shall be carried out only by qualified personnel who are instructed and aware of hazards of electrical shocks.

The terminals of the ***sat-nms*** ACU-ODU are located at the lower side of the case. The angle encoders and limit switches have to be connected directly at the ***sat-nms*** ACU-ODM, the core module of the ACU-ODU. The Motors have to be connected directly to the motor drivers. Please refer to the schematic of the ***sat-nms*** ACU-ODU that has been delivered to you. It shows you

where to connect all the units and the mains.

4.2.1 Angle encoder connection

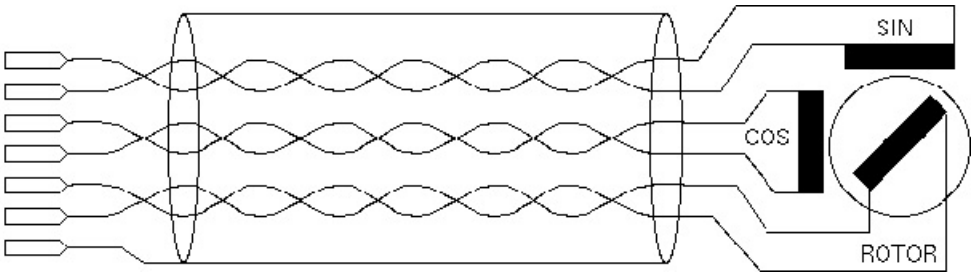
The angle encoders have to be connected directly to the core module of the ***sat-nms*** ACU-ODU, which is called ***sat-nms*** ACU-ODM. Inside, the ***sat-nms*** ACU-ODM consists of a main board and two or three interface boards with the circuitry for the position sensors. These boards are different for each type of position sensor. Actually interfaces for three types of position encoders are available with the ***sat-nms*** ACU:

- resolvers
- SSI digital position encoders
- analog voltage based sensors depending on the interface type you use, different pinouts are used. The following tables show you detailed the pin descriptions: **CON18, CON19, CON20 Resolver Interface**

Below the pinout of a resolver type interface board is shown. The ACU is available with resolver, SSI or analog position sensor interfaces. You have to select type of interface when you order the ACU.

pin	*signal*	*description*	*type*
1	GND		
2	SIN	resolver SIN	IN
3	GND	resolver SIN	IN
4	COS	resolver COS	IN
5	GND	resolver COS	IN
6	REF	drive signal to resolver	OUT
7	GND	drive signal to resolver	OUT
8	GND		

The ACU resolver interface is designed for resolvers with an impedance of 100 Ohms or more and transfer factor 0.5. The interface applies 4Veff / 2000Hz to the resolver drive coil. It expects 2Veff at the sine / cosine inputs at the maximum positions.



resolv.gif

When connecting a resolver to the ACU, please consider the following:

- Use a shielded, twisted pair cable.
- Connect the cable shield **either** to pin 1/8 at the ACU **or** to the ground at the resolver

housing. Never connect the shield at both ends, this will introduce a ground loop and cause a significant degradation of the resolver's accuracy.

CON18, CON19, CON20 SSI Positional Encoder Interface

Below the pinout of a SSI type positional encoder interface board is shown. The ACU is available with resolver, SSI or analog position sensor interfaces. You have to select type of interface when you order the ACU.

The SSI positional encoder may be powered from the ACU internal power supply. +5V and +24V clamps are provided at the connector. To avoid ground loops, the cable shield should be connected **either** to pin 1 at the ACU **or** to the ground at the encoder housing, never at both ends.

pin	*signal*	*description*	*type*
1	GND		
2	SSI-Data+	SSI data	IN
3	SSI-Data-	SSI data	IN
4	SSI CLK+	SSI clock	OUT
5	SSI CLK-	SSI clock	OUT
6			
7	+5V	encoder power supply	
8	+24V	encoder power supply	

CON18, CON19, CON20 Analog Angle Sensor Interface

Below the pinout of an analog type positional sensor interface board is shown. The ACU is available with resolver, SSI or analog position sensor interfaces. You have to select type of interface when you order the ACU.

pin	*signal*	*description*	*type*
1	AGND	analog ground	OUT
2	INPUT	A/D converter input	IN
3	REF	reference voltage	OUT
4	AGND	analog ground	OUT
5	+15V (opt)	optional DC out	OUT
6	-15V (opt)	optional DC out	OUT
7	+9V (opt)	optional DC out	OUT
8	GND	digital ground	OUT

4.2.2 Limit switch and emergency switch connection

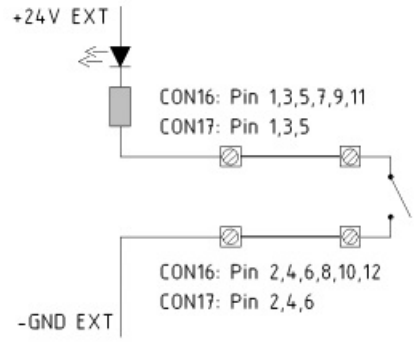
Limit switches have to be connected directly to the ***sat-nms*** ACU-ODM, emergency switch has to

be connected to the terminals bottom right of the cabinet. Please refer to the schematics for the exact cabling. The ACU treats a closed contact as OK, contacts have to be opened to indicate the 'limit reached' or 'emergency stop' condition. Opening the emergency stop contact disconnects the frequency inverters, motor drivers or conductors from mains supply immediately.

The pinout of limit switch connector is as follows:

CON16 Limit Switches

The limit switch inputs internally are connected to the external 24V / GND rails. The switches are connected directly to the input pairs without any external ground or supply cabling. The ACU treats a closed contact as OK, contacts have to be opened to indicate the 'limit reached' condition.



limit-alarm-in.gif

Example for wiring the limit switches

Please note, that the left/right azimuth and polarization limit switches have to be swapped when the antenna is operated at the southern hemisphere.

pin	*signal*	*description*	*type*
1	AZ High	azimuth right limit (view from behind antenna)	IN
2	GND EXT		IN
3	AZ Low	azimuth left limit (view from behind antenna)	IN
4	GND EXT		IN
5	El High	upper limit Elevation	IN
6	GND EXT		IN
7	El Low	lower limit Elevation	IN
8	GND EXT		IN
9	Pol High	polarization right limit (view from	IN

		behind antenna)	
10	GND EXT		IN
11	Pol Low	polarization left limit (view from behind antenna)	IN
12	GND EXT		IN

4.2.3 Motors connection

Connect the azimuth, elevation and if available polarization motors directly to the motor drivers. Use shielded cable only. Take care, that the shield is connected to the PE terminal of the motor driver and is NOT connected to the crankcase. Please refer to the schematics shipped together with your ***sat-nms*** ACU-ODU for more detailed informations and pin descriptions. The ACU knows two different configuration modes to control a motor driver. They are called 'DIR-START' and 'DUAL-START'. In 'DIR-START' mode, the 'FWD' signal switches the motor on/off, the 'REV' signal controls the motor direction. This is the configuration many frequency inverters use. In 'DUAL-START' mode, the 'FWD' signal switches the motor on in forward direction, 'REV' activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays. At ***sat-nms*** ACU-ODU it has to be configured as DUAL-START for AZ, EL and if available for POL drive.

4.2.4 Mains connection

Connect mains to the terminals at the lower side of the cabinet. Please refer to the schematics shipped with your ***sat-nms*** ACU-ODU for detailed pin description.

4.2.5 Ethernet connection

Connect the ethernet cable for remote controlling directly to the ***sat-nms*** ACU-ODM, the core module of the cabinet. Use a standard network cable with RJ45 connectors to connect the ***sat-nms*** ACU-ODU to an ethernet hub. If you want to connect your computer and the ACU directly without using a hub, you need a crossover cable for this with swapped RX/TX lines. Please refer to chapter 5 Operation and to chapter 7 Remote Control for detailed informations about remote controlling.

4.3 Start-up

This chapter describes how to install and set-up the ***sat-nms*** ACU-ODU. It is a step-by-step description without detailed description. If you need more detailed description for e.g. some parameter settings, please refer to chapter 5 Operation , all of the parameters are described here.

Before you start, please first read the Safety Instructions chapter. It contains some important recommendations to prevent damage from the ACU.

Then, we strongly recommend to do a first setup of the ACU on a lab desk before installing it at it's final location. This is mainly for the following reason:

To setup the ACU's IP parameters, the PC used for configuring and the ACU must either be connected to the same Ethernet hub or must be connected directly with a crossover cable. The initialization program does not work through routers or intelligent network switches.

Hence, the typical sequence of tasks when putting an ***sat-nms*** ACU outdoor module into

operation is as follows:

1. Read the chapter Safety Instructions .
2. Set the ACU's IP address .
3. Mechanically mount the ACU.
4. Connect the ACU to the antenna (position encoders, limit switches and motor drivers). Finally connect the UPS power supply and the Ethernet network.
5. Start up the system and set the parameters as described below.

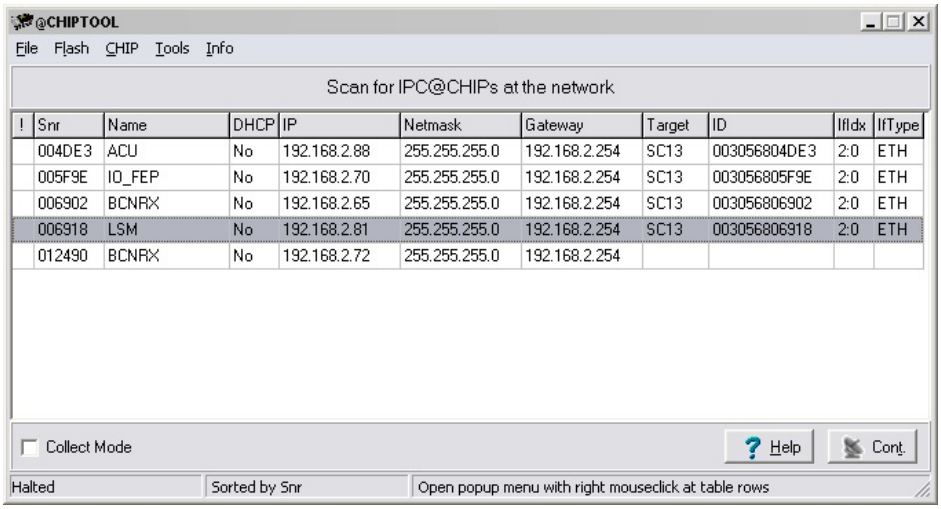
4.3.1 Setting the IP Address

Before you can operate the ***sat-nms*** ACU-ODU, you need to set the ACU's IP address. There is a special configuration program on the documentation CD shipping with the ACU for this purpose. We recommend to configure the ACU's TCP/IP settings before you install the ***sat-nms*** ACU-RMU at it's final place. To configure the ACU, the following equipment is required:

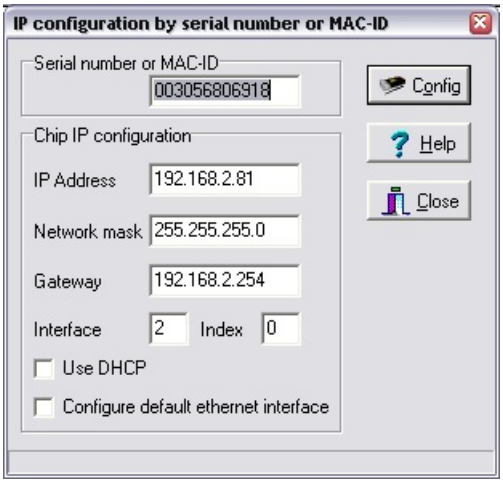
- The ***sat-nms*** ACU-ODU itself.
- 230V AC power at UPS mains terminals.
- A Computer running a Microsoft Windows operating system equipped with CD-ROM drive and Ethernet network card.
- A CAT5 crossover network cable or an Ethernet hub and standard network cables to connect the ACU and the computer.
- The CD-ROM shipping with the ***sat-nms*** ACU.

Setting the ACU's IP parameters now is easily done within a few minutes.

1. First install a network cable between the ACU and your computer. If you have a crossover cable available, this is very easy: simply put the cable into the network connectors of computer and ACU. Without a crossover cable, you need to connect both, the computer and the ACU to the same network hub using two standard network cables. It is essential, that the computer and the ACU are connected to the same network segment, the configuration program is not able to find the ACU through routers or network switches.
2. Now power on your computer and connect the ACU to the UPS power supply. Take care, that circuit breaker for the ACU inside the ***sat-nms*** ACU-ODU is switched to on state, the other ones have to be switched off.
3. Insert the CD-ROM into the computer's drive and inspect it's contents through the 'My Computer' icon on your desktop. Double-click to the 'ChipTool.exe' program in the 'ChipTool' directory.
4. When the ChipTool program is running, the program shows a list containing at least one entry describing the actual network parameters of the ***sat-nms*** ACU-RMU.



5. The serial number of the core module shown in the first column of the list. If the list stays empty, the ACU is not connected properly. If there are more entries in the list, the configuration program has found other devices in this network segment which use the same technology.
6. Now open with a right-click the sub-menu **IP configuration** to open the IP configuration window of the program. In this form the ACU's MAC address is shown on top, below you find the fields to configure the new IP address and network mask. If the ACU later shall be operated through a router, enter the address of the router on the gateway field, otherwise leave this field blank. Be sure, that the 'DHCP' mark is unchecked, the other values have to be set as shown on the picture. Finally click to the 'Yes' button to set the new parameters at the ACU.



Now the IP configuration of the ACU is completed. You may finally want to test if the ACU is reachable now. Start your web browser and type the ACU's IP address into the URL field of the browser. The ACU should reply with it's main page, provided that the ACU and your computer are configured for the same subnet.

4.3.2 Limit switches

Connect the limit switches to the ***sat-nms*** ACU-ODU as described in chapter 4.2 Pin description .

1. Switch on circuit breaker for the ACU-ODM to on state, take care, that the other ones are in off-position. The ACU should be reachable via Ethernet now.
2. Check the function and correlation of all limit-switches manually. On the ***sat-nms*** ACU-ODMs main-website a limit fault is shown as soon it occurs. On the test-page every single limit

switch is displayed. For more detailed informations see chapter 5 Operation

4.3.3 Angle detectors

Connect the angle detectors directly to the ***sat-nms*** ACU-ODU as described in chapter 4.2.1 Pin description .

1. Configure the desired type of detector on the setup-page.
2. Set the soft-limits to the expected values (at first it is ok if you do this approximately, later on you need to type in here the exact values).
3. Check the rotational direction of the resolvers. If possible, do this by turning the resolver axis directly, otherwise you have to move the antenna by hand. Maybe you have to invert the rotational direction on the setup page.
4. Set the offset of the angle detectors to the desired values by using the **calc** function.

If you need more detailed information, please refer to chapter 5.6 Setup .

4.3.4 Motors

Before you connect the motors to the ***sat-nms*** ACU-ODU, take care that the circuit breakers for the frequency inverters, motor drivers or conductors are in **off** position before connecting the motors.

1. Connect the motors to the sat-nms ACU-ODU as described in chapter 4.2.3 .
2. Connect the emergency stop button to its terminals, see chapter 4.2.2 . If you do not have one, take care that these terminals are bridged. Without a connection between these pins the power supply of the motors is disabled.
3. Press the **STOP** button on the sat-nms ACU-ODMs website. By this you can be sure that no motor movement will occur by switching on the circuit breakers.
4. Turn on circuit breakers of the frequency inverters, they have to run now.
5. Check the motor rotating directions, if necessary change it by interchanging the power wires of the motor cable.
6. Drive the antenna in every direction (AZ, EL and POL) until the limit switches stop the motor movement to ensure that the limit switches work well. **ATTENTION!** While doing this test it is absolutely necessary to be very mindful to check, if nothing collides!
7. Set the soft-limits to the desired values (e.g. 1° before the hardware limit switch is activated) If you need more detailed informations about the motor drivers, please refer to chapter 3.4 .

4.3.5 Pointing/ Tracking

Now, the setup of all interfaces to the antenna is done. By this everything is prepared to configure the ACU-RMU to the desired operation mode, to save targets and finally to set the sat-nms ACU-RMU into service.

In chapter 5 Operation you find a detailed description of the pointing and tracking parameters.

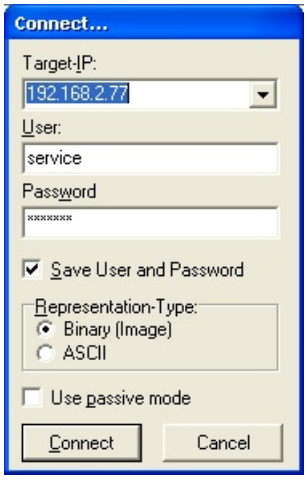
To use the function pointing by stating an orbit position you have to configure the ‘Location’ parameters on the setup page to the geodetic location of your antenna. Take care to type in position with enough accuracy (0.001°). For further informations, please refer to chapter 5.6 Setup for location parameters and 5.3 Target Memory for using this pointing function.

4.3.6 Backup of ACU settings

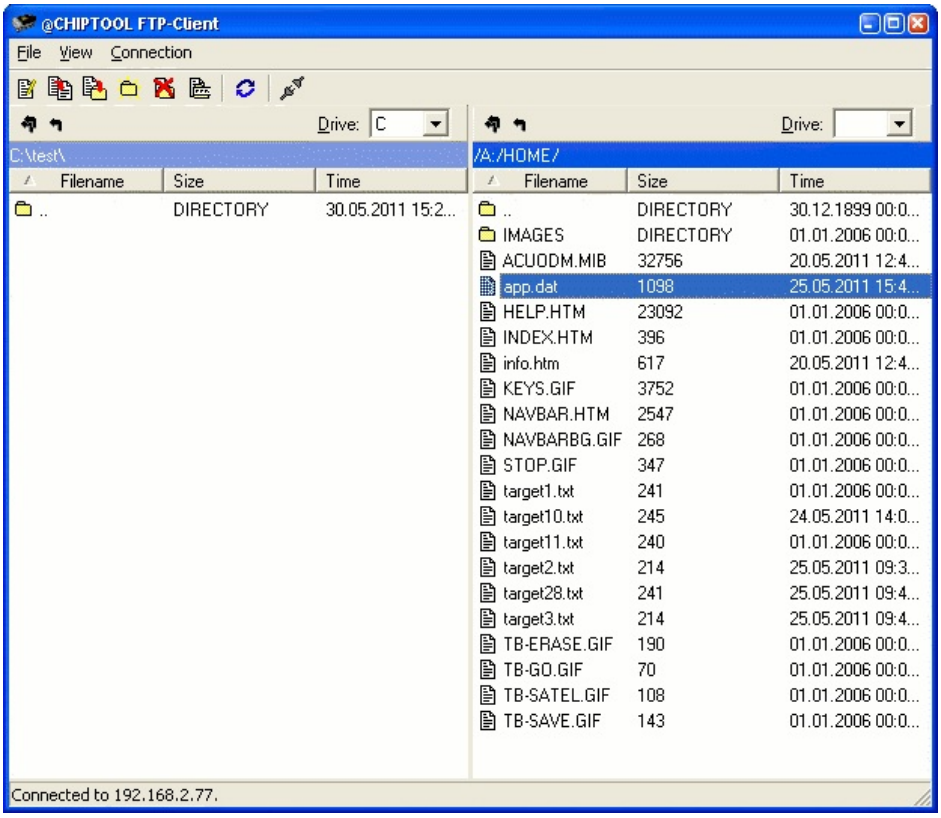
The last step that is recommended to be done is the backup of ACU settings. By this way an easy replacement of the ACU-ODM could be performed. The following step-by step description shows

how to do this.

1. Open the chiptool
2. Right click to the desired unit. A drop-down list will open, choose **FTP**
3. A small window like shown on the following picture. Please double-check the displayed IP, you might adjust it in the drop-down list here.



4. Login with username **service** and password **service**
5. Now you see on the right side the file system of the ACU like shown on the following picture. On the left side you see the computers file system.



6. Browse on the left side to the desired location to which you like to save the backup
7. Right-click the **app.dat** file and choose **copy** in the drop down list. The file will immediately be copied to the location shown on the left side. If you have saved targets, you might backup them in the same way. They are named **targetXX.txt** . XX represents the number of the target.
8. To copy a backup file to the ACU, browse on the left side if the window to the desired

app.dat file and copy this file to the ACU in the same way (right click->copy)

9. After copying an **app.dat** file to the ACU, you have to reboot the unit (power off). By next starting up, the new **app.dat** file will be used.

5 Operation

The ***sat-nms*** ACU outdoor module is designed to be controlled over a network link using a standard web browser. This means in practice, that the user interface to the ACU appears in your browser window after you type in the ACU's IP address in the address field of the browser program.

Operating the ACU is mostly self-explanatory.

5.1 The Web-based User Interface

After having connected the ACU to a power supply and set the ACU's IP address, you can access the ACU's user interface. To do this, start your favorite web browser program (Internet Explorer, Netscape Navigator, Opera or what else program you prefer). At the address field, where you normally enter the URL of a web page you want to see, type in the IP address of the ***sat-nms*** ACU you want to control.

The ACU shows a web page consisting of a navigation bar at the left side of the browser window and the actual antenna pointing in the main part of the window. The readings automatically refresh once a second. (this may be adjusted on the setup-page).

The navigation bar at the left contains a couple buttons which build the ACU's main menu:

keys.png

- Pointing : This button switches back to the main page you already see when you connect to the ACU. This page displays the actual antenna pointing together with some status information. You also use this page to move the antenna to a certain pointing given as azimuth / elevation values.
- Target : By clicking to this button you switch to the 'Target' page where you can store and recall the antenna pointing for up to 200 satellites.
- Orbital Data : By clicking to this button you switch to two pages where you can store and recall up to 99 sets of TLE ephemeris data and 99 sets if I11 satellite data. At the Tracking page you can assign TLE/I11 data sets to the satellite to be tracked.
- Tracking : ***sat-nms*** ACUs with the tracking option installed offer the tracking mode and tracking fine tune parameters on this page.
- Test : By clicking to this button you switch to the 'Test' page. The 'Test' page shows the low level I/O signals of the ACU. It helps you to install the ACU or to identify a malfunction of peripheral components.
- Setup : This button switches to the 'Setup' page which lets you inspect or change less common parameters which usually are set only once to adapt the ACU to it's working environment.
- Info : After a mouse click to this button, the ACU outdoor module shows a table with information like the serial number of the device or the revision ID and compilation date of the software.
- Help : Clicking to this button shows the on-line version of this user manual
- **Step Move** : Clicking to the buttons in this area moves the antenna a small step to the indicated direction. For azimuth and elevation 'small step' and 'large step' buttons are provided. A 'small step' is the angle defined with the 'XX step delta' parameters at the Setup page, a 'large step' is ten times this value. With the polarization axis, steps always are 1°.
- **STOP** : Clicking to the STOP button immediately stops all motors. The ACU indicates a fault. A click to the RESET button releases this fault.
- **RESET** : The RESET button lets the ACU acknowledge any motor diver faults by activating the reset-circuit to the motor drivers for 800 msec. All faults internally latched by the ACU are cleared and the target pointing values are set to the values actually read from the position sensors.
- **STANDBY** : The STANDBY button puts the pointing loop of all axes to 'standby' mode: Differences between measured and commanded value do not cause the motors to be driven in this mode. Standby mode can be used for maintenance purposes or to move the antenna by actuating the frequency inverters directly by hardware circuits. To leave standby mode, click the STANDBY button again or RESET.

5.2 Antenna Pointing

The 'Pointing' page is the main page of the ACU user interface which shows the actual antenna pointing and some status information. The 'Pointing' page automatically refreshes once a second. The refresh-rate may be adjusted on the setup-page.

Azimuth	Elevation	Polarization
159.542°	36.264°	-.---°
Target value 159.525 °	Target value 36.269 °	Target value -126.431 °

Target name	ASTRA2C 10951M5 (#1)
Pointing state	target position reached.
Tracking mode	STEP TRACK (PEAKING AZ-FIRST) (fill=49.1h age=0.0h)
Beacon level	rel. -1.43 dB / abs. -62.00 dBm (var 0.22 dB)

Temperature	33.9 °C
ACU Faults	
Tracking Faults	
AZ Tracking State	M=SMALL A=329% J=9% B=0.518° S=0.074°
EL Tracking State	M=SMALL A=1308% J=2% B=0.518° S=0.060°
Pol Prediction State	OFF
Time	2020-11-09 08:37:30 (last synced 2020-11-09 08:37:22 from NTP1)
GPS State	DISABLED

point.gif

The table below describes the information shown by this page:

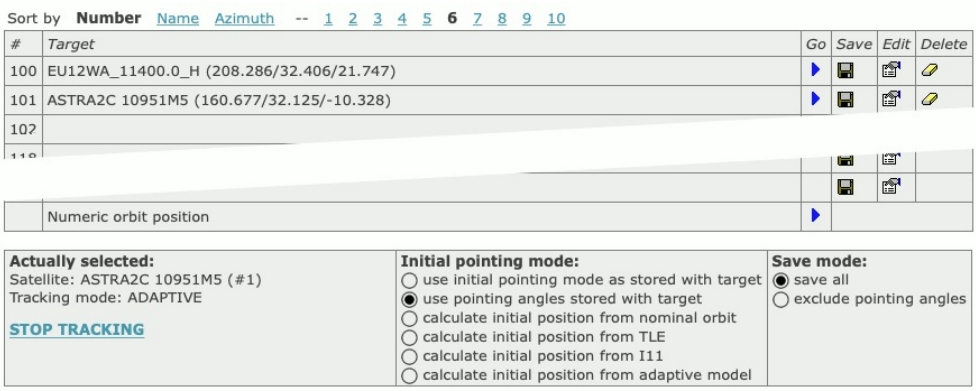
- **Azimuth Elevation Polarization** — The bold printed figures show the actual antenna pointing angles as read from the position sensors. If the polarization axis is not controlled by the ACU, '-.—°' is displayed in the polarization field. ACU versions equipped with a fourth axis show four columns here, the fourth column labeled "Polarization 2��?.
- **Xx. target value** — Below the measured angles the ACU displays the target values of the antenna pointing. The target values are the angles which have been commanded to the ACU. You may click to a target angle in order to change the pointing manually. The ACU display a dialog page where you can enter the new pointing angle. If you click to the 'SUBMIT' button in this dialog page, the antenna immediately moves to the new position. To go back to the main page without changing the pointing, click to the 'Back' button of your Web browser.
- **Axis state flags** — Below the target values, for each axis there is a field reserved which contains some state information for this axis. While the motor is running, 'MOVING' is displayed at this place. If the motor has been stopped due to a fault or an emergency stop request, a red label 'STOPPED' is displayed. Finally, if the ACU recognizes the activation of a limit switch, the orange colored label 'LIMIT' is displayed in this field. If the ACU is in standby mode, 'STANDBY' ist displayed for all axes.
- **Target name** — The name of the satellite the antenna is pointing to. Click to the name to get a dialog page where you can change the name. The name is stored together with a satellite's pointing at the target memory page. If you change the target pointing values, the target name is set to 'unknown' by the ACU. Hence you first should adjust the antenna pointing, then enter the satellite's name.
- **Tracking mode** — ***sat-nms*** ACUs with the tracking option installed display the actual tracking mode / state in this field. ACUs without tracking show 'OFF' all the time. In STEP and ADAPTIVE tracking modes this field shows what the tracking actually is doing and some information about the tracking data in memory:
  - **fill** — tells how many hours of step track data for calculating a model the ACU actually has in memory. This data may be used in ADAPTIVE mode to predict the satellite movement in case of a beacon failure. The smoothing which may be applied to the step track also relies on this data.
  - **age** — means the age of the most recent successful tracking step. In other words this

describes how many hours ago the beacon was lost in case of a beacon failure.

- **Beacon level** — This field shows the beacon level as read from the beacon receiver. Depending on the source defined at the Setup page, this either is the beacon level reported by a ***sat-nms*** LBRX beacon receiver via TCP/IP of the level derived from the ACU's analog input.
- **Temperature** — The actual temperature inside the ACU enclosure. This value is for information only.
- **ACU Faults** — If there are any faults with the ACU, they are displayed in this field. If there is more than one fault at a time, the ACU concatenated the fault descriptions. More detailed information about faults are available in chapter Faults and Tracking . If one axis stops operation due to a fault, the step tracking also stops operation. Possible faults are:
  - **EMERGENCY-STOP** — Someone opened the emergency stop circuit. The ACU stopped all motors and stays in this state until the 'RESET' button at the navigation bar is clicked.
  - **HUB-FAULT** — The ACU detected a 'hub fault' condition.
  - **CABINET-OPEN** — The ACU detected a 'cabinet open' condition.
  - **BCRX-TIMEOUT** — If the ACU reads the beacon level via TCP/IP from a ***sat-nms*** LBRX and the latter does not respond, a BCRX-TIMEOUT fault is reported
- **Tracking Faults** — If the ACU has the tracking option installed, any faults of the tracking module are shown in this field. With tracking option, this field is always empty.
- **AZ/EL Tracking State** — If the ACU has the tracking option installed and ADAPTIVE tracking is selected, these give some information about the model of antenna/satellite movement the ACU has calculated from the step track data:
  - **M(model)** — The complexity of the model the ACU uses (small/medium/large). With a small amount of tracking data available, the ACU uses a smaller, less complex model than with a completely filled tracking memory.
  - **A(amplitude)** — The amplitude of the antenna movement in this axis, expressed as a percentage of the full 3dB beamwidth.
  - **J(jitter)** — The jitter of the antenna movement in this axis, expressed as a percentage of the full 3dB beamwidth.
  - **B(beamwidth)** — The 3dB beamwidth as calculated by the ACU from the antenna diameter in this axis and the beacon receive frequency. This is the full beamwidth, the angle between both 3dB points in the antenna pattern.
  - **S(step size)** — The absolute step size used by the step track in this axis.
- **Time** — The actual time of the ACU's internal clock.
- **GPS State** — The actual state of an external GPS receiver connected to the ACU (if applicable).

5.3 Target Memory

The page 'Targets' gives access to the ACU's target memory. The ACU is capable to remember the pointing (and tracking parameters, if the ACU has the tracking module installed) of up to 199 satellites. Managing these memories is done with the 'Targets' page. Target memories are organized in 10 pages with 20 memory places each, you may click to the numbers shown above the table to select a certain page. Additionally, the target memories may be sorted either by target number, by azimuth angle or by name. Click to the sort modes above the table to select the appropriate sort mode.



target.gif

Below the target table the ACU shows the actually selected target, the initial pointing mode to be used with the next **Go** command anf the save mode.

- **Actually selected:** This displays the name and number of the actually tracked satellite as well as the currently active tracking mode. If the antenna is tracking, a STOP_TRACKING label is shown, permitting to stop tracking before moving to another satellite without leaving this page. The **Actually selected:** field may be empty if the Antenna has been moved since a target has been selected.
- **Initial pointing mode:** With this selection you may overwrite the initial pointing mode stored with a target. With the next **Go** command the selected initial pointing is executed unless you have made the selection 'use initial pointing as stored with target'.
- **Save mode:** The selection in this field affects the next **Save** command.
  - **save all** — Saves all actual tracking settings and the content of the tracking memory to the selected target number. This includes the actual pointing angles as the angles stored with the target.
  - **exclude pointing angles** — Saves the actual tracking settings and the content of the tracking memory to the selected target number as well, but leaves the pointing angles stored with the target unchanged. You may want to use this option to update a target memory without replacing the center of box position by the actual pointing angles.

The target table itself displays 20 of the stored target memories. By clicking the icons in the table, settings may be stored, recalled or deleted:

- **Go** — If a memory location has stored a pointing, the table shows a blue arrow in the 'Go' column of the table. Clicking to this arrow recalls the settings stored for that target as well as the stored tracking data for this satellite and moves the antenna to position according to the selected initial pointing mode. After the antenna has reached this position, the tracking mode stored with the target gets activated. The ACU displays a confirmation dialog before it actually recalls the target memory. Only if you click to 'Submit' in this dialog, the antenna moves to the stored location. With ADAPTIVE tracking, the ACU uses the stored tracking data to calculate a model as soon as tracking ist started as long as the stored tracking data is not outdated.
- **Save** — For each memory location the table shows a floppy disk icon in the 'Save' column. Clicking to this icon saves the actual tracking parameters, the tracking memory and - if at the bottom of the page **Save mode** is set to **save all** - also the actual antenna pointing to the selected memory location. Again, there is a confirmation dialog page before the data actually is saved.
- **Edit** — For each memory location the table shows a document edit icon in the 'Edit' column. Clicking to this icon opens the target editor page for this target memory. With this editor you

can edit the stored parmeters in a target memory without actually applying them. Chapter 5.8 Target Editor describes this function more detailled.

- **Delete** — Analogous to the 'Save' icon, the table shows an eraser icon in the 'Delete' column. The icons only are shown for the memory locations which are in use. Clicking to the eraser icon clears the selected memory location after a confirmation inquiry.
- **Numeric orbit position** — The table contains an additional row at the bottom labeled 'Numeric orbit position'. Clicking to the blue arrow icon in this row opens a dialog where you are requested to enter the orbit position of a satellite you want the antenna to point to. After you pressed 'Submit' in this dialog, the ACU computes the antenna pointing for the orbit position you entered and **immediately** moves the antenna to the calculated position. To make this function work satisfactory, it is necessary to have the geodetic location of the antenna entered at the Setup page with a sufficient accuracy.

5.3.1 How to make a new target

There are serval ways to make a new target. The following guideline should help to avoid common mistakes.

Common/Normal procedure: Save a live Target

- Set the Tracking Mode to OFF, otherwise no new settings are possible.
- **Clear Tracking Memory** in the Tracking Menu, to avoid wrong tracking calculation at the new satellite position with the previous tracking results.
- Set the new Beacon Receiver Parameter in the Tracking Menu or at the beacon receiver itself
- Check or reset the General Settings in the Tracking Menu, especially the Initial pointing mode and the target orbit postion.
- Set the Level threshold in the tracking menu to a large value e.g. -100dB.
- If TLE or I11-Parameter for the satellite available (Menu Orbit Data), choose the corresponding Prediction Parameters in the Tracking Menu.
- Move the Antenna to the new Satellite position. These can be done by entering the new azimuth, elevation and polarization target value in the Pointing Menu or use the Numeric orbit position calculator in the Target Menu.
- Enter the new Target name in the Pointing Menu
- If you already on the target you can start the step or adaptiv tracking and optimizing your parameter. If not, you can use the TLE or I11 Tracking to find the target, especially for inclined orbit satellites is this recommended.
- If the step/adaptive tracking could be established, recalculate the Level Offset in the Tracking Menu und set the Level threshold to a value between -6..-10dB.
- If you finalized the optimization for the target and you find the final best settings, don't forget to save the Target in the Target Menu to a free position.
- If you want change single settings for a target, you can also use the target editor in the Target Menu.

Advanced procedure: Prepare a Target with the Target editor

- Open a empty or unused target with the Target Editor in the Target Menu. If the Target empty the Parameter will be filled with the actual live Target otherwise you will get the stored parameter.
- Set the new Target name
- Set the **Tracking Mode** to **OFF** .
- Check or reset the General Settings in the Tracking Menu, especially the Initial pointing

mode and the target orbit postion.

- Set the Level threshold in the tracking menu to a large value e.g. -100dB.
- Set the new Pointing Angles (e.g. Center of the Box) of the new satellite.
- If TLE or I11-Parameter for the satellite available (Menu Orbit Data), choose the corresponding Prediction Parameters.
- Set the new Beacon Receiver Parameter.
- Then Save the target
- If you recall the target the following additional steps are necessary to make it operational.
- **Clear Tracking Memory** in the Tracking Menu, to avoid wrong tracking calculation at the new satellite position with the previous tracking results. This step is only necessary if not a empty target is used.
- If you already on the target you can start the step or adaptiv tracking and optimizing your parameter. If not, you can use the TLE or I11 Tracking to find the target, especially for inclined orbit satellites is this recommended.
- If the step/adaptive tracking could be established, recalculate the Level Offset in the Tracking Menu und set the Level threshold to a value between -6..-10dB.
- If you finalized the optimization for the target and you find the final best settings, don't forget to resave the Target in the Target Menu.

5.4 Tracking Parameters

sat-nms ACUs with the tracking function installed give access to the tracking mode and the fine tune parameter which lets you adapt the tracking to the individual requirements of the antenna and the satellite you are tracking to. ACUs without tracking function show an empty page at this place.

General Settings

Tracking mode	ADAPTIVE		Initial pointing mode	STORED-POSITION
Tracking cycle time	120 sec		Polarization prediction	OFF
Target orbit position	23.600 °E		Inclination	2.760 °
Satellite pol offset	0.000 °		Max. prediction age	999.0 h

Steptrack Parameters

Tracking step size	23 %		Beacon RX frequency	10951.500 MHz
Level offset	-60.48 dB	calc.	Level threshold (rel.)	-10.00 dBm
AZ Maximum model type	SMALL		EL Maximum model type	SMALL
Measurement delay	5000 msec		Recovery delay	10000 msec
Level averaging	5 samples		Retry after motor fault	FOREVER
Smoothing interval	6 h		Peak jitter threshold	20 %
Spindle save mode	OFF		Spindle save threshold	100 %

Prediction Parameters

I11 Epheremides	14: Astra-2C		TLE Epheremides	99: EUTELSAT 174A
Target azimuth offset	0.060 °		Target elevation offset	0.010 °

Beacon Receiver Parameters

RF receive frequency	10951.500 MHz		Polarization	H-X
Attenuation (dB)	10		Measurement bandwidth (kHz)	30
Post detector filter (Hz)	5		Alarm threshold	-77.00 dBm
C/N measurement mode	OFF		Frequency tracking	OFF
Noise measurement frequency	11450.000 MHz		Frequency tracking interval	3600 sec
Noise measurement interval	5 sec		Frequency tracking width	100 kHz
Signal search enable	OFF		Analog output offset	-80.00 dB
Signal search delay	15 sec		Analog output scale	0.2500 V/dB
Spectrum compensation	OFF			

CLEAR TRACKING MEMORY

track.gif

General Settings

- **Tracking mode** — The tracking mode parameter selects the tracking method, the ACU actually uses. Possible selection are:
  - **OFF** — No tracking is performed.
  - **STEP** — Step track mode. In regular intervals, the antenna performs small search steps to optimize the pointing. Chapter '8.3.0 Step Track' gives more information about this mode.
  - **STEP-TLE** — The antenna tries to optimize its pointing like in *STEP* mode. If the level of the received signal is too low for this optimization, the antenna moves along the path calculated from a TLE parameter set instead.
  - **STEP-I11** — The antenna tries to optimize its pointing like in *STEP* mode. If the level of the received signal is too low for this optimization, the antenna moves along the path calculated from an Intelsat 11 parameter set instead.
  - **MEMORY** — The antenna tries to optimize its pointing like in *STEP* mode. If the level of the received signal is too low for this optimization, the antenna moves to the position it had exactly one siderian day before.
  - **ADAPTIVE** — The adaptive tracking mode works the same way as step track, but it additionally is capable to predict the satellite's position when the beacon reception fails. It computes mathematical models of the satellites motion from the step track results recorded over a certain time. Details about this tracking mode are given in chapter '8.4.0 Adaptive Tracking' .
  - **PROGRAM** — The program tracking mode is different from the modes above. The ACU moves the antenna along a path which is described in a data file. No beacon reception is required for this. You have to create such a data file and copy it with FTP to the ACU before you can use this mode. SatService GmbH provides a PC software which lets you easily create data files for program track from commonly used ephemeris data sets for geostationary satellites. Chapter '8.5.0 Program Tracking' describes this tracking mode more detailed.
  - **TLE** — The antenna moves along a path calculated from a TLE ephemeris data set. There are no optimization steps and no receive signal is required for such an optimization.
  - **I11** — The antenna moves along a path calculated from an Intelsat 11 parameter data set. There are no optimization steps and no receive signal is required for such an optimization.
- **Initial pointing mode** — The initial pointing mode specifies how the antenna finds its initial position before it starts the tracking mode selected with the setting above. This parameter only has an effect, when a target memory gets recalled. Changing the initial pointing mode does not re-position the antenna. Possible selection are:
  - **STORED-POSTION** — The antenna moves to the Az/El/Pol angles stored for the particular satellite. After this position has been reached, the tracking selected by the 'tracking mode' is started.
  - **ORBIT** — The antenna's Az/El/Pol angles are calculated from the satellite's orbit position stored in the recalled target memory. The 'target azimuth offset' and 'target elevation offset' values described later on this page are added to the calculated angled before they are applied. After the commanded position has been reached, the tracking selected by the 'tracking mode' is started.
  - **TLE** — The antenna's Az/El angles are calculated from the TLE data set selected in the recalled target memory. The 'target azimuth offset' and 'target elevation offset' values described later on this page are added to the calculated angled before they are applied. The Pol angle is set to its stored position in this mode. After the commanded position has been reached, the tracking selected by the 'tracking mode' is started.
  - **I11** — The antenna's Az/El angles are calculated from the I11 data set selected in the

recalled target memory. The ‘target azimuth offset’ and ‘target elevation offset’ values described later on this page are added to the calculated angled before they are applied. The Pol angle is set to its stored position in this mode. After the commanded position has been reached, the tracking selected by the ‘tracking mode’ is started.

- **MODEL** — The antenna’s Az/El angles are calculated from the adaptive tracking model stored with the recalled target memory. The Pol angle is set to its stored position in this mode. After the commanded position has been reached, the tracking selected by the ‘tracking mode’ is started.

- **Tracking cycle time** — The cycle time specifies how often the ACU shall perform a step track cycle. The value is to be entered in seconds. In fact, the parameter does not specify a cycle time but the sleep time between two tracking cycles. This means, the true cycle time is the time the ACU needs to perform one step track cycle plus the time entered here. 300 seconds (5 minutes) is a good starting value for this parameter. Inclined orbit satellites probably will require a shorter cycle time, very stable satellites can be perfectly tracked with one step track cycle every 15 minutes (900 seconds). The maximum cycle time accepted by the ACU is 1638 seconds. This parameter is also used so specify how often the antenna position shall be moved in the PROGRAM, I11 and TLE tracking modes.
- **Polarization prediction** — Sets the polarization prediction mode to be used during tracking. The following modes van be selected:
  - **OFF** — No polarization prediction is done. The polarization angle is set once when a target memory is recalled and stays at this value while the antenna tracks.
  - **ON** — The polarization angle is calculated from the satellite’s position and it’s inclination angle. With TLE ot I11 tracking, these values are taken from the ephemerid data evaluation. With other tracking modes the polarization angle is calculated from the satelite’s nominal orbit position and the inclination value set with the target parameters. Te polarization angle gets updated with each tracking step in this mode.
  - **ADAPTIVE** — This mode works very much like ‘ON’, but with step track based tracking modes the values for the satelite’s orbit position and inclination are re-calculated from the recorded tracking data every three hours. This does not change the values of these parameters stored with the target memory, but the actual polarization angle calculation the optimized values are used instead of the stored ones.
- **Target orbit position** — The nominal orbit position of the satellite (°E). This value is used for the initial pointing of the antenna if the ‘initial pointing mode’ is set to ‘ORBIT’.
- **Inclination** — The satellite’s inclination used for the polarization prediction calculation.
- **Max. prediction age** — If the epoch of a TLE or I11 parameter set which is actually in use (‘TLE’ or ‘I11’ tracking modes) is older than the time specified here, a TLE-OUTDATED or I11-OUTDATED fault is raised and the antenna does not move with this and following tracking steps. The same applies in ADAPTIVE tracking mode if the antenna follows its calculated model without successful steptrack for a longer time than specified here.

Steptrack Parameters

- **Tracking step size** — The tracking step size is a very important parameter for the performance of the tracking. It defines the size of every depointing step, the ACU makes in order to find out where the optimal antenna pointing is. Setting too high values will cause significant signal degradations during the step track cycle because the antenna moves a too large amount away from the satellite. Setting the value too small will let the beacon level jitter mask the level differences caused by the test steps, the antenna will not track the satellite properly.The step size is specified as a percentage of the antenna’s half 3dB beamwidth. The ACU calculates the beamwidth from the antenna diameter and the beacon frequency. Expressing the step size in this relative way keeps the value in the same range, regardless

of the type of antenna. The recommended value for this parameter is 15-20%. You may want to start with 20% and try to reduce down to 15% if the signal degradation during tracking becomes too high.The tracking step size is a common parameter for both axes. If both axes behave differently, you can tweak the antenna diameter settings in the setup. Specifying a larger diameter makes the ACU using a smaller step size for this axis.If the tracking step seems to be completely out of range, you should check if the beacon frequency is set properly. The frequency must be the true receive frequency at the antenna, entered in MHz, not an L-band frequency or other IF.

- **Beacon frequency** — This parameter tells the ACU the frequency of the beacon signal to be used for tracking. The ACU calculates the antenna beam width from this frequency and the antenna diameter configured at the setup page. The value has to be entered as true receive frequency, no L-band or other IF frequency. When used with a SatService beacon receiver, the ACU automatically reads the beacon frequency at the start of each tracking cycle from the receiver. Any value entered here will be overwritten in this case. The beacon frequency entered here never sets the frequency at the receiver, neither with a SatService receiver nor with a third party device!

- **Level offset** — Principally there are two ways to display a beacon receive level: Either as an absolute level in dBm as reported by the receiver or as a relative level with '0dB' signalling the nominal level at clear sky conditions. The latter gives an easy measure for any degradation of the receive level.The parameter 'Level offset' lets you calibrate the absolute reading of the beacon receiver to the relative level. You may either enter a value to shift the reading by this offset or you may click to the 'calc.' link beside this parameter to set the offset to the actual absolute level reading, making the actual level being 0dB relative.

- **Level threshold** — If the *relative* beacon level falls below this threshold value, the ACU does not perform a step track cycle. If the level falls below the threshold during the steptrack cycle, the cycle gets aborted. If the ADAPTIVE tracking is enabled and there is enough data in the tracking memory, the ACU computes a mathematical model from the stored data and predicts the antenna pointing position from the extrapolation of the model. Analogously the antenna is moved to the actual TLE it I11 position in such a case if the 'STEP-TLE' or 'STEP-I11' mode is selected. If the tracking mode is set to 'STEP', the ACU leaves the antenna where it is if the beacon level drops below the limit.

  Adjusting the threshold level that adaptive tracking is switched as expected must be done carefully and may require some iterations, specially if the beacon is received with a low C/N.

  A good starting value for the threshold is 10 dB below the nominal receive level or 2 dB above the noise floor the beacon receiver sees with a depointed antenna, whatever value is higher. As mentioned above, the level threshold refers to the relative beacon level, not to the absolute level reading.

  To turn off the monitoring of the beacon level (this in fact inhibits the adaptive tracking), simply set the threshold the a very low value (e.g. -99 dBm)

- **AZ Maximum model type / EL Maximum model type** — These settings let you limit the adaptive model to a simpler one, the ACU would choose by itself. The maximum model type can be set individually for each axis. Normally you will set both axes to 'LARGE', which leaves the model selection fully to the ACU's internal selection algorithms.In cases where the ACU seems to be too 'optimistic' about the quality of the step track results, the maximum model on one or both axes may be limited to a more simple and more noise-resistant model. Specially inclined orbit satellites which are located close to the longitude of the antenna's

geodetic location may require this limitation for the azimuth axis. With such a satellite, the elevation may move several degrees while the azimuth shows almost no motion.

- **Measurement delay** — During a steptrack cycle, the ACU positions the antenna to a certain offset and then measures the level. Between the moment when the antenna reached commanded position and the beacon level measurement the ACU waits some time to let the beacon level settle. The optimal delay value depends on the beacon receiver's averaging / post detector filter setting and is a quite critical for the steptrack performance.If the delay is too short, the beacon voltage does not reach its final value, the steptrack does not properly recognize if the signal goes better or worse after a test step. If the delay is too long, the impact of fluctuation to the measured level grows and may cover the small level difference caused by the test step. With the ***sat-nms*** LBRX beacon receiver, best results are achieved if the receiver is set to 0.5 Hz post detector filter bandwidth and a measurement delay of 1500 msec.

- **Recovery delay** — After the ACU has done the tracking steps for the elevation axis, it waits some time before it starts tracking the azimuth axis. This is to let the beacon level settle after the final position has been found. A typical value for this parameter is 4000 msec.

- **Level averaging** — When measuring the beacon level, the ACU takes a number of samples and averages them. The standard value of 5 samples normally should not be changed. Larger values will slow down the ACU execution cycle.

- **Retry after motor fault** — When the ACU encounters a motor fault during steptrack, the tracking cycle gets aborted and the ACU shows a fault. This parameter tells the ACU how to proceed after this, with the next tracking cycle:

    - **NEVER** — The ACU will not try to move the antenna again. This will stop tracking until an operator will have checked the antenna motor and re-started the tracking.
    - **FOREVER** — The ACU try to move the antenna again with the next tracking cycle. If the antenna is really blocked, the ACU will try to move the antenna every tracking cycle. This increases the probability to keep the antenna following the satellite - even if the antenna motors show sporadic faults. But this also increases the risk to crash motors and/or spindles of the antenna.
    - **ONCE** — This mode offers a compromise between preserving the motors and trying to keep the antenna following the satellite. The mode ONCE allows the ACU to do exactly one retry after a motor fault, if this fills as well the ACU stops tracking
- **Smoothing interval** — This parameter controls the smoothing function. Setting it to zero disables smoothing. Smoothing lets the ACU point the antenna to positions evaluated from a simple model calculated from the step track peaks of the recent few hours. A detailed description of this function you find at chapter '8.3.3 Smoothing'

- **Peak jitter threshold** — If the jitter value of at least one axis exceeds this threshold, the ACU raises an 'model fault'. If this happens three consecutive times, the ACU resets the models of both axes. Adaptive tracking will be possible not until 6 hours after this happens.During adaptive tracking, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the (currently selected) model. The figure is also expressed as a percentage of the antenna's beamwidth, low values indicate, that the model ideally describes the antenna's path. High values indicate that's something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit.A typical threshold value is 20%, this will detect very early that a model does not fit to describe the satellite's motion. If this value causes false

alarms too often, you may want to raise the threshold to 50%. Setting it to 0 switches the threshold monitoring completely off.

- **Spindle save mode** — If set to OFF, the ACU does a step track optimization with every tracking cycle. If set to a value 1 .. 12, the ACU will insert steps where it positions the antenna following the actual ADAPTIVE model. If e.g. the spindle save mode is set to 2, the ACU will do a step track optimization in the first cycle, in the second and third cycle it skips this and moves the antenna following the actual ADAPTIVE model. This reduces the number of antenna movements and spindle wear.

- **Spindle save threshold** — Defines the model quality (jitter value) neccessary to replace step track optimization steps in spindle save mode. If the jitter value of one axis exceeds this value, the ACU does step track optimization steps everycle even if spindle save mode ist active.

- **Model hysteresis** — If set to a non-zero value, antenna movements below this threshold are suppressed whenever the antenna is controlled by an adaptive model or by ephemeris data. The value is expressed as a percentage of the half 3dB beamwidth of the antenna. You may use this parameter to reduce the number of antenna movements in these modes.

- **Apply model before track** — If set to ON the ACU moves the antenna to a position calculated by the actual adaptive model before it starts a steptrack optimization sequence. With inclined orbit satellites this helps to follow the satellite with minimized level degradation.

Prediction Parameters

- **I11 Ephemerides** — The ACU provides 99 named memory places (numbered 1..99) to store Intelsat 11 parameter sets. With this parameter you address the number of the I11 parameter set to be used with the 'I11' or 'STEP-I11' tracking modes and for the 'I11' initial pointing mode as well. The setting is a reference to the memory location where the I11 parameter are stored, hence, if the parameters at this location are changed the ACU automatically uses the changed parameters.
- **TLE Ephemerides** — The ACU provides 99 named memory places (numbered 1..99) to store TLE Ephemerides sets. With this parameter you address the number of the TLE parameter set to be used with the 'TLE' or 'STEP-TLE' tracking modes and for the 'TLE' initial pointing mode as well. The setting is a reference to the memory location where the TLE parameter are stored, hence, if the parameters at this location are changed the ACU automatically uses the changed parameters.
- **Target azimuth offset / Target elevation offset** — The offsets specified here are added to any antenna pointing which is calculated from ephemeris data or from an orbit position and also to the pointing angles read from a file in PROGRAM tracking mode. The offsets can be used to compensate for differences between measured and calculated angles, e.g. if the azimuth axis of the antenna is not exactly vertical.

Beacon Receiver Parameters

If the ACU is configured to work together with a ***sat-nms*** beacon receiver, the receiver's settings may be remote controlled from this section of the target parameters. The beacon receiver settings are stored when a target memory is saved and and set at the beacon receiver when a target memory is recalled. Beacon receiver parameters are not available if the ACU works with a 3rd party beacon receive

- **RF receive frequency** — This is the receiver's nominal receive frequency. Depending on the LO frequency settings made on the Setup page, the frequency value either is expressed

as the RF receiver frequency or the L-band frequency at the receiver's input. If the '22 kHz Tone' setup parameter is configured as 'AUTO', changing the frequency also may switch the 22kHz modulation on the LNB power supply on or off.

- **Polarization** — If on the Setup page the 'LNB voltage' parameter is set to 'AUTO', the receive polarization may be set with this parameter by changing the LNB Voltage.
- **Attenuation** — The receiver provides a switchable input attenuator which lets you adjust the input level in 10 dB steps. This is specially useful with large Antennas pointing to a satellite which generate a high flux density. With the attenuator you may adjust the input level in order to avoid saturation effects in the receiver. All input attenuator steps are calibrated, the attenuation values are taken into account for the displayed receive level. Available attenuator settings are 0, 10, 20 and 30 dB.
- **Measurement Bandwidth** — The receiver provides four different measurement bandwidth filters (6, 12, 30 and 100 kHz). The 30 kHz filter is suitable for majority of cases.
- **Post detector filter** — The receiver's software applies a low pass filter to the measured level values. This is much like the video filter at a spectrum analyzer. Available bandwidth settings for this filter are 0.1 to 5 Hz in 1/2/5 steps. Lower bandwidth settings make the reading more stable, reduce the fluctuation. Please keep in mind, it will take a noticeable time until the level reading settles after an input level change with a very low bandwidth setting.
- **Alarm Threshold** — With this parameter you set the level threshold. If the measured level falls below this value, the receiver states a receive level fault. To disable the level alarm, set the threshold to a very low value, e.g. -120 dBm.Please note, that the threshold value refers to the signal level, even if the receiver operates in a C/N measurement mode.
- **C/N Noise measurement** — With this parameter you select if the receiver shall perform a plain input level measurement or a C/N measurement. A description of the C/N measurement function of the receiver is given in chapter 5.3 C/N Measurement . You may select one of the following measurement modes:
  - **OFF** — The receiver performs a plain level measurement. The Readings page shows the input level in dBm.
  - **C/N** — The receiver measures the signal / noise ratio. The Readings page shows the C/N in dB.
  - **C/N0** — Like the C/N mode, but the receiver normalizes the C/N value to 1 Hz measurement bandwidth. The Readings page shows the C/N0 in dBHz.
- **Frequency Tracking** — This parameter switches the the frequency tracking facility of the receiver ON or OFF. A description of the frequency tracking facility is given in chapter 5.4 Frequency Tracking .
- **Noise Measurement Frequency** — With this parameter you specify the frequency at which the receiver shall measure the noise level at a certain interval. Like with the receive frequency, the LO frequency settings made at the Setup page are taken into account also for this frequency value.To get reasonable results with a C/N measurement, you should consider the following:
  1. The receiver does not change the LNB frequency band setting when it switches from the level measurement to the noise measurement. The LNB probably would change it's gain in this case. The noise measurement frequency hence must be in the same frequency band as the receive frequency.
  2. Measuring the noise level at the band edge may falsify the result due to the LNB's band filter. The measured noise level may be too low in this case.
  3. You should verify with a spectrum analyzer, that no signal disturbs the noise measurement at the selected frequency.
- **Frequency Tracking Interval** — This parameter sets the interval on which the frequency tracking procedure operates. The value is in seconds. Recommended settings are 15

seconds to tune the receiver quickly to a frequency you do not know precisely. For normal operation a frequency tracking interval of one hour (3600 secs) is recommended.

- **Noise Measurement Interval** — This parameter defines the interval at which the receiver inserts noise measurements in the C/N modes. The time is specified in seconds. 3600 secs being one hour is a suitable setting in most cases.
- **Frequency Tracking width** — With this setting you limit the frequency offset the frequency tracking procedure may apply to the nominal frequency. The frequency tracking never tunes the receiver to a frequency outside the nominal frequency +/- this value, a frequency track fault is generated if the tracked frequency reaches the limit.
- **Signal search enable** — Setting this parameter to ON enables the automatic signal search function. With signal search enabled, the receiver searches the signal within the frequency tracking range when the signal ist lost. Chapter 5.5 Signal search describes this function more detailed. 'SEARCH NOW' starts a search scan immediately, regardless of the enable setting.
- **Analog output offset** — The beacon level shown as 0V at the analog output.
- **Signal search delay** — This parameter defines the time, the receiver waits after the signal was lost until a search scan ist started. The valid range of this parameter is 0 .. 600 seconds.
- **Analog output scale** — The analog output scale (V/dB)
- **Spectrum Compensation** — With this parameter set to 'OFF', the receiver's level reading is calibrated for a C/W signal. By selecting a modulation type for this parameter, the level display gets compensated for the selected modulation type.

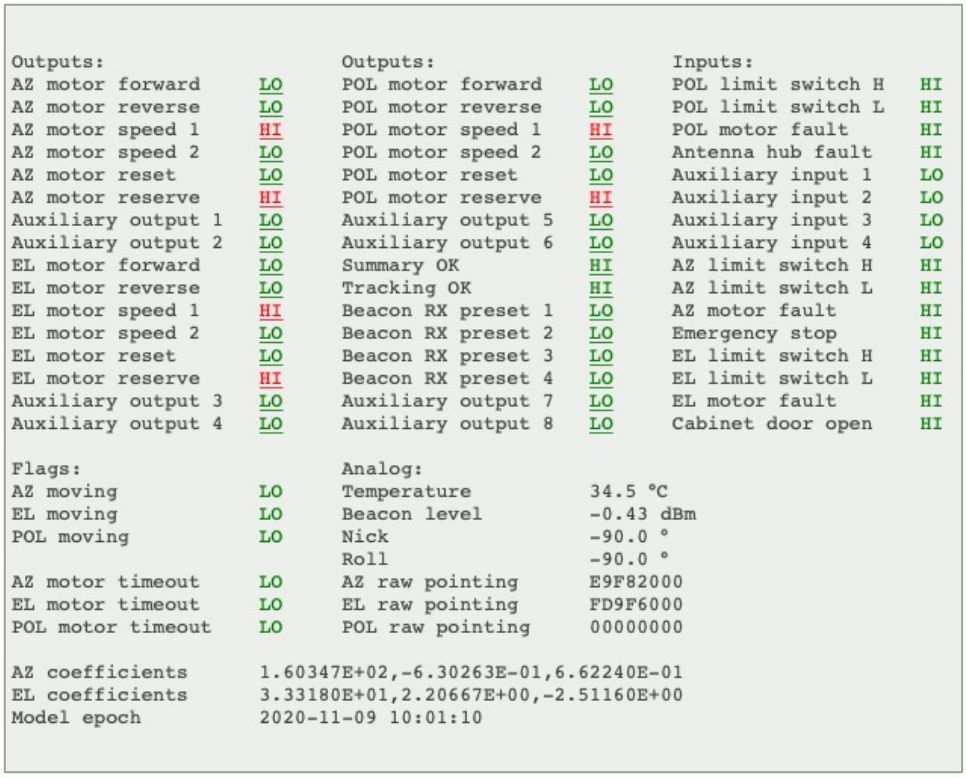
CLEAR TRACKING MEMORY

Clicking to this mark clears the tracking memory. You should do this when you start to track a new satellite. Clearing the tracking memory about half an hour after tracking started significantly improves the quality of the first adaptive tracking model which will be evaluated after 6 hours of tracking. This is because the model does not get disturbed by the first search steps the antenna does until the optimal pointing to the satellite is found.

Please refer to chapter 8.3 Steptrack , 8.4 Adaptive Tracking and 8.5 Program Tracking for more detailed informations about the tracking algorithms.

5.5 Test Page

The page 'Test' displays the electrical / logical level of all inputs and outputs of the ACU. This helps you to install the ACU or to identify a malfunction of peripheral components. The layout of this page differs slightly for ACUs equipped with a fourth axis. The POL2 raw angle encoder reading and the state of the extended inputs / outputs are displayed additionally for the 4 axis ACU.



Outputs:		Outputs:		Inputs:	
AZ motor forward	LO	POL motor forward	LO	POL limit switch H	HI
AZ motor reverse	LO	POL motor reverse	LO	POL limit switch L	HI
AZ motor speed 1	HI	POL motor speed 1	HI	POL motor fault	HI
AZ motor speed 2	LO	POL motor speed 2	LO	Antenna hub fault	HI
AZ motor reset	LO	POL motor reset	LO	Auxiliary input 1	LO
AZ motor reserve	HI	POL motor reserve	HI	Auxiliary input 2	LO
Auxiliary output 1	LO	Auxiliary output 5	LO	Auxiliary input 3	LO
Auxiliary output 2	LO	Auxiliary output 6	LO	Auxiliary input 4	LO
EL motor forward	LO	Summary OK	HI	AZ limit switch H	HI
EL motor reverse	LO	Tracking OK	HI	AZ limit switch L	HI
EL motor speed 1	HI	Beacon RX preset 1	LO	AZ motor fault	HI
EL motor speed 2	LO	Beacon RX preset 2	LO	Emergency stop	HI
EL motor reset	LO	Beacon RX preset 3	LO	EL limit switch H	HI
EL motor reserve	HI	Beacon RX preset 4	LO	EL limit switch L	HI
Auxiliary output 3	LO	Auxiliary output 7	LO	EL motor fault	HI
Auxiliary output 4	LO	Auxiliary output 8	LO	Cabinet door open	HI

Flags:		Analog:	
AZ moving	LO	Temperature	34.5 °C
EL moving	LO	Beacon level	-0.43 dBm
POL moving	LO	Nick	-90.0 °
		Roll	-90.0 °
AZ motor timeout	LO	AZ raw pointing	E9F82000
EL motor timeout	LO	EL raw pointing	FD9F6000
POL motor timeout	LO	POL raw pointing	00000000

AZ coefficients	1.60347E+02,-6.30263E-01,6.62240E-01
EL coefficients	3.33180E+01,2.20667E+00,-2.51160E+00
Model epoch	2020-11-09 10:01:10

test.gif

Below some information how to interpret the values in this page are given.

Electrical I/O Levels

The electrical state of an input or output is indicated by the HI / LO label displayed with the signal. HI means that current is flowing through the optocoupler for this input or output. LO means that no current flows. As some signals are defined to be ‘true’ when a switch is opened, the electrical level of the signal not necessarily describes the logical level of this signal, too.

Logical I/O Levels

The logical level of an input or output is described by it’s color: Green means this signal is inactive, OK or ‘false’. Read means the signal is active or ‘true’.

Toggling output levels manually

The ‘Test’ page also lets you toggle the actual state of each output signal simply by clicking to the underlined HI/LO mark of the signal. If you do this, you should consider the following:

- The ACU sets the motor driver outputs eight times a second for each axis having the motor driver type set to ‘DIR-START’ or ‘DUAL-START’. This immediately will overwrite any change you make. If you want to test if the motor driver outputs command the motor driver as expected, switch the motor driver type for this axis to ‘NONE’ at the Setup page before you set the outputs manually.
- The ‘Test’ page is re-read by the Web-browser about once a second. Some browsers seem to ignore mouse clicks occasionally due to the screen refresh.

Adaptive tracking coefficients:

In adaptive tracking mode the ACU displays the coefficients of the actual model in two lines at the bottom of the text page. The number of coefficients displayed depends on the size of the model:

- SMALL: *a0,a1,a2* (1)
- MEDIUM: *a0,a1,a2,a3,a4* (2)
- LARGE: *a0,a1,a2,a3,a4,a5* (3)

If the beacon signal drops below it's threshold, the antenna movement is calculated from these coefficients using the formulas shown below:

$$\alpha_{small} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) \quad (1)$$

$$\alpha_{medium} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) + a_3 \cos(2\omega t) + a_4 \sin(2\omega t) \quad (2)$$

$$\alpha_{large} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) + a_3 \cos(2\omega t) + a_4 \sin(2\omega t) + a_5 t \quad (3)$$

formula.gif

5.6 Setup

The page 'Setup' contains the ACU's installation parameters. The page displays a table with the parameters actually set. Each parameter value is a hyper-link to a separate page which lets you change this parameter. This parameter change page shows the actual parameter setting either in an entry field or in a drop down box. You may change the parameter to the desired value and then click to the 'Submit' button to pass the changed value to the ACU ODM. The ACU automatically returns to the setup page when the parameter has been changed. To cancel a parameter modification you already started, either use the 'Back' button of you web browser or click to the 'Setup' button on navigation bar. Both returns to the setup page without changing the parameter you edited.

General

Note	3.7m Antenna		Date / time	2020-11-09 10:10:17
Display refresh	1 sec		Watchdog pulse on AUX8	OFF
Axes control mode	PARALLEL		Antenna mount type	AZ-OVER-EL
RS232 address	NONE		RS232 bauddate	9600
RS485 address	A		RS485 bauddate	9600
Use cab-open as handheld active	OFF		Use hub-fault as summary limit	OFF
Antenna mount declination	0.000 °		Show debug trace	GO

Azimuth

AZ Antenna diameter	3.7 m		AZ step delta	0.040 °
AZ Position sensor type	SSI-19B		AZ Motor driver type	DUAL-START
AZ Sense invert	NORMAL		AZ Motor timeout	8000 msec
AZ Pre scale offset	F3F1EEBD	calc.	AZ Post scale offset	207.500 °
AZ Calibration scale	0.000000		AZ Pointing hysteresis	0.025 °
			AZ Low speed threshold	3.0 °
AZ Lower limit	150.000 °		AZ Upper limit	265.000 °

Elevation

EL Antenna diameter	3.7 m		EL step delta	0.040 °
EL Position sensor type	SSI-19B		EL Motor driver type	DUAL-START
EL Sense invert	NORMAL		EL Motor timeout	8000 msec
EL Pre scale offset	FD658141	calc.	EL Post scale offset	42.500 °
EL Calibration scale	0.000000		EL Pointing hysteresis	0.025 °
			EL Low speed threshold	3.0 °
EL Lower limit	0.000 °		EL Upper limit	90.000 °

Polarization

Linear/Circular switch	DISABLED		PO step delta	0.20 °
PO Position sensor type	NONE		PO Motor driver type	NONE
PO Sense invert	NORMAL		PO Motor timeout	6000 msec
PO Pre scale offset	BD3471C8	calc.	PO Post scale offset	-32.500 °
PO Calibration scale	0.000000		PO Pointing hysteresis	0.500 °
			PO Low speed threshold	2.0 °
PO Lower limit	-90.000 °		PO Upper limit	92.000 °

Beacon Receiver

Beacon RX type	SATNMS		Beacon RX IP address	10.10.1.11
Beacon RX voltage scale	n/a		Beacon RX 0V level	n/a
Beacon RX frequency	10951.500 MHz		Beacon RX Pol. aliases (H,V)	H-X,V-Y

Location / Clock Sync

GPS receiver type	NONE		Antenna longitude	8.915 °E
Antenna course	0.000 °		Antenna latitude	47.782 °N
	[sync now]		Antenna abs. altitude	426 m
NTP server 1 address	192.53.103.108 [check]		NTP server 2 address	0.0.0.0 [check]

Orientation

Compass type	NONE		Inclinometer type	NONE
Nick offset	n/a		Roll offset	n/a

SNMP Control

SNMP read community	public		SNMP system name	ACU145
SNMP write community	private		SNMP system location	Default
SNMP trap community	public		SNMP system contact	SatService GmbH
SNMP traps	ENABLED		MIB File	ACU2.MIB
SNMP trap IP 1	192.168.2.32		SNMP trap IP 2	0.0.0.0
SNMP trap IP 3	0.0.0.0		SNMP trap IP 4	0.0.0.0

Access Control

User password	******		Admin password	******

setup.gif

The table below lists the settings provided by this page.

General

This section of the setup page contains some general setup parameters.

- **Note** — The text you enter here appears as the title of the main page of the ACU WebGUI. You may want to set this to a descriptive name of the Antenna controlled by this ACU.
- **Date/time** — By changing this value you can set the internal clock of the ACU. The clock is set as soon you click to the ‘Submit’ button in the data entry dialog. The most precise method to set the time is to enter a time one or two minutes ahead and click to ‘Submit’ when this time is reached.

- **Display refresh** — With this parameter you select the refresh-rate of the ACU's main window.
- **Watchdog pulse on AUX8** — The AUX 8 output may be configured to act as a heartbeat output. If enabled, the output switches every 1000 ms between on/off. If using this signal for an external watchdog circuit, be aware that in adaptive tracking mode delays of some seconds are possible while the acu calculates the orbital model.
- **Axes control mode** — The ACU knows two axes control modes. The PARALLEL mode treats the azimuth/elevation axes independently. If a new pointing is commanded, both motors are activated in parallel, the antenna moves to the new location in the shortest possible time. In SEQUENTIAL mode, the ACU does not move the elevation axis while the azimuth motor is running. The antenna movement is done sequentially: First azimuth, then elevation. You should prefer the PARALLEL mode unless special conditions require a sequential antenna movement. The performance of the ACU in terms of pointing speed and wind load compensation will be much better in PARALLEL mode.
- **Antenna mount type** — Sets if the antenna mount is azimuth/elevation based or a Polamount.
- **RS232 address** — With this parameter you select the device address used to control the ACU through the RS232 interface. At ACU-RMU and ACU19 this parameter has to be set to 'NONE'. If you use a ***sat-nms*** Handheld this parameter has to be set to 'TERM'. The Handheld function is not implemented in ACU-RMU and ACU19 Version.
- **RS232 baudrate** — Sets the baudrate of the RS232 interface.
- **RS485 address** — With this parameter you select the device address used to control the ACU through the RS485 interface.
- **RS485 baudrate** — Sets the baudrate of the RS485 interface.
- **Use cab open as hand held active** — This controls the way, the cab-open input is interpreted. OFF makes the ACU show a CAB OPEN FAULT if this input is active, ON treats this input as an indication that the ACU is controlled by an analog handheld unit.
- **Use hub fault as summary limit** — This controls the way, the hub-fault input is interpreted. OFF makes the ACU show a HUB FAULT if this input is active, ON treats this input as a summary limit switch input for all axes.
- **Antenna mount declination** — The declination angle of a polamount antenna. This parameter is not used with az/el based mounts.
- **Show debug trace** — Clicking to GO shows a list of the recent debug messages issued by the ACU. the newest message is shown on top, the list gets updated automatically every few seconds.

Azimuth / Elevation / Polarization

The 'Azimuth' / 'Elevation' / 'Polarization' sections contains the parameters which are specific to the individual axis. They are the same for each axis. ACUs equipped with a fourth axis show a 'Polarization 2' section as well.

- **Antenna diameter** — Set this parameter to the dish diameter. Units with the tracking function installed use this value to estimate some tracking parameters. With offset antennas, the diameter settings are different for the azimuth / elevation axes. This lets the ACU calculate suitable tracking step sizes individually for each axis.
- **Step delta** — This parameter defines size of a step the antenna moves when you click to the arrow buttons on the ACU main page. If you are using the arrow buttons to fine-tune the antenna pointing manually, the best value is the pointing hysteresis described below. This lets you move the antenna the smallest possible step when you click to an arrow button. For special applications however it might be helpful to set the step delta to a much greater value.
- **Position sensor type** — With this parameter you set the type of position sensor the ACU

shall read for this axis. Principally, the ACU is capable to read SSI, RESOLVER and ANALOG type position sensors. The selected sensor type **must** match the type of interface board installed in your ACU. It is not possible to switch from SSI to RESOLVER or vice versa without changing the interface module.When selecting a SSI type position encoder, also the number of bits and the encoding scheme must be selected. For the position sensor type parameter these values are combined to one name. E.g. 'SSI-13G' means 13 bit, Graycode SSI sensor, 'SSI-24B' means 24 bit binary encoded SSI sensor.Beside the SSI-xxX, RESOLVER and ANALOG selections this parameter offers the choice 'NONE' which tells the ACU not to read a position encoder at all. With this selection you can tell the ACU if the polarization is not to be controlled by the ACU.If you are using multiturn SSI encoders you will have to scale the reading (See 'Calibration scale' below).

- **Prescale offset** — The pre-scale calibration offset is added to the raw position encoder reading *before* scaling is applied. The pre scale offset is defined as an 8-digit hexadecimal value in normalized position encoder ticks (00000000-FFFFFFFF equivalent to the full range of the encoder (0-360° with single turn encoders).The pre scale offset must be adjusted to avoid any 7FFFFFF to 8000000 overflow within the used range of the encoder. The value is added to the encoder reading, neglecting an overfly eventually occurring. Thus, the offset implements a 360° turnaround automatically.The pre scale offset may be computed and set manually or by assistance of the ACU's automatic calibration function as described below.
- **Post scale offset** — The post scale calibration offset is added to the position value before the angle value is displayed, but after the scaling is applied. The post scale offset is defined in degrees of AZ/EL/POL.The ACU provides a function to calculate and set both, the pre-scale and the post-scale offset from a known pointing:
  1. Set the calibration scale / gear ratio for the axis (this calibration parameter is described with the next paragraph).
  2. Set the soft limits of the axis to preliminary values. In most cases this needs not to be very accurate, the ACU needs this information to calculate the pre-scale offset to shift the encoder overflow outside the used range.
  3. Optimize the satellite pointing for the reception from a satellite for which the azimuth and elevation values are known.
  4. Click to the 'calc' label beside the calibration offset.
  5. Enter the known pointing angle for the satellite and click to submit.
  6. The ACU calculates and sets the calibration offsets to a value so that the actual pointing is displayed as the angle you entered.

For the azimuth axis there is another offset which also is taken into account, the 'Antenna course'. This value is provided for mobile applications where a compass reading has to be included into the azimuth value.

- **Calibration scale** — Normally the ACU assumes that the full range of a position sensor corresponds 360°. If you are using a multiturn position sensor or if the position sensor is mounted to the shaft of a gear rather than to the antenna axis directly, the position sensor reading must be scaled. The displayed angle is computed as follows: *displayed-value = ((raw-reading+pre-scale-offs) * scale) + pos-scale-offs*. Mathematically a scale value of 1.0 disables the scaling. Beside this, the ACU also accepts the special value 0 to disable scaling at all. If you set 1.0, the ACU performs the scaling with this factor. With the value 0 the scaling is skipped completely, including the conversion of the reading to floating point. This ensures, that the full accuracy is retained in cases where no scaling is necessary.
- **Sense invert** — With this parameter you easily can reverse the sense of a position sensor. The sense should be as follows:
  - Azimuth: The antenna looks more to the west for larger values.

  - Elevation: Larger values mean higher elevation.
  - Polarization: The feed turns clockwise (when looking through the antenna to the satellite) for increasing values. When operated on the southern hemisphere, the polarization sense must be set the other way round.
- **Motor driver type** — The ACU knows two different configuration modes to control a motor driver. They are called DIR-START and DUAL-START. In DIR-START mode, the FWD signal switches the motor on/off, the REV signal controls the motor direction. This is the configuration many frequency inverters use. In DUAL-START mode, the FWD signal switches the motor on in forward direction, REV activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays. Beside the modes DIR-START and DUAL-START you may set the motor driver type to NONE which prevents the ACU from controlling the motor at all.
- **Low speed threshold** — The ACU controls a motor at two speeds. If the actual position is far away from the target value, the ACU commands the motor to use the fast speed. Once the antenna comes close to the target value, the ACU slows down the motor. The low speed threshold sets the angle deviation which lets the ACU use the fast motor speed.
- **Pointing hysteresis** — The ACU performs the motor control as a closed loop: if the angle reading and the target value differ, the motor is switched on to compensate the difference. If the difference is less than the hysteresis value, the ACU leaves the motor switched off. This prevents the antenna from oscillating around the target value.
- **Motor timeout** — The ACU monitors the position readings while the motor is running. If there is no change in the position readings for some time, the ACU assumes to motor to be blocked and switches it off. This 'motor timeout' fault must be reset by the operator to release it. A timeout value 0 disables the timeout.
- **Lower limit** — The minimum target value accepted at the user interface and via remote control. This software limit prevents the ACU from running the antenna to the limit position under normal conditions.
- **Upper limit** — The maximum target value accepted at the user interface and via remote control. This software limit prevents the ACU from running the antenna to the limit position under normal conditions.

Beacon Receiver

- **Beacon RX type** — Selects the source of the beacon level the ACU shall use. Available options are ***sat-nms*** and VOLTAGE. In ***sat-nms*** mode the ACU reads the beacon level from a ***sat-nms*** beacon receiver via UDP, in VOLTAGE mode the A/D converter input of the ACU is read. Please mention, that in ***sat-nms*** mode, the beacon receiver must be set to send UDP datagrams to the ACU/ODM.
- **Beacon RX IP address** — The IP address of the beacon receiver. Applicable only in ***sat-nms*** mode.
- **Beacon RX voltage scale** — The scale factor for the analog beacon level input. The value must match the scaling of the beacon level signal.
- **Beacon RX 0V level** — The beacon level which is displayed if the ACU recognizes 0V beacon level input.

Location

- **GPS receiver type** — Defines the type of GPS receiver the ACU uses to read its geodetic location.'NONE' tells the ACU that no GPS receiver is connected. The geodetic position of the Antenna has to be entered manually. The ACU synchronized its internal clock to the CMOS clock chip on the board.'NMEA' tells the ACU to expect messages from a NMEA GPS receiver connected to the serial interface at CON8, pins 1-3. The ACU automatically sets the

antenna's geodetic location to the values received and synchronizes the clock to the GPS timestamps. If no NMEA messages are received, the ACU states a fault.

- **Antenna course** — The Antenna course is an additional offset which is included into the azimuth calibration. It is used for mobile antennas to set the orientation of the antenna without recalibrating it. For stationary antennas this value always should be set to 180°.
- **Antenna longitude** — The geodetic longitude of the antenna. For a precise orbit to pointing calculation this value should be entered with 0.001° accuracy.
- **Antenna latitude** — The geodetic latitude of the antenna. For a precise orbit to pointing calculation this value should be entered with 0.001° accuracy.
- **Antenna abs. altitude** — The absolute altitude over sea of the antenna location.

Orientation

- **Compasstype** — Applicable only for car-mobile variants of the ACU
- **Inclinometer type** — Applicable only for car-mobile variants of the ACU
- **Nick offset** — Applicable only for car-mobile variants of the ACU
- **Roll offset** — Applicable only for car-mobile variants of the ACU

SNMP Control

From Software version 2.1.007 or higher, the ***sat-nms*** ACU contains an SNMP agent listening at UDP port 161. The SNMP agent provides a common subset of the MIB-II system / interface parameters and gives full access to the remote control capabilities of the ***sat-nms*** ACU with a number of MIB objects placed in the private.enterprises tree.

The actual MIB file defining the ACU's private MIB may be downloaded from the ACU itself by FTP (user 'service', password 'service'). The file 'ACUODM.MIB' contains all necessary information.

- **SNMP read community** — Sets the SNMP community string expected for read access. The default is 'public'.
- **SNMP write community** — Sets the SNMP community string expected for write access. The default is 'public'.
- **SNMP trap community** — Sets the SNMP community string sent with traps. The default is 'public'.
- **SNMP traps** — This parameter decides if the SNMP traps are enabled or disabled.
- **SNMP system name** — The ACU replies to MIB-II sysName requests with the text entered at this place.
- **SNMP system location** — The ACU replies to MIB-II sysLocation requests with the text entered at this place
- **SNMP system contact** — The ACU replies to MIB-II sysContact requests with the text entered at this place.
- **MIB File** — click here to download the MIB file
- **SNMP trap IP 1-4** — Enter up to 4 trap destination IP addresses (dotted quad notation) to make the ACU sending traps by UDP to these hosts. Setting the parameter to 0.0.0.0 disables the trap generation.

Access Control

- **User password** — Here you can define the password for the 'user' login. Default password is 'user'. When you are logged in as 'user' you can command the antenna pointing, set the tracking parameters (if applicable) and store / recall targets. You can't modify the setup parameters or issue low level commands on the test page while logged in as 'user'.
- **Admin password** — Here you can define the password for the 'admin' login. Default

password is ‘admin’. When you are logged in as “admin��? you have full access to all parameters of the ACU, including the setup and the tweaks on the test page.

5.7 Handheld/ Frontpanel Operation

The antenna may be moved by means of the optional handheld or frontpanel controller. There are five different version available which will be supported by the ***sat-nms*** ACU:

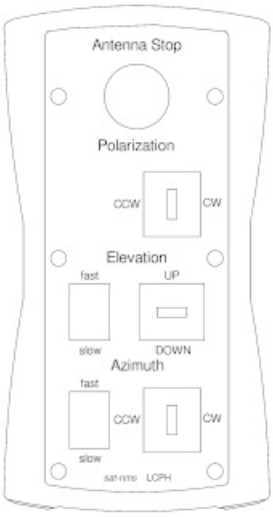
- **LCPH** , a very basic handheld which allows the movement of all three axis. It will be connected via the optional LCPI interface module, located between ACU-ODM and motor driver.
- **LCPHD-PT** , similar to the LCPH, but with angular display.
- **RCPH** , a ruggedized frontpanel controller connected via serial interface to the ***sat-nms*** ACU-ODM.
- **RCPH19** , similar to the RCPH but in a 19��? rack version.
- **Handheld Terminal** , not longer available but still supported in the ACU software.

Remark:

The ACU-RMU and ACU19xx Versions have already a build in frontpanel control and therefor, there is no additional Handheld interface available at these units.

5.7.1 LCPH (Local Maintenance Controller)

The Local Maintenance Controller is a Handheld, which realize a ***sat-nms*** ACU-ODM independent direct control of all 3 motor driver.



LCPH.png

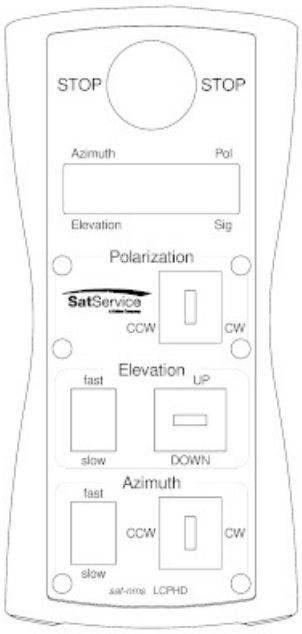
Operation

The operation is more or less self explanatory. Please make sure that the “Ant Stop��? button is released before you try to move the antenna. Use the button which is for each axis available to move the antenna in the defined direction. With the fast/slow switch you can choose the speed of the azimuth and elevation axis.

Remark: Requires LCPH-UP if ***sat-nms*** ACU-ODU-AC was delivered before 5/2014.

5.7.2 LCPHD-PT (Local Maintenance Controller with Display)

The LCPHD-PT is very similar to LCPH, but with angular Display and PT-Connector for direct connection to the outdoor cabinet. Have a look to the previous chapter for the description.

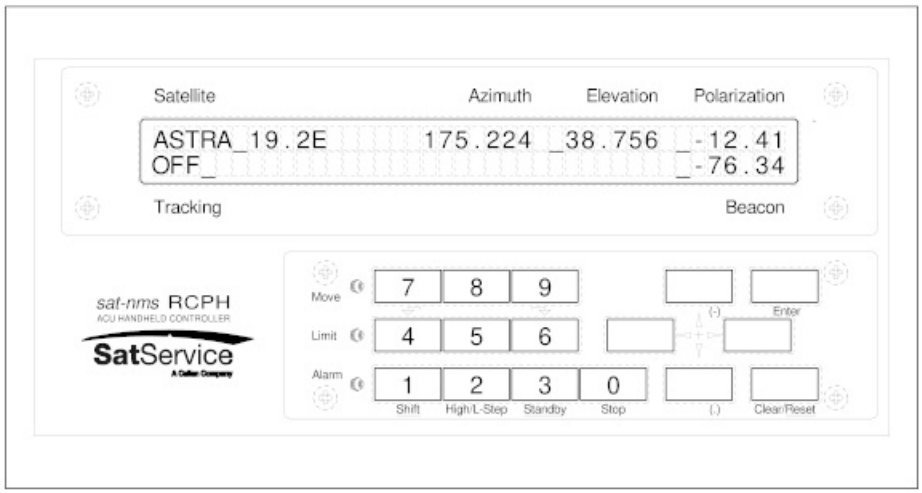


LCPHD.png

Remark: Requires LCPH-PT-UP if ***sat-nms*** ACU-ODU-AC was delivered before 5/2018.

5.7.3 RCPH (ACU Handheld Controller)

The RCPH is a ruggedized control panel which is useable to control the basic settings of the ACU without the need of a Ethernet connection. The interface to the ACU-ODM is a serial RS422 link. The integrated display shows angle values of all 3 axes and beacon level. There is possible to control of all 3 axes manually as Jog-Control or by enter desired angle values via keyboard. Also step move and a target call will be supported. For a detailed operation description see chapter 6.



RCPH.png

Remark: Requires RCPH-UP for ***sat-nms*** ACU-ODU-xx to realize the interconnection.

5.7.4 RCPH19 (ACU Handheld Controller 19��?)

The RCPH19 is very similar to the RCPH, but mounted in a 1RU 19 Inch rack drawer. Have a look to the previous chapter for the description.

RCPH19.png

Remark: Requires RCPH-UP for ***sat-nms*** ACU-ODU-xx to realize the interconnection.

5.7.5 Handheld Terminal

This unit is not longer available. This chapter is for existing handheld terminals only.

Startup

Set parameter 'RS485 address' on the ACUs Setup-page to 'TERM'. This enables communication between the ACU and the ***sat-nms*** handheld.

Connect the Handheld with the provided cable (Handheld: 9pol DSUB + Power supply, ACU-Cabinet: 15pol DSUB). After connecting the Handheld, push the Redraw button once. The start-up screen, that shows the installed software version is displayed for a few seconds. After that the menu for controlling the antenna is displayed automatically.

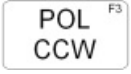
Operation

hh-keys.gif

-

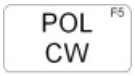
— Emergency STOP, stops all Motors immediately, it has to be released by pushing the -button
-

— Releases the motor-lock that was set by pushing the STOP-button.
-

— Back to start screen
- 

— Turns the Polarisation counterclockwise

-

— Selects the step-size: small steps: x°/keypress (x is the value that was set on the setup-screen), large steps: 10*x°/keypress, continuous mode: the antenna moves as long until the -button is pushed or a limit switch or limit value is reached.
- 

— Turns the Polarisation clockwise
-

— Moves the antenna up (EL)
-

— Moves the antenna to the left (AZ)
-

— Stops the antenna movement (only in continuous mode)
-

— Moves the antenna to the right (AZ)
-

— Moves the antenna down (EL)

Remark: This unit is not longer available, but still software supported from the ***sat-nms*** ACU-ODM.

5.8 Target Editor

The target editor lets you edit the contents of a target memory without actually applying the target setting. Using the editor permits to edit target setting while the antenna is tracking and in operative use.

You enter the target editor for a certain target memory by clicking to the ‘edit’ icon in the target’s line in the target selection page. The editor page looks much like the tracking parameters page, it contains the same information with some additional parameters. You edit each single parameter the same way as at the trackon parameter page: click to the parameter, edit the value, and finally submit the change. All this happens with a temporary copy of the tareget memory. The target memory itself is not changed by this unless you click the ‘Save’ button at the very bottom of the page.

General Settings

- **Target name** — A descriptive name for this target memory. If the ACU-ODM is used stand alone, you are free to enter any text here. Target memories are saved and recalled by number, hence it does not matter if there are duplicate target names. If however the ACU-ODM is controlled by a ***sat-nms*** monitoring and control system, targets are recalled by name with this software. In this case you should avoid duplicate names and you should be aware, that the ***sat-nms*** software will remove all punctuation characters from the target name. Target names in the ***sat-nms*** software may only consist of characters A-Z (upper or lower case), digits and the characters space, ‘-’ and ‘.’.
- **Tracking mode** — The tracking mode parameter selects the tracking method, the ACU actually uses. Possible selection are:
  - **OFF** — No tracking is performed.
  - **STEP** — Step track mode. In regular intervals, the antenna performs small search steps to optimize the pointing. Chapter ‘8.3.0 Step Track’ gives more information about this mode.
  - **STEP-TLE** — The antenna tries to optimize its pointing like in *STEP* mode. If the level of

the received signal is too low for this optimization, the antenna moves along the path calculated from a TLE parameter set instead.

- **STEP-I11** — The antenna tries to optimize its pointing like in *STEP* mode. If the level of the received signal is too low for this optimization, the antenna moves along the path calculated from an Intelsat 11 parameter set instead.
- **MEMORY** — The antenna tries to optimize its pointing like in *STEP* mode. If the level of the received signal is too low for this optimization, the antenna moves to the position it had exactly one siderian day before.
- **ADAPTIVE** — The adaptive tracking mode works the same way as step track, but it additionally is capable to predict the satellite's position when the beacon reception fails. It computes mathematical models of the satellites motion from the step track results recorded over a certain time. Details about this tracking mode are given in chapter '8.4.0 Adaptive Tracking' .
- **PROGRAM** — The program tracking mode is different from the modes above. The ACU moves the antenna along a path which is described in a data file. No beacon reception is required for this. You have to create such a data file and copy it with FTP to the ACU before you can use this mode. SatService GmbH provides a PC software which lets you easily create data files for program track from commonly used ephemeris data sets for geostationary satellites. Chapter '8.5.0 Program Tracking' describes this tracking mode more detailed.
- **TLE** — The antenna moves along a path calculated from a TLE ephemeris data set. There are no optimization steps and no receive signal is required for such an optimization.
- **I11** — The antenna moves along a path calculated from an Intelsat 11 parameter data set. There are no optimization steps and no receive signal is required for such an optimization.

- **Initial pointing mode** — The initial pointing mode specifies how the antenna finds its initial position before it starts the tracking mode selected with the setting above. This parameter only has an effect, when a target memory gets recalled. Changing the initial pointing mode does not re-position the antenna. Possible selection are:
  - **STORED-POSTION** — The antenna moves to the Az/El/Pol angles stored for the particular satellite. After this position has been reached, the tracking selected by the 'tracking mode' is started.
  - **ORBIT** — The antenna's Az/El/Pol angles are calculated from the satellite's orbit position stored in the recalled target memory. The 'target azimuth offset' and 'target elevation offset' values described later on this page are added to the calculated angled before they are applied. After the commanded position has been reached, the tracking selected by the 'tracking mode' is started.
  - **TLE** — The antenna's Az/El angles are calculated from the TLE data set selected in the recalled target memory. The 'target azimuth offset' and 'target elevation offset' values described later on this page are added to the calculated angled before they are applied. The Pol angle is set to its stored position in this mode. After the commanded position has been reached, the tracking selected by the 'tracking mode' is started.
  - **I11** — The antenna's Az/El angles are calculated from the I11 data set selected in the recalled target memory. The 'target azimuth offset' and 'target elevation offset' values described later on this page are added to the calculated angled before they are applied. The Pol angle is set to its stored position in this mode. After the commanded position has been reached, the tracking selected by the 'tracking mode' is started.
- **Tracking cycle time** — The cycle time specifies how often the ACU shall perform a step track cycle. The value is to be entered in seconds. In fact, the parameter does not specify a cycle time but the sleep time between two tracking cycles. This means, the true cycle time is

the time the ACU needs to perform one step track cycle plus the time entered here. 300 seconds (5 minutes) is a good starting value for this parameter. Inclined orbit satellites probably will require a shorter cycle time, very stable satellites can be perfectly tracked with one step track cycle every 15 minutes (900 seconds). The maximum cycle time accepted by the ACU is 1638 seconds. This parameter is also used so specify how often the antenna position shall be moved in the PROGRAM, I11 and TLE tracking modes.

- **Polarization prediction** — Actually not implemented.
- **Target orbit position** — The nominal orbit position of the satellite (°E). This value is used for the initial pointing of the antenna if the 'initial pointing mode' is set to 'ORBIT'.
- **Inclination** — Actually not implemented.

Pointing Angles

- **Az target value /El target value / Pol target value / Pol2 target value** — The pointing angles stored with the target are used to position the antenna if the initial pointing mode is set to 'STORED-POSITION'.

Steptrack Parameters

- **Tracking step size** — The tracking step size is a very important parameter for the performance of the tracking. It defines the size of every depointing step, the ACU makes in order to find out where the optimal antenna pointing is. Setting too high values will cause significant signal degradations during the step track cycle because the antenna moves a too large amount away from the satellite. Setting the value too small will let the beacon level jitter mask the level differences caused by the test steps, the antenna will not track the satellite properly.The step size is specified as a percentage of the antenna's half 3dB beamwidth. The ACU calculates the beamwidth from the antenna diameter and the beacon frequency. Expressing the step size in this relative way keeps the value in the same range, regardless of the type of antenna. The recommended value for this parameter is 15-20%. You may want to start with 20% and try to reduce down to 15% if the signal degradation during tracking becomes too high.The tracking step size is a common parameter for both axes. If both axes behave differently, you can tweak the antenna diameter settings in the setup. Specifying a larger diameter makes the ACU using a smaller step size for this axis.If the tracking step seems to be completely out of range, you should check if the beacon frequency is set properly. The frequency must be the true receive frequency at the antenna, entered in MHz, not an L-band frequency or other IF.
- **Beacon frequency** — This parameter tells the ACU the frequency of the beacon signal to be used for tracking. The ACU calculates the antenna beam width from this frequency and the antenna diameter configured at the setup page. The value has to be entered as true receive frequency, no L-band or other IF frequency. When used with a SatService beacon receiver, the ACU automatically reads the beacon frequency at the start of each tracking cycle from the receiver. Any value entered here will be overwritten in this case. The beacon frequency entered here never sets the frequency at the receiver, neither with a SatService receiver nor with a third party device!
- **Level offset** — Principally there are two ways to display a beacon receive level: Either as an absolute level in dBm as reported by the receiver or as a relative level with '0dB' signalling the nominal level at clear sky conditions. The latter gives an easy measure for any degradation of the receive level.The parameter 'Level offset' lets you calibrate the absolute reading of the beacon receiver to the relative level. You may either enter a value to shift the reading by this offset or you may click to the 'calc.' link beside this parameter to set the offset to the actual absolute level reading, making the actual level being 0dB relative.
- **Level threshold** — If the beacon level falls below this threshold value, the ACU does not

perform a step track cycle. If the level falls below the threshold during the steptrack cycle, the cycle gets aborted.If the ADAPTIVE tracking is enabled and there is enough data in the tracking memory, the ACU computes a mathematical model from the stored data and predicts the antenna pointing position from the extrapolation of the model. Analogously the antenna is moved to the actual TLE it I11 position in such a case if the 'STEP-TLE' or 'STEP-I11' mode is selected. If the tracking mode is set to 'STEP', the ACU leaves the antenna where it is if the beacon level drops below the limit.Adjusting the threshold level that adaptive tracking is switched as expected must be done carefully and may require some iterations, specially if the beacon is received with a low C/N. A good starting value for the threshold is 10 dB below the nominal receive level or 2 dB above the noise floor the beacon receiver sees with a depointed antenna, whatever value is higher.To turn off the monitoring of the beacon level (this in fact inhibits the adaptive tracking), simply set the threshold the a very low value (e.g. -99 dBm)

- **AZ Maximum model type / EL Maximum model type** — These settings let you limit the adaptive model to a simpler one, the ACU would choose by itself. The maximum model type can be set individually for each axis. Normally you will set both axes to 'LARGE', which leaves the model selection fully to the ACU's internal selection algorithms.In cases where the ACU seems to be too 'optimistic' about the quality of the step track results, the maximum model on one or both axes may be limited to a more simple and more noise-resistant model. Specially inclined orbit satellites which are located close to the longitude of the antenna's geodetic location may require this limitation for the azimuth axis. With such a satellite, the elevation may move several degrees while the azimuth shows almost no motion.
- **Measurement delay** — During a steptrack cycle, the ACU positions the antenna to a certain offset and then measures the level. Between the moment when the antenna reached commanded position and the beacon level measurement the ACU waits some time to let the beacon level settle. The optimal delay value depends on the beacon receiver's averaging / post detector filter setting and is a quite critical for the steptrack performance.If the delay is too short, the beacon voltage does not reach its final value, the steptrack does not properly recognize if the signal goes better or worse after a test step. If the delay is too long, the impact of fluctuation to the measured level grows and may cover the small level difference caused by the test step. With the ***sat-nms*** LBRX beacon receiver, best results are achieved if the receiver is set to 0.5 Hz post detector filter bandwidth and a measurement delay of 1500 msec.
- **Recovery delay** — After the ACU has done the tracking steps for the elevation axis, it waits some time before it starts tracking the azimuth axis. This is to let the beacon level settle after the final position has been found. A typical value for this parameter is 4000 msec.
- **Level averaging** — When measuring the beacon level, the ACU takes a number of samples and averages them. The standard value of 5 samples normally should not be changed. Larger values will slow down the ACU execution cycle.
- **Retry after motor fault** — When the ACU encounters a motor fault during steptrack, the tracking cycle gets aborted and the ACU shows a fault. This parameter tells the ACU how to proceed after this, with the next tracking cycle:
  - **NEVER** — The ACU will not try to move the antenna again. This will stop tracking until an operator will have checked the antenna motor and re-started the tracking.
  - **FOREVER** — The ACU try to move the antenna again with the next tracking cycle. If the antenna is really blocked, the ACU will try to move the antenna every tracking cycle. This increases the probability to keep the antenna following the satellite - even if the antenna motors show sporadic faults. But this also increases the risk to crash motors and/or spindles of the antenna.
  - **ONCE** — This mode offers a compromise between preserving the motors and trying to keep the antenna following the satellite. The mode ONCE allows the ACU to do exactly

one retry after a motor fault, if this fils as well the ACU stops tracking

- **Smoothing interval** — This parameter controls the smoothing function. Setting it to zero disables smoothing. Smoothing lets the ACU point the antenna to positions evaluated from a simple model calculated from the step track peaks of the recent few hours. A detailed description of this function you find at chapter '8.3.3 Smoothing'
- **Peak jitter threshold** — If the jitter value of at least one axis exceeds this threshold, the ACU raises an 'model fault'. If this happens three consecutive times, the ACU resets the models of both axes. Adaptive tracking will be possible not until 6 hours after this happens.During adaptive tracking, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the (currently selected) model. The figure is also expressed as a percentage of the antenna's beamwidth, low values indicate, that the model ideally describes the antenna's path. High values indicate that's something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit.A typical threshold value is 20%, this will detect very early that a model does not fit to describe the satellite's motion. If this value causes false alarms too often, you may want to raise the threshold to 50%. Setting it to 0 switches the threshold monitoring completely off.

Prediction Parameters

- **I11 Ephemerides** — The ACU provides 99 named memory places (numbered 1..99) to store Intelsat 11 parameter sets. With this parameter you address the number of the I11 parameter set to be used with the 'I11' or 'STEP-I11' tracking modes and for the 'I11' initial pointing mode as well. The setting is a reference to the memory location where the I11 parameter are stored, hence, if the parameters at this location are changed the ACU automatically uses the changed parameters.
- **TLE Ephemerides** — The ACU provides 99 named memory places (numbered 1..99) to store TLE ephemerides sets. With this parameter you address the number of the TLE parameter set to be used with the 'TLE' or 'STEP-TLE' tracking modes and for the 'TLE' initial pointing mode as well. The setting is a reference to the memory location where the TLE parameter are stored, hence, if the parameters at this location are changed the ACU automatically uses the changed parameters.
- **max. TLE/I11 age** — If the epoch of a TLE or I11 parameter set which is actually in use ('TLE' or 'I11' tracking modes) is older than the time specified here, a TLE-OUTDATED or I11-OUTDATED fault is raised. This has no impact on the TLE/I11 tracking but signals, that the ephemeris data should be updated for an optimal antenna pointing
- **Target azimuth offset / Target elevation offset** — The offsets specified here are added to any antenna pointing which is calculated from ephemeris data or from an orbit position and also to the pointing angles read from a file in PROGRAM tracking mode. The offsets can be used to compensate for differences between measured and calculated angles, e.g. if the azimuth axis of the antenna is not exactly vertical. The buttons at the bottom of the target editor page let you either save the edited value, save the edited values to another memory location or you may leave the editor without saving the changes.
- **CANCEL** — This abadons the editing process, leaves the stored values unchanged. You are returned to the target selection page
- **SAVE** — This saves the edited values and returns to the target selection page. The updated target memory is not recalled, not applied to the 'live' settings. If you want this, you have to click 'go' for this target memory at the target selection page.
- **SAVETO** — This saves the edited values to the memory location set at the entry field right beside the button. The value in this field is preset with the target number for which the editor

has been opened. It has to be changed if the editor shall save the edited target to another location. After saving the ACU returns to the target selection page. Like with ‘SAVE’, the saved target memory is not recalled, not applied to the ‘live’ settings.

All three buttons work immediately when clicked, there is no ‘do you really want’ query before the clicked action is executed.

Please note, that the ACU-ODM uses one single temporary memory for the target editor. The implies that the target editor may not be used from more than one browser window at a time or the edited values will be messed up. This also applies to a remote controlled edit session, either a target memory may be edited in the WebGUI or via an external software, not from both sources at the same time.

Target Editor Page Example:

General Settings

Target name	EUTELSAT 8W I11			
Tracking mode	OFF		Initial pointing mode	I11
Tracking cycle time	15 sec		Polarization prediction	n/a
Target orbit position	19.200 °E		Inclination	n/a

Pointing Angles

Az. target value	47.010 °		El. target value	0.000 °
Pol. target value	21.852 °			

Steptrack Parameters

Tracking step size	20 %		Beacon RX frequency	11000.000 MHz
Level offset	0.00 dB		Level threshold (rel.)	-80.00 dBm
AZ Maximum model type	SMALL		EL Maximum model type	SMALL
Measurement delay	3000 msec		Recovery delay	5000 msec
Level averaging	5 samples		Retry after motor fault	FOREVER
Smoothing interval	6 h		Peak jitter threshold	20 %

Prediction Parameters

I11 Epheremides	10: EUTELSAT 8 WEST B		TLE Epheremides	70: EUTELSAT 8 WEST B
max. TLE/I11 age	72.0 h			
Target azimuth offset	0.000 °		Target elevation offset	0.000 °

CANCEL SAVE SAVE TO 3

targedit.gif

5.9 Orbital Data Editor

The ACU permits to store up 99 TLE ephemerides data sets and up to 99 Intelsat 11 parameter data sets. The datasets are numbered 1..99 and are referenced in the target memory data by this number. This means you assign a data set to a target satellite by its number rather than by its name.

Position 0 in the table is reserved and labeled ‘NONE’. In the Target Editor or when editing the actual tracking parameters, you may select dataset 0 to tell the ACU that there are no TLE/I11 ephemerides known for this particular satellite.

The Orbital Data Editor page shows a table of all 99 datasets of a type (TLE or I11) with their memory number and their name. Unused datasets have no name assigned, they are shown with their memory number only. The table shows either the TLE datasets of the I11 datasets, the heading above the table described which type of ephemerides are actually shown. At the top right corner of the page there is a link which you can click to switch between TLE and I11.

A click to the number or name of a dataset in the table opens a page which lets you edit the parameters of this particular dataset. For TLE parameter sets this is the TLE Dataset Editor , for I11 datasets the I11 Dataset Editor . At these pages the parameters of the datasets may be

edited, the changed values may saved to the original or to another memory location.

At the bottom of the Orbital Data Editor page below the table there is link labeled “re-read the TLE.TXT file??? (or “re-read the I11.TXT file??? if the I11 datasets are actually shown). Clicking this link makes the ACU re-read the file like at power up.

At the end of each of the data set editor chapters you find a step by step instruction how to upload a complete set of 99 TLE or I11 datasets with FTP and how to make the ACU use the new data.

Orbital Data Editor Page Example:

Two Line Elements I11 Elements

00: NONE	25: SES-2	50: ECHOSTAR 17	75:
01: INTELSAT 17 (IS-17)	26: ARABSAT-5C	51: METEOSAT-10 (MSG-3)	76:
02: EUTELSAT KA-SAT 9A	27: EUTELSAT 8 WEST B	52: SES-5	77:
03: ASTRA 5B	28: QUETZSAT 1	53: TIANLIAN 1-03	78:
04: HISPASAT 30W-5	29: INTELSAT 18 (IS-18)	54: INTELSAT 20 (IS-20)	79:
05: KOREASAT 6	30: EUTELSAT 16A	55: HYLAS 2	80:
06: BEIDOU 8	31: VIASAT-1	56: INTELSAT 21 (IS-21)	81:
07: INTELSAT NEW DAWN Ho Ho	32: ASIASAT 7	57: ASTRA 2F	82:
08: YAHSAT 1A	33: BEIDOU 10	58: GSAT-10	83:
09: SBIRS GEO-1 (USA 230)	34: LUCH 5A	59: INTELSAT 23 (IS-23)	84:
10: TELSTAR 14R	35: NIGCOMSAT 1R	60: BEIDOU 16	85:
11: GSAT-8	36: FENGYUN 2F	61: LUCH 5B	86:
12: ST-2	37: WGS F4 (USA 233)	62: YAMAL 300K	87:
13: CHINASAT 10 (ZX 10)	38: SES-4	63: STAR ONE C3	88:
14: TIANLIAN 1-02	39: BEIDOU 11	64: EUTELSAT 21B	89:
15: GSAT-12	40: MUOS-1	65: ECHOSTAR 16	90:
16: ASTRA 1L	41: INTELSAT 22 (IS-22)	66: CHINASAT 12 (ZX 12)	91:
17: SES-3	42: APSTAR 7	67: EUTELSAT 70B	92:
18: KAZSAT-2	43: YAHSAT 1B	68: YAMAL 402	93:
19: BEIDOU 9	44: AEHF-2 (USA 235)	69: SKYNET 5D	94:
20: ASTRA 1N	45: JCSAT-13	70: MEXSAT 3	95:
21: BSAT-3C (JCSAT-110R)	46: VINASAT-2	71: EUTELSAT 8 WEST B	96:
22: PAKSAT-1R	47: NIMIQ 6	72:	97:
23: CHINASAT 1A (ZX 1A)	48: CHINASAT 2A (ZX 2A)	73:	98:
24: COSMOS 2473	49: INTELSAT 19 (IS-19)	74:	99:

re-read the TLE.TXT file

orbdata.gif

5.9.1 TLE Dataset Editor

If you click to a TLE dataset number at the Orbital Data Editor page, the ACU opens the TLE Dataset Editor page for this particular dataset. The editor shows the TLE data in a multiline text field where it can be edited or modified with copy&paste. A number of buttons are provided to tell the ACU what to do with the edited dataset.

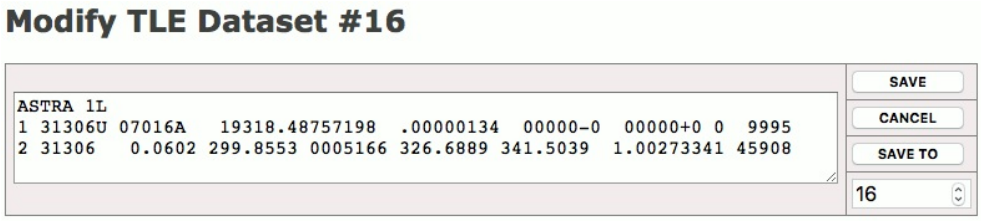
The buttons at the right side of the TLE dataset editor page let you either save the edited values, save the edited values to another memory location or you may leave the editor without saving the changes.

- **CANCEL** — This abadons the editing process, leaves the stored values unchanged. You are returned to the orbital data selection page
- **SAVE** — This saves the edited values and returns to the orbital data selection page. If the ACU actually uses the TLE dataset with this number for tracking, the new dataset will be used with the next tracking cycle.
- **SAVETO** — This saves the edited values to the memory location set at the entry field right beside the button. The value in this field is preset with the TLE memory number for which the editor has been opened. It has to be changed if the editor shall save the edited TLE data to

another location. If the ACU actually uses the TLE dataset with this number for tracking, the new dataset will be used with the next tracking cycle.

All three buttons work immediately when clicked, there is no 'do you really want' query before the clicked action is executed. To delete a dataset, clear the text input field and save the dataset, its content will be cleared.

TLE Dataset Editor Page Example:



tleedit.gif

You may use copy&paste to get the TLE data from the external source into this form field, this is a convenient way to edit or update single TLE datasets at the ACU. Beside this, the ACU permits to upload a text file with all 99 datasets with FTP. This way you may update / replace all TLE data at once. The procedure for this is described below step by step:

Step 1: prepare a text file named TLE.TXT containing all 99 TLE datasets

In this file, each dataset occupies exactly 3 lines of text: one line with the satellite name followed by two lines of TLE data. The TLE data format is commonly used, a detailled specification of the format may be found at Wikipedia.

```
TDRS 3
1 19548U 88091B   21039.70744037 -.00000308  00000-0  00000-0 0  9992
2 19548  14.0431 355.3612 0039480 323.7372  25.7572  1.00275903105784



SKYNET 4C
1 20776U 90079A   21039.50845519  .00000115  00000-0  00000-0 0  9996
2 20776  13.9269   3.9374 0002599 315.1892  36.0996  1.00268879111281
TDRS 5
1 21639U 91054B   21039.72583038  .00000073  00000-0  00000-0 0  9991
2 21639  14.2519   8.6689 0026423 358.2787 225.7580  1.00268316108116
TDRS 6
1 22314U 93003B   21039.89348271 -.00000306  00000-0  00000-0 0  9994
2 22314  14.0797  11.8449 0005571  62.6291 340.3063  1.00279982102812









ASTRA 1D
1 23331U 94070A   21039.48377461 -.00000282  00000-0  00000-0 0  9990
2 23331   9.4282  40.8176 0003567 279.7873 279.3655  1.00273492 96683
...
```

The example above shows the the beginning of a TLE.TXT file defining the 'TDRS 3' satellite in

dataset 1, ‘SKYNET 4C’ in dataset 3, ‘TDRS 5’ in dataset 4 and so on. Datasets 2, 6 and 7 are empty in this example, unused datasets have to be expressed as three empty lines. Please note, that this scheme must be strictly followed as the software interprets the file content based on the line numbers.

Step 2: upload the TLE.TXT file to the ACU using FTP

You may use the FTP client of your preference for this, simply connect to the ACU’s IP address and log in with user name ‘service’, password ‘service’. Then upload the TLE.TXT file to the default directory on the ACU. You may be asked to confirm if the existing TLE.TXT file shall be overwritten.

Step 3: reload the TLE.TXT file in the ACU software

For this last step open the Orbital Data Editor page from the navigation bar and ensure that the page shows the TLE ephemerides list (The heading ‘Two Line Elements’ is shown at the top left).

Now click to the ‘re-read the TLE.TXT file’ link at the bottom of the page.

The TLE data is now imported from the TLE.TXT file, replacing all TLE ephemerides previously stored on the ACU.

5.9.2 I11 Dataset Editor

If you click to a I11 dataset number at the Orbital Data Editor page, the ACU opens the I11 Dataset Editor page for this particular dataset. The editor shows the I11 data as a form with multiple fields where each parameter can be edited. A number of buttons are provided to tell the ACU what to do with the edited dataset.

The buttons at the bottom of the I11 dataset editor page let you either save the edited values, save the edited values to another memory location or you may leave the editor without saving the changes.

- **CANCEL** — This abadons the editing process, leaves the stored values unchanged. You are returned to the orbital data selection page
- **SAVE** — This saves the edited values and returns to the orbital data selection page. If the ACU actually uses the I11 dataset with this number for tracking, the new dataset will be used with the next tracking cycle.
- **SAVETO** — This saves the edited values to the memory location set at the entry field right beside the button. The value in this field is preset with the I11 memory number for which the editor has been opened. It has to be changed if the editor shall save the edited I11 data to another location. If the ACU actually uses the I11 dataset with this number for tracking, the new dataset will be used with the next tracking cycle.

All three buttons work immediately when clicked, there is no ‘do you really want’ query before the clicked action is executed. To delete a dataset, clear the ‘name’ input field and save the dataset, its content will be cleared.

170 Hour Prediction Values Check

The I11 ephemerides contain the predicted satellite at 170 hours after the epoch of the data set. The I11 dataset editor uses this predicted position to verify if the ephemerides data has been entered correctly. When the a data set has been saved (‘SAVE’ or ‘SAVE TO’), the ACU calculates the satellite position for 170 hours after the epoch and compares the calculated position to the predicted values in the data set. If they differ more than 0.005°, a warning is displayed with both,

the calculated and the predicted angles.

The edited dataset is saved even with this warning displayed, but you should re-edit it and check if all values have been entered correctly.

I11 Dataset Editor Page Example:

Modify I11 Dataset #01

Name:	Astra-1N / 19.20 DEG. E			Epoch:	2019 05 23 20 00 00		
LM0:	19.2190	LM1:	-0.0118	LM2:	0.001014		
LONC:	0.0351	LONC1:	-0.0003	LONS:	-0.0549	LONS1:	0.0001
LATC:	-0.0358	LATC1:	0.0017	LATS:	-0.0424	LATS1:	-0.0001
Predicted satellite position at 170 hours after epoch				LON:	19.1801	LAT:	-0.0449
				SAVE	CANCEL	SAVE TO	1

i11edit.gif

For Intelsat ephemerides there is no compact standard format defined as is for TLE ephemerides, hence entering each particular parameter into the form shown above is the way to edit or update single I11 datasets at the ACU.

Beside this, the ACU permits to upload a text file with all 99 datasets with FTP. This way you may update / replace all I11 data at once. The procedure for this is described below step by step:

Step 1: repare a text file named I11.TXT containing all 99 I11datasets

In this file, each dataset occupies exactly 3 lines of text: one line with the satellite name followed by two lines of I11 data. The expected format for the I11 data is described below the example shown here:

```
EUTELSAT 10A
2020 04 29 00 00 00;10.0156;-0.0041;-0.000151;-0.0139;0.0005;-0.0598;-0.0003...
9.9328;-0.0580



EUTELSAT 12 WEST B
2020 04 29 00 00 00;-12.4836;-0.0024;-0.000200;0.0337;0.0005;-0.0746;-0.0001...
347.4772;0.5068
EUTELSAT 16A
2020 04 29 00 00 00;15.9867;0.0034;-0.000108;-0.0047;0.0004;-0.0584;-0.0004...
15.9675;-0.0562
EUTELSAT 33E
2020 04 29 00 00 00;33.0998;-0.0036;-0.000029;-0.0299;0.0003;-0.0370;-0.0004...
33.0263;-0.0425









EUTELSAT 7A
2020 04 29 00 00 00;59.6893;0.0029;0.000033;-0.0404;0.0000;-0.0292;-0.0004...
59.6600;-0.1654
```

The example above shows the the beginning of a I11.TXT file defining the ‘EUTELSAT 10A’ satellite in dataset 1, ‘EUTELSAT 12 WEST B’ in dataset 3, ‘EUTELSAT 16A’ in dataset 4 and so on. Datasets 2, 6 and 7 are empty in this example, unused datasets have to be expressed as three empty lines. Please note, that this scheme must be strictly followed as the software interprets the file content based on the line numbers.

The ACU uses a special text format for I11 parameters which contains the data for one satellite in three lines:

- **Line 1** contains the satellite name
- **Line 2** contains the epoch time and the 11 parameters of the satellite model. They have to be formatted as a semicolon separated line containing the coefficients in the following order:

  EPOCH;LM0;LM1;LM2;LONC;LONC1;LONS;LONS1;LATC;LATC1;LATS;LATS1

  The epoch has to be (exactly) defined in the format ‘YYYY MM DD HH MM SS’. Numbers have to be given with (exactly) 4 digits precision, except for the LM2 parameter which must be formatted with 6 digits following the decimal point.
- **Line 3** contains the prediction values as two numbers **LON;LAT**, each with 4 digits precision.

Step 2: upload the I11.TXT file to the ACU using FTP

You may use the FTP client of your preference for this, simply connect to the ACU’s IP address and log in with user name ‘service’, password ‘service’. Then upload the I11.TXT file to the default directory on the ACU. You may be asked to confirm if the existing I11.TXT file shall be overwritten.

Step 3: reload the I11.TXT file in the ACU software

For this last step open the Orbital Data Editor page from the navigation bar and ensure that the page shows the I11 ephemerides list (The heading ‘I11 Elements’ is shown at the top left).

Now click to the ‘re-read the I11.TXT file’ link at the bottom of the page.

The I11 data is now imported from the I11.TXT file, replacing all I11 ephemerides previously stored on the ACU.

6 Frontpanel operation

The sat-nms ACU-ODM and ACU-ODU do not provide frontpanel operation. For these units, we provide an optional handheld for local controlling and monitoring without a laptop. Please refer to chapter 5.7 Handheld/ Frontpanel Operation for more informations.

7 Remote Control

The ***sat-nms*** ACU may be controlled remotely by a monitoring and control application either through the TCP/IP interface or through a serial RS232 interface (RS232 not yet implemented in ACU19 and ACU-RMU). Both communication methods use the same commands and parameters. However, there are different frames around each message depending communication method used.

Controlling the device from the web interface, the TCP/IP remote control interface or via the serial interface is completely equal, commands may sent to any interface at any time, the ACU will use the parameter it receives last.

7.1 General command syntax

The ACU knows a number of parameters, each identified by a parameter name. To set a certain parameter to a new value, a message:

name=value

has to be sent to the ACU. The ACU interprets this command, checks the range of *value* , sets the internal parameter and then answers:

name=value

The *value* in the reply is the value actually recognized by the ACU. For instance, if the requested value was out of range, the replied (and internally used) value is limited to the applicable minimum or maximum.

To read a parameter from the ACU, instead of a new parameter value a question mark is sent:

name=?

The ACU replies the actual value in a complete message:

name=value

A complete list of the parameter the ACU knows is shown later in this document in chapter Parameter list . Below, some common rules applying to the remote control message syntax are summarized.

- Parameter names always are of lower case letters, most of them are four characters long.
- Non-numeric parameter values always are written in upper case.
- Numeric (floating point) values may be specified with an arbitrary precision, however the device will reply only a fixed number of places. The ACU recognizes a decimal point ('.'), numbers must not contain any commas.
- There must not be any whitespace in front or after the '=' in a message.
- If the command/query is not of the form **name=value** or **name=?** , the ACU replies the message **?SYNTAX** .
- If the message syntax is OK, but contains an unknown parameter name is used, the reply is **?UNKNOWN**
- Numeric parameters are cut to the limits defined for this particular parameter.
- Misspelled choice values cause the ACU to set the first value of the choice list.
- Assigning a value to a read-only parameter will cause no fault, however the ACU will overwrite this parameter immediately or some seconds later with the actual value.

7.2 The TCP/IP remote control interface

Controlling the ACU through the network is done by means of HTTP GET requests. Setting parameter values or querying readings or settings, all is done by requesting HTTP documents from the ACU. The message *to* the ACU thereby is coded into the URL as a CGI form parameter. The ACU replies a one line document of the MIME type 'text/plain'.

The document name for remote control is **/rmt** , hence (assuming the ACU is listening to the IP address 10.0.0.1), requesting a document with the URL

```
http://10.0.0.1/rmt?blev=?
```

Will let the ACU reply the actual beacon level in a one line text document:

blev=-52.31

This way all parameters may be queried or set, you may use your favorite web browser to try out the remote control of the ACU manually.

7.3 The RS232 remote control interface

Beside the network interface, the ACU also provides an RS232 serial port which can be used to control the device remotely. Depending on the device address set, the ACU either runs framed protocol with start/stop characters and checksum or it provides a dumb terminal interface. The RS232 interface always operates at 9600 baud, no parity, 8 data bits, one stop bit.

This interface is not yet implemented in the ACU19 and ACU-RMU! At these versions, you have to select 'NONE' to enable the function of optional frontpanel display and keyboard. If another setting is selected, an optional frontpanel and keyboard has no function.

If an address 'A' .. 'G' is selected, the ACU expects each message it receives to be packed into a frame as described below.

char #	***example***	***description***
1	{	start character, always ' {'
2	A	device address (A..G)
3	l	first character of the message body
.	e	message body …
.	v	..
.	l	..
.	=	..
n-1	?	last character of the message body
n .tc}	end character, always '}'	
n+1	.	checksum

The checksum byte is calculated using an algorithm as implemented by the following formula:

$$\text{sum} = 32 + \left(\sum_{i=1}^{n} (\text{byte}[i] - 32) \right) \text{ modulo } 95$$

mod95.gif

This protocol type is known as *MOD95-* or *Miteq protocol* . The ACU also packs its reply in a protocol frame as described above. Incomplete frames, checksum errors or address mismatches let the ACU ignore the message. The time between the characters of a message must be less than 5 seconds or the ACU will treat the message as incomplete.

If the ACU is set to the device address 'NONE', it uses a simple line protocol instead of the framed protocol described above. Messages sent to the ACU have to be terminated with a carriage return character (ASCII 13), the ACU terminates replies with a CR/LF pair (ASCII 13/10). There is no echo for characters entered, hence this protocol easily may be used for computer based remote control. This setting is also used for allowing communication to an optional frontpanel display and

keyboard if implemented.

If 'TERM' is selected the serial interface is used to allow communication between the ACU and a ***sat-nms*** Handheld. This function is not available at ACU-RMU and ACU19 Version.

7.4 Parameter list

The table below shows the complete list of M&C parameters the ACU knows in alphabetical order. For each parameter the valid range and a short description is given.

name		***range***	***unit***	***description***
aabw	r/o		°	AZ antenna 3dB beamwidth
aalt		0 .. 8000	m	Antenna abs. altitude
aamp	r/o		%	AZ Amplitude
acal		-3600.000 .. 3600.000	°	AZ Calibration offset
aclc			°	Calculate offset from Az. value
acoe	r/o	see below	-	AZ model coefficients
acou		-180.000 .. 180.000	°	Antenna course
add5		A B C D E F G NONE	-	RS485 address
addr		A B C D E F G NONE TERM	-	RS232 address
ahys		0.000 .. 2.000	°	AZ Pointing hysteresis
ainv		NORMAL INVERTED	-	AZ Sense invert
ajog		R r x f F	-	AZ jog command
ajtr	r/o		%	AZ Peaking jitter
alat		-90.000 .. 90.000	°N	Antenna latitude
alon		-180.000 .. 180.000	°E	Antenna longitude
amax		-3600.000 .. 3600.000	°	AZ Upper limit

amdt	r/o	character string		AZ Model type
amin		-3600.000 .. 3600.000	°	AZ Lower limit
ammx		SMALL MEDIUM LARGE	-	AZ Maximum model type
amnt		AZ-OVER-EL POLAR	-	Antenna mount type
amot		DUAL-START DIR-START NONE	-	AZ Motor driver type
aofs		########		AZ Pre scale offset
apos	r/o	-180.000 .. 180.000	°	AZ Pointing
araw	r/o	00000000 .. FFFFFFFF		AZ raw pointing
asca		0.000000 .. 100000.000000		AZ Calibration scale
asen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	AZ Position sensor type
asth		0.0 .. 10.0	°	AZ Low speed threshold
astp		0.000 .. 90.000	°	AZ Step delta
atar		-180.000 .. 180.000	°	Az. target value
atot		0 .. 32000	msec	AZ Motor timeout
atsz	r/o		°	AZ tracking step size
attn		0 10 20 30	dB	BCRX Attenuation
autr		DISABLED		SNMP traps

aatr		ENABLED		SNMP traps
auxo		see below.	-	AUX output switch command
axmd		PARALLEL SEQUENTIAL	-	Axes control mode
babs	r/o	#.##	dBm	Beacon level (absolute)
bavg		1 .. 25	samples	Level averaging
bcfr		1000.000 .. 40000.000	MHz	Beacon RX frequency
bcip		aaa.bbb.ccc.ddd		Beacon RX IP address
bclc				Calculate level offset
bcof		-200.00 .. 0.00	dBm	Beacon RX 0V level
bcsc		-5.0000 .. 5.0000	V/dB	Beacon RX voltage scale
bcty		***sat-nms*** VOLTAGE	-	Beacon RX type
bdrt		1200 2400 4800 9600 19200 38400 57600 115200	-	RS232 baudrate
bdr5		1200 2400 4800 9600 19200 38400 57600 115200	-	RS485 baudrate
blev	r/o	#.##	dBm	Beacon level
bofs		#.##	dB	Level offset
brip	r/o	#.##	dB	Beacon level ripple
btrh		-999.00 .. 100.00	dBm	Level threshold
caps	r/o	00 .. FF		Software capabilities **1)**
cmod		DISABLED ENABLED		Linear/Circular switch

cnmf		#.###	MHz	BCRX Noise measurement frequency
cnmi		#	sec	BCRX Noise measurement interval
coha		OFF ON		Use cab-open as handheld active
coty		NONE	-	Compass type **2)**
cpos	r/o	LINEAR CIRCULAR SWITCHING INVALID		Lin/Crc switch position
ctar		LINEAR CIRCULAR UNKNOWN		Linear / circular switch
daco		#.##	dB	BCRX Analog output offset
dacs		#.####	V/dB	BCRX Analog output scale
decl		-90.000 .. 90.000	°	Antenna declination
dele		0 .. 199		Delete target
diaa		0.0 .. 100.0	m	AZ Antenna diameter
diae		0.0 .. 100.0	m	EL Antenna diameter
eabw	r/o		°	EL antenna 3dB beamwidth
eamp	r/o		%	EL Amplitude
ecal		-3600.000 .. 3600.000	°	EL Calibration offset
eclc			°	Calculate offset from El. value
ecoe	r/o	see below		EL model coefficients
ehys		0.000 .. 2.000	°	EL Pointing hysteresis

einv		NORMAL INVERTED	-	EL Sense invert
ejog		R r x f F	-	EL jog command
ejtr	r/o	0 ..	%	EL Peaking jitter
emax		-3600.000 .. 3600.000	°	EL Upper limit
emdt	r/o	character string		EL Model type
emin		-3600.000 .. 3600.000	°	EL Lower limit
emmx		SMALL MEDIUM LARGE	-	EL Maximum model type
emot		DUAL-START DIR-START NONE	-	EL Motor driver type
eofs		########		EL Pre scale offset
epoc	r/o			Model epoch
epos	r/o	0.000 .. 90.000	°	EL Pointing
eraw	r/o	00000000 .. FFFFFFFF		EL raw pointing
esca		0.000000 .. 100000.000000		EL Calibration scale
esen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	EL Position sensor type
esth		0.0 .. 10.0	°	EL Low speed threshold
estp		0.000 .. 90.000	°	EL Step delta
etar		0.000 .. 90.000	°	El. target value
etot		0 .. 32000	msec	EL Motor timeout

etsz	r/o		°	EL tracking step size
fltr		0.1 0.2 0.5 1 2 5	Hz	BCRX Post detector filter
freq		#.###	MHz	BCRX RF receive frequency
ftri		#	sec	BCRX Frequency tracking interval
ftrk		OFF ON		BCRX Frequency tracking
ftrw		#	kHz	BCRX Frequency tracking width
goto		0 .. 199		Goto target
gper	r/o	#		GPS error status
gpsa	r/o	#		GPS satellites
gpty		NONE NMEA	-	GPS receiver type
hfsl		OFF ON	-	Use hub-fault as summary limit
i11c		1 .. 99		I11 parameter clear
i11d			-	I11 parameter data **3)**
i11d			-	I11 parameter name **3)**
i11n				I11 parameter name
i11p			-	I11 parameter predict **3)**
i11s		0 .. 99	-	I11 parameter select **3)**
ibit		00000000 .. FFFFFFFF		Input bits (described

		. . . . .		below)
ibi2		0000 .. FFFF		Extended input bits (described below)
icty		NONE	-	Inclinometer type **4)**
incl				Satellite inclination
inpo		STORED-POSITION ORBIT TLE I11 MODEL FROM-TARGET		Initial pointing mode overwrite
inpt		STORED-POSITION ORBIT TLE I11	-	Initial pointing mode
ipt1				SNMP trap IP 1
ipt2				SNMP trap IP 2
ipt3				SNMP trap IP 3
ipt4				SNMP trap IP 4
ivpr				Invalid parameter value
jogm		OFF ON	-	Jog mode
jtrh		0 .. 100	%	Peak jitter threshold
lsyn	r/o			Last time synchronization
mbtr		OFF ON		Apply model before track
mdly		0 .. 9999	msec	Measurement delay
mhys		0 .. 100	%	Model hysteresis
mmod		OFF C/N C/N0		BCRX C/N measurement mode
msbw		6 12 30 100	kHz	BCRX Measurement bandwidth

msct	r/o	0 .. 999	msec	Measured software cycle
mstp	w/o	0 .. 1		1 stops all motors (STOP at the Web UI), 0 releases the stop (RESET at the Web UI). Command only, reading returns the recently commanded value, not the actual state.
nick	r/o	-90.0 .. 90.0	°	Nick angle
niko		-90.0 .. 90.0	°	Nick offset
note		character string		Note
ntp1				NTP server 1 address
ntp2				NTP server 2 address
obit		00000000 .. FFFFFFFF		Output bits (described below)
obi2		0000 .. FFFF		Extended qutput bits (described below)
orbt		-180.000 .. 180.000	°E	Orbit position
pcal		-3600.000 .. 3600.000	°	PO Calibration offset
pclc			°	Calculate offset from Pol. value
pcnt			°	Peak count
phys		0.000 .. 10.000	°	PO Pointing hysteresis
pinv		NORMAL INVERTED	-	PO Sense invert
pjog		R r x f F	-	PO jog command

plal				Beacon RX Pol. aliases (H,V)
pmax		-3600.000 .. 3600.000	°	PO Upper limit
pmin		-3600.000 .. 3600.000	°	PO Lower limit
pmot		DUAL-START DIR-START NONE	-	PO Motor driver type
pofs		########		PO Pre scale offset
ppos	r/o	-90.000 .. 90.000	°	PO Pointing
pprd		OFF ON ADAPTIVE	-	Polarization prediction **10)**
ppst	r/o			Pol prediction status **10)**
praw	r/o	00000000 .. FFFFFFFF		PO raw pointing
prds				Single prediction calculation
pred				Prediction file creation
psca		0.000000 .. 100000.000000		PO Calibration scale
psen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	PO Position sensor type
psth		0.0 .. 10.0	°	PO Low speed threshold
pstp		0.000 .. 90.000	°	PO Step delta
ptar		-90.000 .. 90.000	°	PO target value

ptot		0 .. 32000	msec	PO Motor timeout
qcal		-3600.000 .. 3600.000	°	PO2 Calibration offset **11)**
qclc			°	Calculate offset from Pol.2 value **11)**
qhys		0.000 .. 10.000	°	PO2 Pointing hysteresis **11)**
qinv		NORMAL INVERTED	-	PO2 Sense invert **11)**
qjog		R r x f F	-	PO2 jog command **11)**
qmax		-3600.000 .. 3600.000	°	PO2 Upper limit **11)**
qmin		-3600.000 .. 3600.000	°	PO2 Lower limit **11)**
qmot		DUAL-START DIR-START NONE	-	PO2 Motor driver type **11)**
qofs		########		PO2 Pre scale offset **11)**
qpos	r/o	-90.000 .. 90.000	°	PO2 Pointing **11)**
qraw	r/o	00000000 .. FFFFFFFF		PO2 raw pointing **11)**
qsca		0.000000 .. 100000.000000		PO2 Calibration scale **11)**
qsen		SSI-13B SSI-13G SSI-17B SSI-17G SSI-18B SSI-18G SSI-19B SSI-19G SSI-20B SSI-20G SSI-24B SSI-24G RESOLVER VOLTAGE NONE	-	PO2 Position sensor type **11)**
				PO2 Low

qsth		0.0 .. 10.0	°	speed threshold **11)**
qstp		0.000 .. 90.000	°	PO2 Step delta **11)**
qtar		-90.000 .. 90.000	°	PO2 target value **11)**
qtot		0 .. 32000	msec	PO2 Motor timeout **11)**
rcom				SNMP read community
rfsh		0 .. 60	sec	Display refresh, 0=manual refresh only
roll	r/o	-90.0 .. 90.0	°	Roll angle
rolo		-90.0 .. 90.0	°	Roll offset
rxpl		H V		BCRX Polarization
save		0 .. 199		Save target
scmp		character string		BCRX Spectrum compensation
scnt	r/o	0 .. 65535		Save count
scon				SNMP system contact
sdly		#	sec	BCRX Signal search delay
slee	r/o	0 .. 65535	sec	Sleep time up to the next tracking action
sloc				SNMP system location
smod		ALL NO-POINTING��?		Save mode
smth		0 .. 6	h	Smoothing interval
snam				SNMP system name
splo		-45.000 ..	°	Satellite polarization

spfo		45.000		polarization offset
srno	r/o	character string		Device serial no
ssen		OFF ON		BCRX Signal search enable
ssmd		OFF 1 .. 20		Spindle save mode
ssth		0 .. 100	%	Spindle save threshold
stby		0 .. 1		Standby mode
step		command		Step move **5)**
stim	w/o	character string		Sets date / time, command only **6)**
sver	r/o	character string		Software version
tage	r/o	#.#	h	Tracking model age
taof		-180.000 .. 180.000	°	Target azimuth offset
tcom				SNMP trap community
tcyc		1 .. 1638	sec	Tracking cycle time
tdir	r/o			Target directory (HTTP only)
tdly		100 .. 9999	msec	Recovery delay
tdsc		0..99 / character string	-	Target description **7)**
tedt		0 .. 199		Load target memory to editor
temp	r/o	#.#	°C	Temperature
teof		-180.000 .. 180.000	°	Target elevation offset
tflt	r/o	00 .. FF		Tracking fault bits (described

				below)
tgac		ACK NEW		Acknowledge position change
tgnr	r/o	-1 .. 199		Loaded target number, -1 = unknown
tgtd	r/o	0 .. 1		Target tainted
thrh		#.##	dBm	BCRX Alarm threshold
thrs	r/o	#.#	h	Tracking memory
ti11		0 .. 99		I11 parameter set selected in target
time	r/o	character string		Date / time **6)**
tle1		character string		TLE parameter line 1
tle2		character string		TLE parameter line 2
tlec		1 .. 99		TLE parameter clear
tlen		character string		TLE parameter name
tles		0 .. 99		TLE parameter select **8)**
tltm	r/o	character string		Last tracking memory entry
tmod		OFF STEP ADAPTIVE STEP-TLE STEP-I11 MEMORY TLE I11 PROGRAM	-	Tracking mode **9)**
tmxa		0 .. 999	h	max. TLE/I11 age
tnam		character string		Target name
torb		-360.000 .. 360.000	°E	Target orbit position
trcd		0 .. 1		Target position

trcd		0 .. 1		reached
trst		1 .. 1		Reset tracking memory
trty		NEVER ONCE FOREVER		Tracking retry on fault
trty		NEVER ONCE FOREVER		Tracking retry on fault
tsav		0 .. 199		Save edited target to position n
tsta	r/o	character string		Tracking state
tstp		1 .. 100	%	Tracking step size
tsya	r/o	0 .. 2		NTP time sync alarm, 0=OK, 1=FAULT, 2=using NTP2 because NTP1 does not answer
ttle		0 .. 99		TLE parameter set selected in target
wcom				SNMP write community
wdog		OFF ON		ON Sends a heatbeat to the AUX 8 output
xipt		1 .. 1		Execute initial pointing
eammx		same as ‘ammx’		Copy of ‘ammx’ in the target editor
eatar		same as ‘atar’		Copy of ‘atar’ in the target editor
eattn		same as ‘attn’		Copy of ‘attn’ in the target editor
ebavg		same as ‘bavg’		Copy of ‘bavg’ in the target editor

ebcfr		same as 'bcfr'		Copy of 'bcfr' in the target editor
ebofs		same as 'bofs'		Copy of 'bofs' in the target editor
ebtrh		same as 'btrh'		Copy of 'btrh' in the target editor
ecnmf		same as 'cnmf'		Copy of 'cnmf' in the target editor
ecnmi		same as 'cnmi'		Copy of 'cnmi' in the target editor
ectar		same as 'ctar'		Copy of 'ctar' in the target editor
edaco		same as 'daco'		Copy of 'daco' in the target editor
edacs		same as 'dacs'		Copy of 'dacs' in the target editor
eemmx		same as 'emmx'		Copy of 'emmx' in the target editor
eetar		same as 'etar'		Copy of 'etar' in the target editor
efltr		same as 'fltr'		Copy of 'fltr' in the target editor
efreq		same as 'freq'		Copy of 'freq' in the target editor
eftri		same as 'ftri'		Copy of 'ftri' in the target editor
eftrk		same as 'ftrk'		Copy of 'ftrk' in the target editor

eftrw		same as 'ftrw'		Copy of 'ftrw' in the target editor
eincl		same as 'incl'		Copy of 'incl' in the target editor
einpt		same as 'inpt'		Copy of 'inpt' in the target editor
ejtrh		same as 'jtrh'		Copy of 'jtrh' in the target editor
embtr		same as 'mbtr'		Copy of 'mbtr' in the target editor
emdly		same as 'mdly'		Copy of 'mdly' in the target editor
emhys		same as 'mhys'		Copy of 'mhys' in the target editor
emmod		same as 'mmod'		Copy of 'mmod' in the target editor
emsbw		same as 'msbw'		Copy of 'msbw' in the target editor
epprd		same as 'pprd'		Copy of 'pprd' in the target editor
eptar		same as 'ptar'		Copy of 'ptar' in the target editor
eqtar		same as 'qtar'		Copy of 'qtar' in the target editor
erxpl		same as 'rxpl'		Copy of 'rxpl' in the target editor
escmp		same as 'scmp'		Copy of 'scmp' in the target editor
				Copy of 'sdly'

esdly		same as ‘sdly’		in the target editor
esmth		same as ‘smth’		Copy of ‘smth’ in the target editor
esplo		same as ‘splo’		Copy of ‘splo’ in the target editor
essen		same as ‘ssen’		Copy of ‘ssen’ in the target editor
essmd		same as ‘ssmd’		Copy of ‘ssmd’ in the target editor
essth		same as ‘ssth’		Copy of ‘ssth’ in the target editor
etaof		same as ‘taof’		Copy of ‘taof’ in the target editor
etcyc		same as ‘tcyc’		Copy of ‘tcyc’ in the target editor
etdly		same as ‘tdly’		Copy of ‘tdly’ in the target editor
eteof		same as ‘teof’		Copy of ‘teof’ in the target editor
ethrh		same as ‘thrh’		Copy of ‘thrh’ in the target editor
eti11		same as ‘ti11’		Copy of ‘ti11’ in the target editor
etmod		same as ‘tmod’		Copy of ‘tmod’ in the target editor
etmxa		same as ‘tmxa’		Copy of ‘tmxa’ in the target editor
				Copy of ‘tnam’

etnam		same as 'tnam'		in the target editor
etorb		same as 'torb'		Copy of 'torb' in the target editor
etrty		same as 'trty'		Copy of 'trty' in the target editor
etstp		same as 'tstp'		Copy of 'tstp' in the target editor
ettle		same as 'ttle'		Copy of 'ttle' in the target editor

Remarks:

1) Software capabilities are summed from the following values:

value	**description**
1	step track & adaptive tracking included
2	polar mount antennas supported
4	memory tracking included
8	linear / cirular polarization switch supported
16	supports relative beacon level
32	implements the a standby mode for the positioner
64	has 200 target memories
128	supports I11 and TLE tracking modes
256	support 4-axis positioning control

2) ACU variants with compass support provide other choices beside NONE for this parameter.

3) To set a I11 parameter set from extern, first select the parameter set to edit (0..99) by writing the parameter set number to 'i11s', then set the I11 parameters ('i11d'), the I11 prediction values ('i11p') and optionally the parameter set name ('i11n'). For details, see *I11 parameter data* below.

4) ACU variants with inclinometer support provide other choices beside NONE for this parameter.

5) for single step move, use following commands:

command	***description***
ll	Azimuth large step left
l	Azimuth small step left

r	Azimuth small step right
rr	Azimuth large step right
dd	Elevation large step down
d	small step down
u	small step up
uu	large step up
c	Polarisation clockwise step
cc	Polarisation counter clockwise step

6) Use the 'time' parameter to read the actual time used by the ACU. Use the 'stim' parameter to set the time.

7) This parameter reports the description (name and pointing angles) for a given target number. 'tdsc=12' e.g. is interpreted by the ACU as a request to report the target description for target no. 12. The reply to this command is something like 'tdsc=ASTRA 19.2 (167.335/43.412/-15.455)'

8) To set a TLE parameter set from extern, first select the parameter set to edit (0..99) by writing the parameter set number to 'tles', then set the two TLE lines ('tle1', 'tle2') and optionally the parameter set name ('tlen'). For details, see *TLE parameter data* below.

9) ACU variants without tracking support only accept NONE for this parameter.

10) The polarization prediction mode controls if the ACU shall calculate and command the polarization angle during tracking. The following modes are defined:

mode	***description***
OFF	No polarization prediction is done
ON	The ACU calculates and commands the pol angle with each tracking cycle. With TLE or l11 it calculates the angle from there, with steptrack modes it calculates the pol angle from the satellite's orbital position and inclination as set with the *sorb* and *incl* parameters.
ADAPTIVE	Like 'ON', but the ACU refines the satellite's orbital position and inclination based on the recorded tracking data every three hours

The polarization prediction status shows from which data the polarization prediction is actually calculated in a free format string.

11) This parameter is only avaliable with ACU models equipped with a four axis position control. With 3-axis models, this parameter returns a dummy value when read, setting this parameter has no effect in this case.

Bit definitions in 'ibit' (input bits and flags):

The ‘ibit’ value is returned as a 32 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 31 the most significant bit in this number.

no.	*name*	*description*
0	IN_PLHLM	polarization hi limit
1	IN_PLLLM	polarization lo limit
2	IN_PLFLT	polarization motor fault
3	IN_HBFLT	antenna hub fault
4	IN_AUX1	reserved
5	IN_AUX2	reserved
6	IN_AUX3	reserved
7	IN_AUX4	reserved
8	IN_AZHLM	azimuth hi limit
9	IN_AZLLM	azimuth lo limit
10	IN_AZFLT	azimuth motor fault
11	IN_EMERG	emergency stop
12	IN_ELHLM	elevation hi limit
13	IN_ELLLM	elevation lo limit
14	IN_ELFLT	elevation motor fault
15	IN_COPEN	cabinet open
16	AZMOV	azimuth moving
17	ELMOV	elevation moving
18	PLMOV	polarization moving
19	MOVING	moving summary bit
20	AZTOT	azimuth timeout
21	ELTOT	elevation timeout
22	PLTOT	polarization timeout
23	TIMEOUT	timeout summary bit
24	TRKPEAK	peaking in progress
25	LOWBEAC	low beacon signal
26	BCRXFLT	beacon receiver fault
27	LIMIT	limit switch summary
28	AZSTOP	azimuth stopped

29	ELSTOP	elevation stopped
30	PLSTOP	polarization stopped
31	GPSFLT	GPS receiver fault

Bit definitions in 'ibi2' (input bits and flags for the 4th axis):

The 'ibi2' value is returned as a 16 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 31 the most significant bit in this number.

no.	***name***	***description***
0	IN_PL2FLT	polarization 2 motor fault
1		reserved
2	IN_PL2HLM	polarization 2 high limit
3	IN_PL2LLM	polarization 2 low limit
4	IN_AUX5	reserved
5	IN_AUX6	reserved
6	IN_AUX7	reserved
7	IN_AUX8	reserved
8	PL2MOV	polarization 2 moving
9	PL2TOT	polarization 2 timeout
10	PL2TOT	polarization 2 stopped
11		reserved
12		reserved
13		reserved
14		reserved
15		reserved

Bit definitions in 'obit' (output bits):

The 'obit' value is returned as a 32 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 31 the most significant bit in this number.

no.	***name***	***description***
0	OUT_AZ_FWD	azimuth motor forward
1	OUT_AZ_REV	azimuth motor reverse
2	OUT_AZ_SPD1	azimuth motor low speed
3	OUT_AZ_SPD2	azimuth motor hi speed
4	OUT_AZ_RESET	azimuth motor driver reset

5	OUT_AZ_RESERVE	reserved for extended motor control
6	OUT_AUX1	not used
7	OUT_AUX2	not used
8	OUT_EL_FWD	elevation motor forward
9	OUT_EL_REV	elevation motor reverse
10	OUT_EL_SPD1	elevation motor low speed
11	OUT_EL_SPD2	elevation motor hi speed
12	OUT_EL_RESET	elevation motor driver reset
13	OUT_EL_RESERVE	reserved for extended motor control
14	OUT_AUX3	not used
15	OUT_AUX4	not used
16	OUT_POL_FWD	polarization motor forward
17	OUT_POL_REV	polarization motor reverse
18	OUT_POL_SPD1	polarization motor low speed
19	OUT_POL_SPD2	polarization motor hi speed
20	OUT_POL_RESET	polarization motor driver reset
21	OUT_POL_RESERVE	reserved for extended motor control
22	OUT_AUX5	not used
23	OUT_AUX6	not used
24	OUT_SUMMARY	summary fault relay (1 == OK)
25	OUT_TRACKING	tracking fault relay (1 == OK)
26	OUT_BCPR1	reserved for beacon receiver frequency select
27	OUT_BCPR2	reserved for beacon receiver frequency select
28	OUT_BCPR3	reserved for beacon receiver frequency select
29	OUT_BCPR4	reserved for beacon receiver frequency select
30	OUT_AUX7	not used
31	OUT_AUX8	not used

The meaning of the ‘FWD’ / ‘REV’ motor control outputs depend on the motor control mode set for this axis.

Bit definitions in ‘obi2’ (output bits 4th axis):

The ‘obit’ value is returned as an 8 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 7 the most significant bit in this number.

no.	*name*	*description*
0	OUT_PL2_FWD	polarization 2 motor forward
1	OUT_PL2_REV	polarization 2 motor reverse
2	OUT_PL2_SPD1	polarization 2 motor low speed
3	OUT_PL2_SPD2	polarization 2 motor hi speed
4	OUT_PL2_RESET	polarization 2 motor driver reset
5	OUT_PL2_RESERVE	reserved for extended motor control
6	OUT_AUX9	not used
7	OUT_AUX10	not used

The meaning of the 'FWD' / 'REV' motor control outputs depend on the motor control mode set for this axis.

AUX output control

By means of the 'auxo' command, the ACU's auxiliary outputs may be controlled. The command expects two numbers, separated by a comma character. The first one is the AUX output number (1..10), the second one is 0 or 1 to switch this output off or on. Example:

```
auxo=2,1
```

switches the AUX2 output on.

Bit definitions in 'tflt' (tracking faults):

The 'tflt' value is returned as a 9 bit hexadecimal number. The bit number 0 means the least significant bit, bit number 9 the most significant bit in this number.

no.	*name*	*description*
0	APEAKFLT	azimuth peaking fault
1	EPEAKFLT	elevation peaking fault
2	MODELFLT	model match fault
3	JITTRFLT	jitter fault
4	TLEAGEFLT	the used TLE data is outdated
5	TLEFMTFLT	the used TLE data cannot be parsed
6	I11AGEFLT	the used I11 data is outdated
7	I11FMTFLT	the used I11 data cannot be parsed
		TLE/I11 data resulted in

8	TLIMITFLT	pointing angles outside the soft limits

Tracking coefficients on 'acoe' / 'ecoe':

In adaptive tracking mode the 'acoe' / 'ecoe' commands may be used to read the coefficients of the actual model. The coefficients are returned as a comma separated list of numbers in scientific notation. The number of coefficients returned depends on the size of the model:

- SMALL: *a0,a1,a2* (1)
- MEDIUM: *a0,a1,a2,a3,a4* (2)
- LARGE: *a0,a1,a2,a3,a4,a5* (3)

If the beacon signal drops below it's theshold, the antenna movement is calculated from these coefficients using the formulas shown below:

$$\alpha_{small} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) \quad (1)$$

$$\alpha_{medium} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) + a_3 \cos(2\omega t) + a_4 \sin(2\omega t) \quad (2)$$

$$\alpha_{large} = a_0 + a_1 \cos(\omega t) + a_2 \sin(\omega t) + a_3 \cos(2\omega t) + a_4 \sin(2\omega t) + a_5 t \quad (3)$$

formula.gif

I11 parameter data

The ACU permits to monitor and control the I11 parameter sets used from remote. The commands used for this have been designed to be compatible with third party SNMP based software which may limit the amount of data transferred with a single command. The typical sequence to update an I11 parameter set is as follows:

1. Select the number of the I11 parameter set to write to by setting the 'i11s' parameter to this number (0..99).
2. Write the I11 parameters formatted as described below to the 'i11d' parameter.
3. Write the I11 prediction values formatted as described below to the 'i11p' parameter.
4. Optionally update the name of the parameter set by writing this name to the 'i11n' parameter.

You should ensure, that the 'i11s' parameter is not changed until all parts of the I11 parameter set have been set. This implies, that only one remote control instance may update I11 parameters at a time. After this command sequence the I11 parameter set is stored at the ACU. When changing the parameter set which is actually in use for a STEP-I11 or a I11 tracking mode, the updated parameters will be used when the next tracking step ist started.

I11 parameters ('i11d') are expected as a semicolon separated character string containing the coefficients in the following order:

EPOCH;LM0;LM1;LM2;LONC;LONC1;LONS;LONS1;LATC;LATC1;LATS;LATS1

The epoch has to be (exactly) defined in the format 'YYYY MM DD HH MM SS'. Numbers hare to be given with (exactly) 4 digits precision, except for the LM2 parameter which expects 6 digits following the decimal point.

The I11 prediction values are expected as two numbers LON;LAT, each with 4 digita precision.

TLE parameter data

The ACU permits to monitor and control the TLE parameter sets used from remote. The commands used for this have been designed to be compatible with third party SNMP based software which may limit the amount of data transferred with a single command. The typical sequence to update a TLE parameter set is as follows:

1. Select the number of the TLE parameter set to write to by setting the ‘tles’ parameter to this number (0..99).
2. Write the TLE line 1 to the ‘tle1’ parameter.
3. Write the TLE line 2 to the ‘tle2’ parameter.
4. Optionally update the name of the parameter set by writing this name to the ‘tlen’ parameter.

You should ensure, that the ‘tles’ parameter is not changed until all parts of the TLE parameter set have been set. This implies, that only one remote control instance may update l11 parameters at a time. After this command sequence the TLE parameter set is stored at the ACU. When changing the parameter set which is actually in use for a STEP-TLE or a TLE tracking mode, the updated parameters will be used when the next tracking step ist started.

The ‘tle1’, ‘tle2’ parameter expect the line 1 / line 2 of the TLE parameter set exactly as defined in the TLE specification.

Controlling the target editor from remote

The target editor available at the ACU’s WebGUI can be controlled remotely. This is done by simulating the same steps which would be done by an operator at the ACU’s WebGUI.

The first step to do ist to load as target into the editor. The ‘tedt’ command does this. Seting ‘tedt’ to 25, for eample, loads the target memory 25 into the editor. Now the settings stored in this preset can be read for the external UI by inspecting the parameter commands of the editor. A target preset consists of about 25 parameters which are set when the preset is recalled. Editing the target contents meand to load these values into copies of the real destiniation paramets.

These parameters have 5-character command names, they all start with ‘e’ for ‘edit’. The remaining four characters are identical to the parameter to edit. Example ‘eatar’ is the edit copy of the ‘atar’ parameter, the azimuth target angle. Commanding ‘atar’ immediately moves the antenna to the commanded angle, but commanding ‘eatar’ simply overwrites the value in the editor.

‘tsav’ is command to write the edited values back to a target memory in the ACU. ‘tsav’ also expects a target number, if the number is not the same as used with ‘tedt’, ‘tsav’ act as a ‘save as’ command. Again, saving the edited target does not recall the target, does not change any acitve parameter. The edited target memory is only executed if it is explicitly recalled.

7.5 One line read via TCP/IP

For compatibility with the ***sat-nms*** power sensor, the ACU also may be polled for an automated monitoring by the requesting the ‘position’ document with a HTTP GET command. Assuming the ACU listens to the IP address 10.0.0.1, the complete URL for the request is:

```
http://10.0.0.1/point?fmt=txt
```

The ‘fmt=txt’ parameter forces the power sensor to reply a one line text document rather than the HTML coded page which is normally displayed by the web browser.

The ACU answers a ‘text/plain’ type document which consists of one line. As shown in the example

below, the line consists of a set of keyword - value pairs, separated by '&' characters. Within each pair, keyword and value are separated by the '=' character.

apos=174.688&epos=31.456&ppos=-34.5&atar=174.700&etar=31.500&ptar=-34.5&blev=-64.33&temp=63.5&obit=FFFF0000&ibit=FFFF0000&

4-axis version of the ACU return an extended string with the information for the second polarization axis added:

apos=174.688&epos=31.456&ppos=-34.5&qpos=-22.4&atar=174.700&etar=31.500&ptar=-34.5&qtar=-22.4&blev=-64.33&temp=63.5&obit=FFFF0000&obi2=F0&ibit=FFFF0000&ibi2=FF00&

The format does not use fixed column widths for the values, however the precision of floating point values is always as shown in the example. An application which parses this string should not rely on the order of the values in the line. Future version of the ACU may provide additional values which not necessarily will appear at the end of the line. A description of the parameters is given in the chapter Parameter list above.

7.6 SNMP Remote Control

The ACU provides a SNMP agent which permits to monitor and control all relevant parameters of the device using an SNMP network management system. The SNMP agent listens at the SNMP standard port 162, it complies to the SNMPv1 standard. The read / write community strings default to 'public', this may be changed through the ACU's WebGUI at the 'Setup' page.

All ACU parameters are collected in an enterprise specific MIB which may be downloaded from the device at the 'Setup' page. The 3-axis and 4-axis models of the ACU are using different MIBs. The 3-axis MIB (named ACU2.MIB) is widely compatible to former models of the ACU. The MIB for the 4-axis model (ACU3.MIB) has been re-organized to have the 4th axis' parameters at positions in the MIB where you would expect them rather than putting them at the very end to avoid changes of existing OIDs.

8 Theory of Operation

This section gives some background information about how the ACU works.

Chapter 8.1 Angle Measurement describes how the ACU measures the antenna pointing and how it calculates the angles displayed at the user interface.

Chapter 8.2 Pointing / Motor Control describes the way the ACU performs the antenna pointing and how it controls the motors.

Chapter 8.3 Steptrack describes the step track method used by ***sat-nms*** ACUs providing this function.

Chapter 8.4 Adaptive Tracking describes the adaptive (orbit prediction) tracking method used by ***sat-nms*** ACUs providing this function.

Chapter 8.5 Program Tracking describes the program / file tracking capability built into the ***sat-nms*** ACU.

Chapter 8.6 Prediction Tracking with Ephemeris Data describes the Intelsat eleven Parameter (I11) and the Two Line Elements (TLE) tracking capability built into the ***sat-nms*** ACU.

Chapter 8.7 Polarization Prediction describes the feature of the ***sat-nms*** ACU to use polarization prediction for inclined orbit satellite tracking.

Chapter 8.8 Faults and Tracking describes the specific faults which can be happen during the tracking with the ***sat-nms*** ACU.

8.1 Angle Measurement

The ***sat-nms*** ACU provides exchangeable interfaces for several types of position sensors. Position sensor interfaces may be selected individually for each axis. This gives a maximum of flexibility for application where the ***sat-nms*** ACU replaces an existing antenna controller.

Position sensor types

Actually there are three types of position sensor interfaces available for the ACU. The interfaces principally are field-replaceable, however changing interface boards inside the ACU should be done by skilled personnel only. ESD protection must be followed when handling the ACU boards. The ACU is capable to interface to the following types of positional sensors:

- **SSI** — SSI type digital position encoders are the first choice for antennas which are setup from scratch. They are precise, reliable and provide a standardized interface. The ACU supports types from 13 to 24 bit resolution, both, gray coded and binary variants. The ACU provides 5V and 24V supply voltages (200mA max) for the encoders, so external power supplies may be omitted in most cases.
- **RESOLVER** — Many existing antennas are equipped with resolvers. The resolver interface module permits to re-use these ready mounted and cabled sensors when an old antenna controller is to be replaced by a ***sat-nms*** ACU. The resolver interface board is optimized for the use with 2V type resolvers which are very common. The interface board drives the resolver with 4Veff / 2000Hz and expects 2Veff at the sin/cos inputs. The resolver interface has 16 bit binary resolution.
- **ANALOG** — For small antennas with reduced accuracy requirements using analog angle to voltage sensors (in fact precision potentiometers) is an inexpensive alternative. The analog sensor interface board may be set up for several voltages to connect to the commonly used sensor types. The analog interface board uses a 16 bit precision ADC with a temperature compensated voltage reference.

Angle calibration

Analogous to the modular position interface hardware concept, the ACU software uses configurable drivers to read the different types of position interfaces. From the user's point of view, the ACU accepts and displays pointing angles as floating point numbers with 0.001° resolution. Internally the software treats angles as 32 bit integer numbers where the full 32 bit range corresponds to 360°. This is equivalent to a resolution of 0.000000084°.

When the software calculates the pointing angles from the sensor readings, it includes some calibration parameters configurable at the Setup page. The steps of calculating a pointing angle are as follows:

1. Get the raw value.
2. Extend (left shift) the value to 32 bits.
3. Reverse the sign if this option is set in the setup.
4. Apply (add) the pre-scale offset.
5. Convert to degrees.
6. If the calibration scale is nonzero, multiply by the calibration scale.

7. Add the post scale calibration offset.
8. For the azimuth axis add the antenna course, too.

The angle calculated this way may exceed a full circle of 360° if the scaling ensures that there is no overflow of the encoder reading itself. The value displayed as raw reading at the test page, is the result of step 2.

8.2 Pointing / Motor Control

The ***sat-nms*** ACU performs the pointing / motor control as a closed control loop, independently for each axis. If the measured position value differs from the target value, the motor is activated to compensate this difference. It makes no difference if a new target value has been commanded or if the antenna has moved a little bit due to a squall.

Hysteresis

To avoid that the motor is switched forth and back all the time, the ACU tolerates small differences between measured and target value within a hysteresis value. This hysteresis is individually configurable for each axis at the Setup page. To ensure that the motor stands still when the target position is reached, twice the resolution (step size) of the position sensor / encoder must be set. Common values are:

bit resolution	*angular resolution*	*recommended hysteresis*
13 bit	0.044°	0.090°
16 bit	0.005°	0.012°
17 bit	0.003°	0.006°

If the motor control loop still oscillates with the recommended hysteresis values, this is due to the off-carriage of the antenna drive. Either turn down the motor speed at the motor driver unit or enlarge the hysteresis value in this case.

Motor drive signals

The ***sat-nms*** ACU-ODM, the core module, provides a number of output signals to control a motor driver unit. These signals (they are available for all three axes) are:

- **FWD** — Depending on the motor driver type configured, this signal generally switches the motor on for both directions or for the forward direction only.
- **REV** — Depending on the motor driver type configured, this signal reverses the motor direction or it activates the motor in reverse direction.
- **SPD1** — This signal is active while the ACU wants to run the motor slowly.
- **SPD2** — This signal is active while the ACU wants to run the motor fast.
- **RESET** — The ACU activates this signal for 800 msecs if the operator clicks RESET. The signal may be cabled to an input of the motor driver which resets latching faults.
- **FAULT** — The ACU monitors this signal all the time. The signal is low-active, i.e. the ACU expects current flowing through the optocoupler while the driver is OK, if the circuit is opened, the ACU signals a fault and stops the motor. If the motor driver does not provide a fault signal, the clamps of the FAULT input must be wired to 0V/24V otherwise the ACU will not move the motor!

The ACU knows two different configuration modes to control a motor driver. They are called ‘DIR-START’ and ‘DUAL-START’. In ‘DIR-START’ mode, the ‘FWD’ signal switches the motor on/off, the

'REV' signal controls the motor direction. This is the configuration many frequency inverters use. In 'DUAL-START' mode, the 'FWD' signal switches the motor on in forward direction, 'REV' activates the motor in reverse direction. This configuration mode is convenient to control a motor with relays.

The speed select signal SP1 and SPD2 actually are the same signal, but with different logical polarity. For most motor drivers it is sufficient to connect one of these two signals, select the one which matches the polarity the motor driver expects.

Remark for operation in the northern/southern hemisphere:

Look 'through the antenna' to the satellite for the correct orientation of left/right, up/down and clock/counterclockwise.

axis	***northern hemisphere***	***southern hemisphere***
azimuth	FWD moves the antenna to the right, the position sensor **must** increasing the measured value. FWD moves the antenna 'westward' The center direction to the satellite orbit is 180°. Turning angles are between 0 to 360°	FWD moves the antenna to the right, the position sensor **must** increasing the measured value. FWD moves the antenna 'eastward' The center direction to the satellite orbit is 0°. Turning angles are between -180 to +180°
elevation	FWD moves the antenna up, the position sensor **must** increasing the measured value. Turning angles are between 0 to 90 °	FWD moves the antenna up, the position sensor **must** increasing the measured value. Turning angles are between 0 to 90°
polarization	FWD turns the feed clockwise, the position sensor **must** increasing the measured value. Turning angles are between -180 to 180°	FWD turns the feed clockwise, the position sensor **must** increasing the measured value. Turning angles are between -180 to 180°

8.3 Steptrack

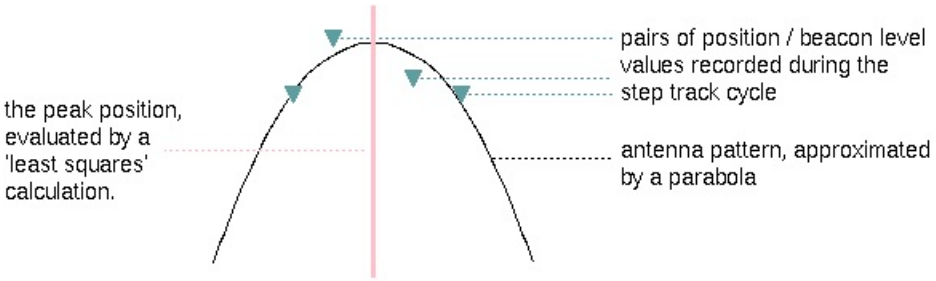
sat-nms ACUs having the "ACU-ODM Software Upgrade Step Track��? installed are capable to track a satellite's position. The following paragraph describes how the ***sat-nms*** steptrack algorithm works. Beside plain step track, this option includes the so called adaptive tracking and a file/program tracking facility as well. While step track and adaptive tracking require a beacon receiver to be connected to the ACU, the file/program tracking works without any beacon measurement.

8.3.1 The ***sat-nms*** Steptrack Algorithm

The principle of satellite step tracking is quite simple: For each axis, move the antenna a small amount away from the satellite, move it a small amount to the other site and finally point the

antenna to that position where the signal is the strongest. The ***sat-nms*** ACU uses an optimized variant of this method which lets the tracking find the best pointing ('peak') with a minimum amount of depointing.

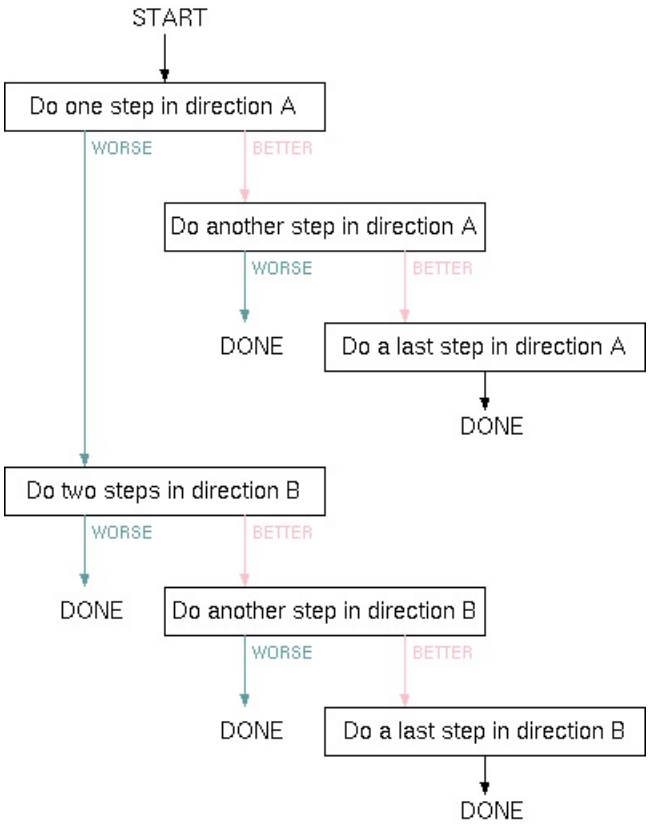
Within one step track cycle on one axis, the ACU does several very small steps. Using the position and beacon level values of all steps in the cycle, the ACU calculates the peak position by aligning the approximated antenna pattern to the measured points.



strack1.gif

This method minimizes the impact of noise and measurement errors to the evaluated peak position. The benefit is, that the size of depointing steps can be reduced to a very small value.

A tracking cycle consists of 2 .. 4 tests steps. With each step the antenna is moved a certain angle increment, the beacon level is measured before and after the movement. The angle increment is an adjustable value, expressed as a percentage of the antenna's 3dB beamwidth. A typical value is 15% of the (half) beamwidth.



strack2.gif

The diagram above shows the sequence of steps the tracking algorithm performs in one cycle on

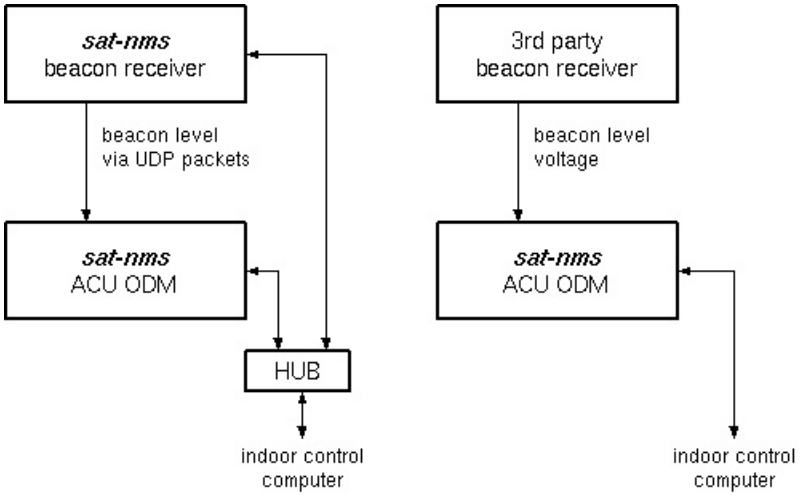
one axis. It starts with a depointing step in one direction (A). If this step lets the signal level decrease, the antenna makes a double step in the opposite direction. It the first step leads to a better receive level, the tracking algorithm adds one or two steps in the same direction.

For a reliable tracking operation the step size have to be big enough to reach the maximum within the 3dB bandwith within in the entered cycle time. This meas for an inclined satellite you need a shorter cycle time than for a geostationary satellite.

8.3.2 ACU and Beacon Receiver

To perform a step track, the ACU requires the actually measured beacon level as a rate of the received signal quality and therefore the closeness of the antenna pointing to the ideal value. The ***sat-nms*** ACU is capable to be operated both with the ***sat-nms*** LBRX beacon receiver and with third party beacon receiver products.

With a third party beacon receiver, the ACU reads the beacon level from an analog voltage input. The beacon receiver therefore must provide a dB-linear output voltage, preferably in the range 0 …10V. If the ***sat-nms*** beacon receiver is used, then the beacon level is sent from the beacon receiver to the ACU via UDP packets on the LAN.



lbrxconn.gif

If a ***sat-nms*** LBRX beacon receiver is used with the ACU, it additionally gets connected to the ACU through an Ethernet cable. Usually an Ethernet hub is used to connect the ACU, the LBRX and the controlling computer. With a ***sat-nms*** LBRX beacon receiver some additional features are available for the tracking:

- The beacon receiver sends the actual level as UDP packets over the LAN. The ACU ODM receives this value without any accuracy degrading due to cascaded digital to analog / analog to digital conversions.
- The ACU reads the beacon frequency from the LBRX at the start of each tracking cycle. The value read from the receiver overwrites the value set by the operator and is used to calculate the antenna's beamwidth.
- The ACU informs the ***sat-nms*** LBRX when a tracking cycle starts and when it ends. The LBRX suspends any background activities like noise reference measurements or frequency tracking. This ensures, that the beacon receiver recognizes level differences without a delay during the tracking cycle.

For a well functioning step track with a third party receiver, it is important to adjust the voltage

level range to the scale and offset provided by the beacon receiver. If at the beacon receiver these values may be adjusted too, a preferable scale is 0.5V/dB for 20dB usable range. The offset should be adjusted, that the receive level at clear sky conditions leave a headroom of 3dB at the top end of the range. The analog voltage never should reach the physical limit of 0V/10V under normal conditions. Clamping the level voltage probably will misslead the tracking.

8.3.3 Smoothing

The peak positions found by the step track may jitter due to noise. Specially, if an almost stable positioned satellite is tracked with a relatively small antenna, this jitter may be more than the real movement of the satellite. To stabilize the tracking in such situations, the ***sat-nms*** ACU provides a smoothing function which lets you reduce the pointing jitter.

The smoothing function is based in the fact, that most satellites (specially that ones which are on a stable orbit position) require the antenna to follow a small amplitude sine function with 24 hours cycle time in order to track the satellite optimally.

If you activate smoothing by setting the smoothing time to a non zero value, all peak positions of the last *n* hours get averaged by a sine function which matches the measured peaks at the best. After each step track cycle the antenna gets moved to the 'smoothed' position rather than to the recently evaluated peak position.

The usage of the smoothing function is recommended when tracking satellites where the antenna pointing oscillates less than 25% of the antenna's 3dB beamwidth. For tracking inclined orbit satellites, the usage of smoothing may be problematic as such satellites may require an significant position oscillation at 12 hours cycle time (sin 2wt). The smoothing function uses a simple sinusoidal model which does not provide this double frequency component. Hence, applying the smoothing function for such a satellite with more than 3 hours smoothing time may average the antenna movement path too much.

8.3.4 Steptrack Parameters

The behavior of the satellite step track is adjustable with a couple of parameters. This permits to tune the step track performance for special preconditions arising from the antenna and also the satellite. The first parameters listed below are setup parameters, they are set once for an ACU installation to adapt the ACU to the antenna and the beacon receiver.

- **AZ Antenna diameter EL Antenna diameter** — The diameter values are used by the ACU software to evaluate the antenna's beamwidth. There are separate values for both axes to handle offset antennas as well.
- **Beacon RX type** — With this parameter you specify which type of beacon receiver. For a ***sat-nms*** LBRX beacon receiver set it to 'SATNMS' and set the receiver's IP address accordingly. To make ACU and beacon receiver work together you should take care of the following:
  - ACU and beacon receiver must be connected to the same Ethernet segment.
  - Both devices must have assigned IP addresses in the same subnet.
  - The LBRX beacon receiver must be configured for the correct LO frequency. The displayed receive frequency must be the true RX frequency rather than the L-band frequency.
  - At the ***sat-nms*** LBRX the ACU's IP address must be set as the 'UDP destination address'.

The setting 'VOLTAGE' is used with any other type of beacon receiver or with a ***sat-nms*** LBRX beacon receiver which has no TCP/IP connection to the ACU.When operating in ***sat-nms*** mode,

the ACU will automatically determine the beacon frequency from the ***sat-nms*** beacon receiver. Also the beacon receiver's background activities like frequency tracking and noise reference measurements get synchronized to the step track sequence in this mode. These features are not available in the VOLTAGE operating mode.

- **Beacon RX IP address** — You need to enter the beacon receiver's IP address in 'dotted quad' notation here if the receiver tape is set to 'SATNMS'.
- **Beacon RX voltage scale Beacon RX 0V level** — These parameters define the slope and offset of the beacon level voltage. The values must be set to match settings of the beacon receiver. With the sat-nms LBRX beacon receiver you can set these parameters there as well, chapter '8.3.2 ACU And Beacon Receiver' explains how to find the best settings for this.

The parameters in the table below are to be set individually for each satellite. They are set at the 'Tracking' page and stored with each target memory.

- **Beacon RX frequency** — This parameter is only of interest if a third party beacon receiver is used. The beacon frequency (you must enter the frequency received by the antenna [MHz], not the IF frequency seen by the receiver.) is used by the ACU to calculate the antenna's beamwidth and an approximated beam pattern. With the ***sat-nms*** LBRX beacon receiver, the ACU automatically reads the frequency from the receiver.
- **Tracking cycle time** — The cycle time specifies how often the ACU shall perform a step track cycle. The value is to be entered in seconds. In fact, the parameter does not specify a cycle time but the sleep time between two tracking cycles. This means, the true cycle time is the time the ACU needs to perform one step track cycle plus the time entered here. 300 seconds (5 minutes) is a good starting value for this parameter. Inclined orbit satellites probably will require a shorter cycle time, very stable satellites can be perfectly tracked with one step track cycle every 15 minutes (900 seconds).
- **Tracking step size** — The tracking step size is a very important parameter for the performance of the tracking. It defines the size of every depointing step, the ACU makes in order to find out where the optimal antenna pointing is. Setting too high values will cause significant signal degradations during the step track cycle because the antenna moves a too large amount away from the satellite. Setting the value too small will let the beacon level jitter mask the level differences caused by the test steps, the antenna will not track the satellite properly.The step size is specified as a percentage of the antenna's half 3dB beamwidth. The ACU calculates the beamwidth from the antenna diameter and the beacon frequency. Expressing the step size in this relative way keeps the value in the same range, regardless of the type of antenna. The recommended value for this parameter is 15-20%. You may want to start with 20% and try to reduce down to 15% if the signal degradation during tracking becomes too high.The tracking step size is a common parameter for both axes. If both axes behave differently, you can tweak the antenna diameter settings in the setup. Specifying a larger diameter makes the ACU using a smaller step size for this axis.If the tracking step seems to be completely out of range, you should check if the beacon frequency is set properly. The frequency must be the true receive frequency at the antenna, entered in MHz, not an L-band frequency or other IF.
- **Tracking mode** — The tracking mode parameter switches the steptrack on or off. With the operation modes 'STEP' and 'ADAPTIVE' the ACU performs steptrack.
- **Level averaging** — When measuring the beacon level, the ACU takes a number of samples and averages them. The standard value of 5 samples normally should not be changed. Larger values will slow down the ACU execution cycle.
- **Level threshold** — If the beacon level drops below this value, the ACU raises a fault signal. Steptrack is inhibited while the beacon level is too low, the antenna position freezes.

- **Recovery delay** — After the the ACU has done the tracking steps for the elevation axis, it waits some time before it starts tracking the azimuth axis. This is to let the beacon level settle after the final position has been found. A typical value for this parameter is 4000 msec.
- **Measurement delay** — During a steptrack cycle, the ACU positions the antenna to a certain offset and then measures the level. Between the moment when the antenna reached commanded position and the beacon level measurement the ACU waits some time to let the beacon level settle. The optimal delay value depends on the beacon receiver's averaging / post detector filter setting and is a quite critical for the steptrack performance.If the delay is too short, the beacon voltage does not reach its final value, the steptrack does not properly recognize if the signal gor better or worse after a test step. If the delay is too long, the impact of fluctuation to the measures level grows and may cover the small level difference caused by the test step. With the ***sat-nms*** LBRX beacon receiver, best results are achieved if the receiver is set to 0.5 Hz post detector filter bandwidth and a measurement delay of 1500 msec.
- **Smoothing interval** — This parameter controls the smoothing function. Setting it to zero disables smoothing. A detailed description of this function you find at chapter '8.3.3 Smoothing'

8.4 Adaptive Tracking

Adaptive tracking is an extension to the standard step track method. The ACU records the tracked positions over several days. It computes a mathematical model from the recorded data which is used to predict the antenna position in case of a beacon receive failure. The following paragraphs describe how the ***sat-nms*** adaptive tracking algorithm works.

8.4.1 The ***sat-nms*** Adaptive Tracking Algorithm

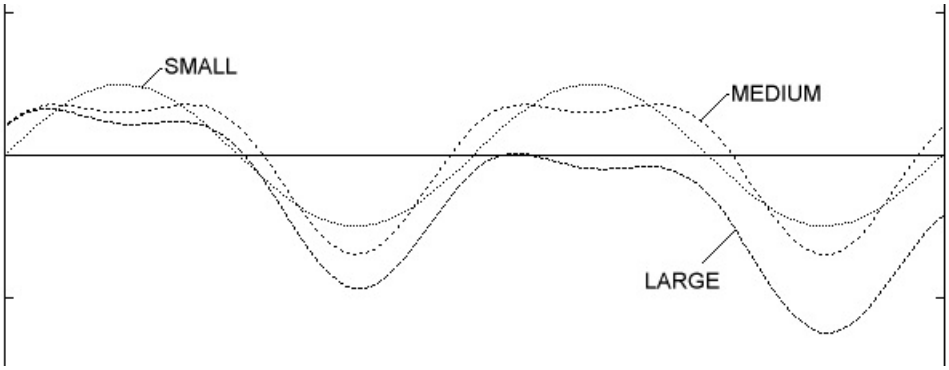
The motion of a geostationary satellite at the sky mainly is caused by an inclination of the satellite's orbit with respect to the earth's equatorial plane, sometimes also by the fact, that satellites decelerate in orbit. The motion seen from the antenna's point of view can be described as the sum of harmonic oscillations with the frequency being multiples of the reciprocal of an sidereal day.

The mathematical models used by the ***sat-nms*** adaptive tracking algorithm to predict the satellite's motion are finite sets of harmonic elements. The coefficients of the elements are evaluated from the step track data recorded for several hours or days by means of the least square fit method.

The more elements are included to a model, the better approximation of the true motion is possible. On the other hand, the number of data points used to evaluate a model is limited, the measurements values are distorted due to inaccuracy and noise. The more complicated a model is, the more susceptible it is to noise. For practical usage, there have to be used varying models, depending on the amount and quality of the recorded steptrack data.

Models

The ACU uses three different mathematical models to describe the movement of the antenna while it tracks the satellite. All models are based on sinusoidal functions with a cycle time on an sidereal day. The models called SMALL, MEDIUM and LARGE differ in their complexity.



models.gif

The SMALL model, the simplest one, emulates the true antenna movement with a plain sine function. There are only three parameters with this model, the nominal antenna pointing, and the amplitude / phase values of the superposed sine. This model is very stable, gives reliable results even with only a few measured step track peaks.

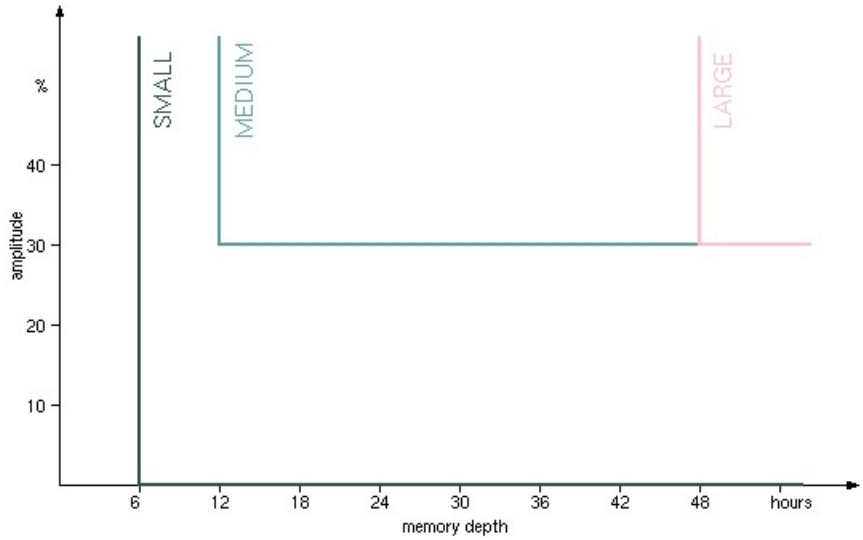
Unfortunately the SMALL model does not fit optimally for all satellites. The MEDIUM model superposes a second sine wave with the double frequency (two cycles for one sidereal day). The model matches very good for almost all stationary satellites. It however requires more and also more precisely measured data points to give reliable results. The MEDIUM model is fully compatible to the SMALL one, this means that also satellites for which the antenna must follow a plain sine function may be tracked with the MEDIUM model. The amplitude of the double frequency sine simply is near zero in such a case.

Finally the LARGE model adds a linear movement to the components of the MEDIUM model. This is required to track significantly inclined satellites over a period of several days. Such satellites tend to drift in their position, the linear movement component can compensate this effect for a couple of days. The LARGE model is the most demanding one concerning the step track data it is based on.

Model selection

The ACU normally by itself selects the adaptive tracking model for each axis individually. The decision which model will be used in case of a beacon drop out is made based on the amount and quality of the data in the tracking memory.

The quality of the recorded data mainly depends on the amplitude of the antenna movement. If the satellite moves only a small amount in 24 hours, the uncertainty of the step track peaks is quite high compared to this amplitude. The ACU compares the movement amplitude to the antenna's (half) 3dB beam width to evaluate this measure. The ACU presents this figure as a percentage value.



mselect.gif

The ACU selects the adaptive tracking model following a scheme as illustrated in the diagram above. Below 6 hours data in the tracking memory there is no adaptive tracking possible at all. With at least 6 hours of data and 18 valid samples the ACU uses the SMALL model. If the movement amplitude is above 30% and there are at least 12 hours with 36 valid samples of data available, the ACU uses the MEDIUM model. The LARGE model requires 48 hours of data with 144 valid samples and an amplitude value of 30%. (Beside the recorded hours of steptrack the ACU also watches the number of samples. With a tracking interval of more than 15 minutes, the required times may be longer than shown in the diagram.

The ACU provides a ‘max. model’ parameter for each axis. You may limit the model size to a smaller one than the ACU would choose by itself. The other way round it is not possible to force the ACU to use a model it has not enough data for.

If the tracking results are bad, the ACU will not be able to calculate a model and set the model to NONE. This occurs also if only one axis have bad tracking results.

Quality information

As mentioned above, the amplitude of the satellite’s movement is used as a measure of the step track quality. This is because the step track measurement uncertainty is an constant angle which primarily depends on the antenna size.

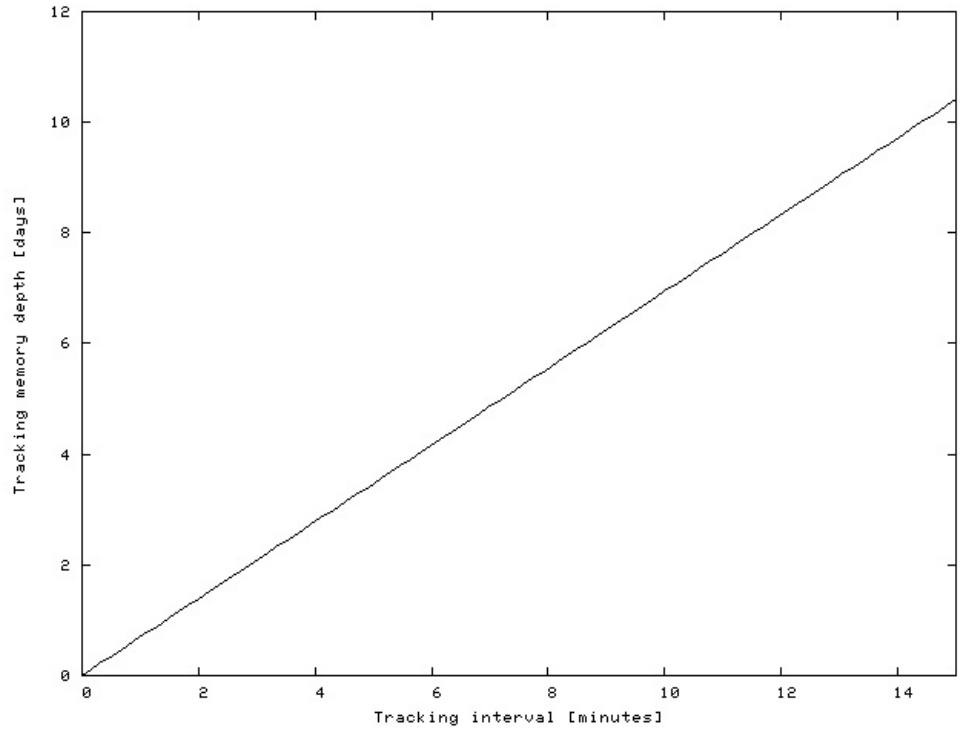
Beside the amplitude, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the model. The figure is also expressed as a percentage of the antenna’s beamwidth, low values indicate, that the model ideally describes the antenna’s path. High values indicate that’s something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit.

You may set a threshold value for the jitter. The ACU raises a fault if at least one axis exceeds the threshold value. If this happens three consecutive times, the models gets reset, all data in the tracking memory gets marked invalid.

8.4.2 The Tracking Memory

In the tracking memory the ACU records all steptrack peak positions. The tracking memory is

used as a data source for the adaptive tracking and for the smoothing function as well. Each record contains a time stamp, the azimuth / elevation values and the beacon level measured after the peaking. The tracking memory has a fixed size (1000 entries). Once 1000 records are stored, the memory works in a first in - first out manner. How many days of tracking data fits into the memory depends on the tracking interval. The diagram below shows the memory depth vs. the tracking interval.



tmemsize.gif

The tracking memory is volatile, it is erased when the ACU gets reset or switched off. Saving the tracking memory in regular intervals to the ACU's flash memory would damage the flash memory quite quickly.

Memory reset

The contents of the tracking memory must be erased when the ACU starts to track a new satellite. This is done in the following situations:

- A stored position (target) is recalled.
- The ACU is switched off.
- 'CLEAR MEMORY' is chosen at the tracking parameters page.

If a new antenna position is entered by setting the azimuth / elevation angles explicitly, the ACU does not know the new position is a manually optimized one for the current satellite or the position of another satellite. The tracking memory is *not* erased in this situation. If the new position belongs to a new satellite, the tracking memory must be erased manually by clicking to 'CLEAR MEMORY' at the tracking parameters page. Beside this it is recommended to perform a 'CLEAR MEMORY' about half an hour after tracking a satellite starts the first time. This erases the first search steps to the satellite's position and significantly improves the quality of the first adaptive model which will be calculated 6 hours later.

Saving the memory contents

The ACU provides one persistent memory location where the tracking memory may by saved into on an operators request. This may be useful to track another satellite for a couple of hours and then to return to the first satellite. If the tracking memory has been saved before the antenna has been moved to the second satellite, it may be restored after the antenna returned to the old position.

To use this feature, store the ACU settings to the target location 0 (Target memory page). This saves the tracking parameters and the tracking memory as well. When this memory location is recalled later on, the parameters and the memory contents are restored. With this function you should keep in mind, that the tracking memory contents becomes useless after about 24 hours.

8.4.3 Adaptive Tracking Parameters

The behavior of the adaptive is adjustable with a couple of parameters. First, adaptive tracking also is a step track algorithm. The parameters described in chapter '8.3.4 Steptrack Parameters' therefore apply to the adaptive tracking as well. The parameters concerning the adaptive tracking in particular are discussed in the table below. All parameter described here are to be set at the Tracking page.

- **AZ Maximum model type / EL Maximum model type** — These settings let you limit the adaptive model to a simpler one, the ACU would choose by itself. The maximum model type can be set individually for each axis. Normally you will set both axes to 'LARGE', which leaves the model selection fully to the ACU's internal selection algorithms.In cases where the ACU seems to be too 'optimistic' about the quality of the step track results, the maximum model on one or both axes may be limited to a more simple and more noise-resistant model. Specially inclined orbit satellites which are located close to the longitude of the antenna's geodetic location may require this limitation for the azimuth axis. With such a satellite, the elevation may move several degrees while the azimuth shows almost no motion.
- **Level threshold** — If the beacon level falls below this threshold value, the ACU does not perform a step track cycle. If the level falls below the threshold during the steptrack cycle, the cycle gets aborted.If the ADAPTIVE tracking is enabled and there is enough data in the tracking memory, the ACU computes a mathematical model from the stored data and predicts the antenna pointing position from the extrapolation of the model. If the tracking mode is set to 'STEP', the ACU leaves the antenna where it is if the beacon level drops below the limit.Adjusting the threshold level that adaptive tracking is switched as expected must be done carefully and may require some iterations, specially if the beacon is received with a low C/N. A good starting value for the threshold is 10 dB below the nominal receive level or 2 dB above the noise floor the beacon receiver sees with a depointed antenna, whatever value is higher.To turn off the monitoring of the beacon level (this in fact inhibits the adaptive tracking), simply set the threshold the a very low value (e.g. -99 dBm)
- **Peak jitter threshold** — If the jitter value of at least one axis exceeds this threshold, the ACU raises an 'model fault'. If this happens three consecutive times, the ACU resets the models of both axes. Adaptive tracking will be possible not until 6 hours after this happens.During adaptive tracking, the ACU evaluates for each axis a figure called jitter. The jitter value describes standard deviation of the measured peak positions with respect to the positions calculated from the (currently selected) model. The figure is also expressed as a percentage of the antenna's beamwidth, low values indicate, that the model ideally describes the antenna's path. High values indicate that's something wrong. The step track results may be to noisy at low amplitudes or the model does not fit at all. This may be the case if a satellite gets repositioned in the orbit.A typical threshold value is 20%, this will detect very early that a model does not fit to describe the satellite's motion. If this value causes false

alarms too often, you may want to raise the threshold to 50%. Setting it to 0 switches the threshold monitoring completely off.

8.4.4 Hardware Protective Mode (Spindle Save Mode)

The so called Spindle Save Mode will reduce the tracking cycles and will therefore increase the life time of the jack screws and other drive components.

The idea behind this mode is, to used the model parameter from the adaptive tracking and perform only a calculate positioning step between the required step track cycles to reduce the movement of the drive components.

With the 'Spindle save mode parameter we can define how many positioning only cycles will be done between the step track cycles.

Example: Tracking cycle Time = 30sec and Spindle Save Mode = 3, than a full steptrack will perform every `(3+1) x 30 sec = 120sec` but we will still have 3 positioning cycles between to keep the antenna on the satellite.

Since the quality of the model must be good for this type of operation, there exist an additional parameter 'Spindle save threshold' which allow to define a limit. The parameter will look to the peak jitter to qualify the model parameter, a value between 3 to 10% should deliver good results. If the peak jitter above the limit the ***sat-nms*** ACU will perform normal steptrack at each cycle.

8.5 Program Tracking

Program tracking is a tracking method which lets the antenna follow a path which usually has been calculated by an extern software. This software produces a list of time stamp / antenna pointing records. The list is copied to the ACU and the ACU is switched to PROGRAM track mode. The ACU now moves the antenna following the path described in the file. This way of tracking has a couple of advantages:

- There is no beacon receiver needed.
- Even very low elevation satellites may be tracked.
- Also objects which are not in a geostationary orbit may be tracked for a couple of hours, provided that the object of interest does not move to fast.

The main disadvantage of program tracking is that prediction calculations for stationary satellites always are only valid for a couple of days, then a new file must be calculated and loaded to the ACU.

8.5.1 Practical Usage

To use the program tracking facility of the ACU, follow the step by step instructions below:

1. Create a "program.txt??? file with the antenna pointings you want to track. SatService GmbH offers a PC Software for this purpose which calculates the antenna pointing from commonly used ephemeris data sets for geostationary satellites. You also may create the file by your own means. The file format is described in chapter '8.5.2 File Format' .
2. Set the 'tracking interval' parameter to a value significantly below the intervals between the position entries in the file. Setting it to 60 seconds will work with most applications.
3. Switch the 'tracking mode' to 'PROGRAM'.

The antenna will move as defined in the "program.txt??? file. The ACU polls the file every 'tracking interval' seconds and moves the antenna if it finds a table entry which is time stamped

within the next ‘tracking interval’. Be aware, that the clock in the ACU must be set precisely to make the feature work as expected.

8.5.2 File Format

The “program.txt��? file is a plain text file containing a three or four column table. Empty lines are ignored, comments starting with a ‘#’ as well. The numbers in the table are parsed as floating point numbers which only may consist of decimal digits, one decimal point ans an optional leading ‘-’ if negative. The columns must be separated by an arbitrary number of space or tabulator characters. They have the following meanings:

1. **time stamp** — The time stamp must be a Julian date with the time of day coded as a fraction of a day. Example: The Julian date for the common base of most computer clocks (1970-01-01 00:00:00) is 2440587.5
2. **azimuth angle** — The azimuth angle in degrees
3. **elevation angle** — The elevation angle in degrees
4. **polarization angle** — The polarization angle in degrees. This column is optional, no polarization pointing is commanded if this column is missing.

The example below shows an excerpts of a program tracking file containing azimuth and elevation angles

```
2459145.02083333          159.5000             32.2000
2459145.02222222          159.6000             32.2150
2459145.02361111          159.7000             32.2300
2459145.02500000          159.8000             32.2450
.
.
.
.
2459145.48194444          192.7000             37.1800
2459145.48333333          192.8000             37.1950
2459145.48472222          192.9000             37.2100
2459145.48611111          193.0000             37.2250
```

Memory space is very limited in the ACU-ODM. The file size is limited to 64 Kbytes, being equivalent to about 12 days of AZ/EL data in 10 minutes intervals.

8.6 Memory Tracking

Memory Tracking is another tracking method which is based on step track using the recorded antenna pointing as a backup if the beacon level drops too low for a successful steptrack. Unlike Adaptive Tracking which calculates a sinusodial model of the antenna movement, Memory Tracking simply moves the antenna to the position it had one siderian day before, if a step track attempt was not successful. Memory Tracking requires at least 24 hours of recorded tracking data.

8.7 Prediction Tracking with Ephemeris Data

The Prediction Tracking move the antenna along a satellite position calculated from ephemeris data. The ***sat-nms*** ACU recognizes the following data formats:

- **Keplerian elements** : The ACU recognizes and parses keplerian elements in the NASA 2-

line format **(TLE)** . The two lines of element definition may be prepended by an additional line with the satellite's name. A common source for Keplerian elements in this format is <www.celestrak.com>. The ***sat-nms*** ACU uses the NORAD SDP4 model to predict a satellite's position from this type of data.

- **Intelsat elements** : Intelsat publish ephemeris data **(I11)** for their communication satellites at their web site but also other satellite operators deliver data in this format. The data format and the mathematical model for this data is Intelsat proprietary and defined in the document IESS412.

8.7.1 Intelsat eleven Parameter Prediction (I11)

The analytical propagation of a satellite in the eleven Parameter format was originally released by Intelsat IESS412 document. The calculations which are used in the ***sat-nms*** ACU are based on Review 3 of this document.

The calculation based on the given algorithm and the provided eleven parameters are very simple:

- Calculate from the I11-Data the satellite position for the particular time of interest.
- Calculate from the satellite's prediction position and the earth station's known position the geometric pointing angles.
- Finally theses pointing angles are corrected for the effects of atmospheric refraction.

To verify the satellite position calculation, there is also the satellite position after 170h available. The ***sat-nms*** ACU use this parameter to verify the correct entry of the data.

The data have to be entered in the menu 'Orbital Data' in the Section I11 Elements. There are 99 datasets possible. To activate a dataset it must be set in the Tracking Parameter menu in the Section Prediction Parameters I11 Ephemerides. To follow a satellite with the chosen dataset, the Tracking Mode have to be set to 'I11'.

Remark:

- The parameter 'max. prediction age' will limit the execution time of the prediction Tracking. After the limit is reached the antenna will stop the execution and an alarm will be displayed in the pointing screen.
- If the calculation distinguish from the 170h prediction value an invalid I11 Alarm will be displayed.

8.7.2 Two Line Elements Prediction (TLE)

The analytical propagation of a satellite was originally released in the 1980 and 1986 in the spacetrack papers (SPACETRACK REPORT NO. 3). A detailed discussion of the theory and history may be found in the 2006 aiaa paper by Vallado, Crawford, Hujsak, and Kelso. David Vallado release based on these documents the calculation code in different programming languages. This code are used with small improvements in the ***sat-nms*** ACU to calculate the satellite position.

The calculation based on the given algorithm and the two line parameters are very simple:

- Calculate from the TLE-Data the satellite position for the particular time of interest.
- Calculate from the satellite's prediction position and the earth station's known position the geometric pointing angles.
- Finally theses pointing angles are corrected for the effects of atmospheric refraction.

The data have to be entered in the menu ‘Orbital Data’ in the Section TLE Elements. There are 99 datasets possible. To activate a dataset it must be set in the Tracking Parameter menu in the Section Prediction Parameters TLE Ephemerides. To follow a satellite with the chosen dataset, the Tracking Mode have to be set to ‘TLE’.

Remark:

- The parameter ‘max. prediction age’ will limit the execution time of the prediction Tracking. After the limit is reached the antenna will stop the execution and an alarm will be displayed in the pointing screen.
- If the calculation failed an invalid TLE Alarm will be displayed.

8.8 Polarization Prediction

The polarization prediction is defined to follow the polarization changes during the tracking caused by the movement of the satellite. These Method is only be effective for geosynchronous satellites in inclined operation. It is assumed that the satellite owners are attempting to hold nominal longitude and a near circular orbit.

To calculate the polarization adjustment it will be necessary to solve the following terms:

- **Pol Offset abs**: This is a linear absolutely offset defined by the satellite operator. The value is defined as offset against the theoretical calculated polarization value. Most satellite polarization offsets are around 0° but nearly all Eutelsat satellites have a polarization offsets of 3.535°.
- **Pol Offset look**: This is an offset caused by the different look angles over time to the satellite, if the satellite moves on an inclined geosynchronous circular orbit. This offset is a sinusoidal movement based on the sidereal time with a time offset. The amplitude can be calculated from the nominal Orbit position and the inclination. The time offset can be calculated from the tracking data look angles and dynamic.
- **Pol Offset incl**: This is an offset caused by the flight path. During the equator crosses of the satellite this value will be + or - the inclination depending on the direction of the cross. At the highest and lowest point this value will be zero. This offset is also a sinusoidal movement based on the sidereal time with a time offset. The amplitude is defined by the inclination. The time offset can be calculated from the tracking data look angles and dynamic.

The summary of these three terms will provided at least the polarization value.

As we see from above definition, it will necessary to have some additional information to initiate a polarization prediction. Therefore it will be necessary to provide the ***sat-nms*** ACU the following parameter in the ‘Tracking Parameter’ menu:

- **Target orbit position**: This Parameter should define the nominal Orbit position of the satellite. This value should be available from the satellite operator. **Remark** : In the Polarization prediction setting ‘ADAPTIVE’ this value will be recalculated after get a valid medium model, but only small changes are allowed per calculation cycle to the bases value (+/-0.5°). Therefore the start orbit position have to set within this range.
- **Inclination**: The actual inclination value of the satellite. This value should be also available from the satellite operator.**Remark** : In the Polarization prediction setting ‘ADAPTIVE’ this value will be recalculated after get a valid medium model, but only small changes are allowed per calculation cycle to the bases value (+/-0.5°). Therefore the start inclination have to set within this range.

- **Satellite Pol offset**: The linear polarization offset of the satellite. This value should be also available from the satellite operator or have to be measured.
- Since we need from the tracking also the dynamic of the satellite (movement up or down), the ***sat-nms*** ACU cannot start the polarization prediction immediately after setting the polarization prediction to 'ON' or 'ADAPTIVE', it need some tracking cycles to clearly identify the direction of movement (15min.). If the main tracking mode is 'I11' or 'TLE' the polarization prediction will start immediately because the movement of the satellite is already defined by the satellite ephemerides.

8.9 Faults and Tracking

There are different faults which could occur during operation. Please also refer to chapter Operation . Below is a collection of all this faults.

There are the following cases for a fault of one axis. 'TIMEOUT' and 'FAULT' are releasable during a tracking cycle. A 'STOPPED' fault have to be released with the RESET button:

- Jump Values of angle encoder; 5° in azimuth and elevation or 10° in polarization ('STOPPED')
- Antenna moves 5sec into the wrong position ('STOPPED')
- Motor timeout occur because of no antenna movement within the entered time ('TIMEOUT')
- Motor fault input triggered for example from frequency converter ('FAULT')

There are the following cases for a 'STOPPED' fault of all axes together, which have to be released with the RESET button:

- Trigger emergency stop input
- Click the STOP button on the web interface

All faults are released by clicking the RESET button on the web interface or by sending the remote command mrst=0. The RESET button activates the 'MOTOR RESET' outputs of all three axes for a quarter second and delete the fault flags. All target angles are set to the actual value to suppress an immediate movement of the antenna.

If a 'TIMEOUT' or 'FAULT' occur during a tracking cycle in one axis and the cycle is canceled, the ACU will retry after 2min again according to the setting of 'Retry after motor fault' (NEVER/ONCE/FOREVER). The retry is a RESET which activates the 'MOTOR RESET' outputs of all three axes for a quarter second and delete the fault flags. All target angles are set to the actual value to suppress an immediate movement of the antenna. This is also valid for tracking faults like a 'PEAKING FAULT'.

If a fault stay active in one axis and don't disappear during a RESET, the tracking stops the operation. For example if the polarization have a fault, azimuth and elevation stop the tracking operation.

9 Specifications

Technical Specification

- **Position Encoding with three different interfaces via daughter boards** : Resolver, digital SSI and potentiometer
- **Quantization Error** : Resolver 16bit: 0.0055°, SSI 13bit 0.044°, 16bit 0.0055°, 17bit 0.0028°, 19bit 0.0007°
- **Display Position resolution** : 0.001°

- **Interface to beacon receivers selectable** : ***sat-nms*** LBRX or analog voltage input
- **Analog voltage input** : 0 to 10V
- **Option Tracking Accuracy** : Better than 5% of receive 3dB beamwidth (RMS). The encoder coupling and alignment error should not exceed 0.003° to achieve the specified tracking accuracy. The influence of antenna structure thermal error is not considered.
- **System Interfaces**
  - angle detectors and Emergency Stop: DSub9 female
  - limit switches: DSub9 male
  - MNC: RJ45
  - analog beacon: SMA female
  - Mains UPS: HAN A 3pol+PE male
  - Motor mains: HAN B 6pol+PE male
  - AZ+EL Motors: HAN B 6pol+PE female
  - POL-Motor: HAN A 3pol+PE female
  - to M&C and ACU-IDU: Ethernet
  - 4 (6) drive limit switches´: Azimuth, Elevation (and Polarization)
  - Emergency stop and motors off switch: terminals
- **2 (3) angular detectors** : Azimuth, Elevation (and Polarization)
- **Motor driver** : DC motor drivers, depending on power supply up to 35VDC/15A, optional 48VDC/15A, standard power supply is 24VDC/10A
- **optional local operation** : Handheld with display and keyboard

M&C Interface Specification

- **Ethernet interface for M&C and user interface** : 10-Base-T, Via http GET requests
- **RS232/RS422 M&C Interface** : Mini Combicon MCV1
- **Summary fault indication** : Relay contact Mini Combicon MCV1

Electrical and Mechanical Specification, Environmental Conditions

- **Supply voltage mains** : 230V AC, 3A with standard motor power supply
- **Temperature range** : -20° to 35° C without optional air ventilation -20° to +55° C with optional air ventilation
- **protection class** : IP66 without optional air ventilation IP54 with optional air ventilation
- **dimensions cabinet** : 380x235x680mm (width x depth x height including roof)
- **Weight** : depending on power supply, approx. 22kg