Antenna Controller

sat-nms ACU-ODU-AC

User Manual

Version 2.3.0

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sat-nms ACU-ODU AC 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.

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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*** ACU-ODM: only the core-module integrated in a compact case prepared for mounting on a 35mm DIN rail
- ***sat-nms*** ACU-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*** ACU-RMU: complete antenna controller system for AC-Motors integrated in a 6RU 19inch rack mount case for indoor use
- ***sat-nms*** ACU19: complete antenna controller system for DC-Motors integrated in a 1RU 19inch rack mount case for indoor use

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

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 ramps are programmed into the inverter module with this solution.
- **Servo controllers:** Used for DC motors at small antennas. 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 ACU-ODM and ACU19).
- 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 Internet-

Explorer 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*** ACU19 and the ***sat-nms*** ACU-RMU optionally are equipped with a frontpanel Human-Machine-Interface. 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.

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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.

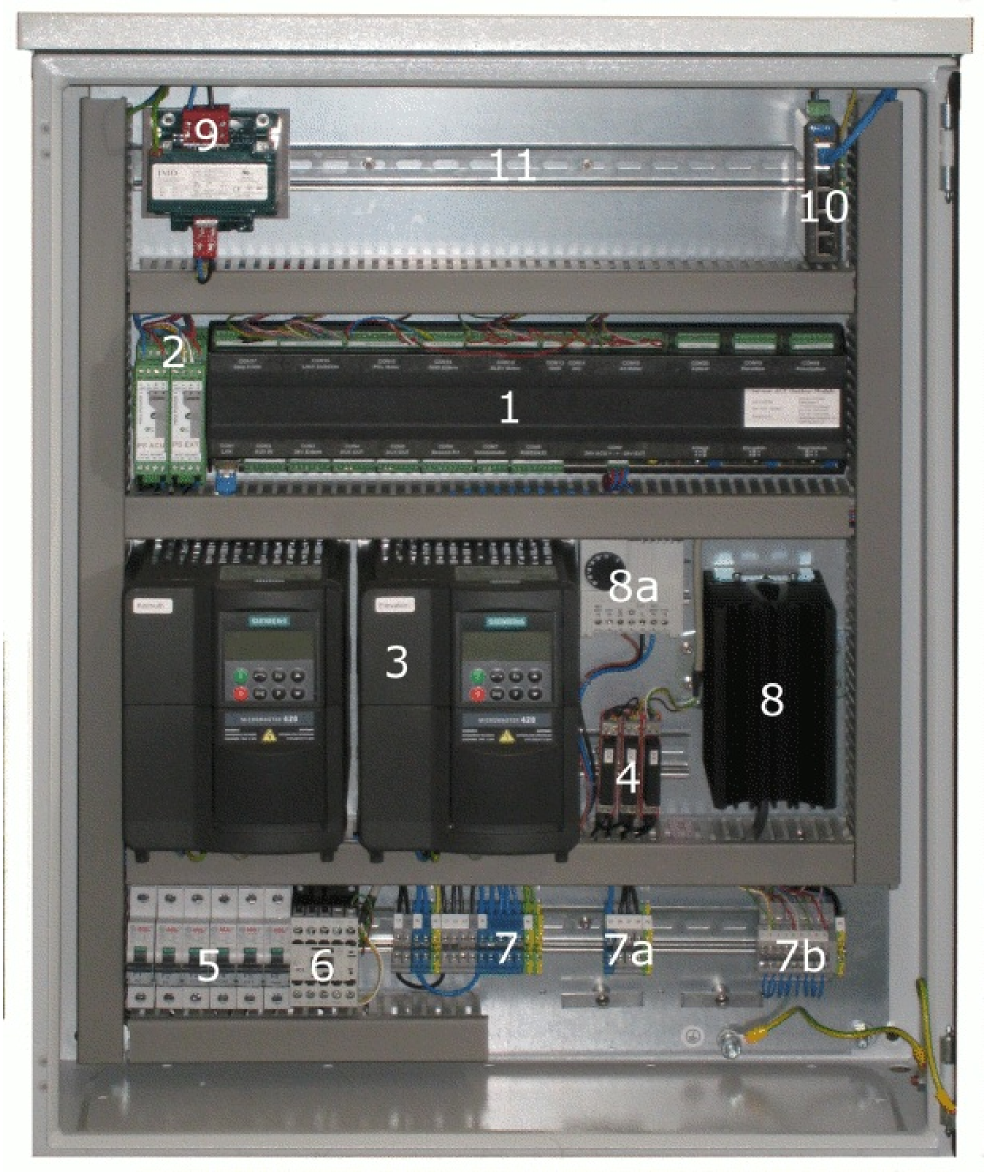
WARNINGS

- 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.
- In case of switching off all the circuit breakers is still voltage available at the mains terminals!
- 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
- **Only ACU-ODU** : If the Unit is equipped with an optional air ventilation, avoid direct contact with jets of water, normal rain is no problem.

3 The *sat-nms* ACU-ODU AC

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 (manufacturer of frequency inverters, tracking / pointing, 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.



No.	component	No.	component
(1)	***sat-nms*** ACU-ODM	(7b)	terminals for limit switches and emergency stop
(2)	power supplies for ***sat-nms*** ACU-ODM	(8)	heater
(3)	frequency inverters	(8b)	thermostat for heater
(4)	solid state relays	(9)	optional 110V transformer for POL motor
(5)	circuit breakers	(10)	optional ethernet switch
(6)	contactor	(11)	optional beacon receiver (n.a. on this picture)
(7)	mains terminal	n.a.	optional air ventilation

(7a)	terminal for POL motor		

(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.

(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 labeled 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 labeled 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) Frequency Inverters For bigger antennas most of the time three phase motors are used. These are connected to frequency inverters which are the high power interface between the ***sat-nms*** ACU-ODM module and the motors. **Please take into account that some of the frequency inverter parameters are motor dependent and that these have to be changed to your specific antenna motors.** The following chapter frequency inverter description gives a short overview of the frequency-inverters operation. If you need more detailed informations, please refer to the manual of the frequency inverters.

(4) Solid State Relais If your ***sat-nms*** ACU-RMU is equipped with the optional POL-drive, you find solid state relais in your ***sat-nms*** ACU-RMU. The POL Motor is normally a small single phase motor that does not need a frequency inverter for driving.

(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!

(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.

(7) Terminals Here the mains, limit- and emergency switches and (if available) POL motor is connected. Please refer to the schematics shipped together with the ***sat-nms*** ACU-ODU to see how to connect them.

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

(9) Optional 110V transformer for Polarisation drive In several antennas 110V Motor are used. For these antennas a transformer can optional be ordered to make the ***sat-nms*** ACU-ODU work with these motors.

(10) Optional ethernet switch The ***sat-nms*** ACU-ODU can be equipped with an optional Ethernet switch. By this way it is easy to connect a notebook for troubleshooting or make some parameter changes. It is also possible to integrate an optional ***sat-nms*** L-Band beacon receiver. So you can upgrade the ***sat-nms*** ACU-ODU to a complete antenna tracking system. For this option the optional Ethernet switch is necessary as well.

(11) Optional *sat-nms* L-Band beacon receiver It is possible to realize a complete antenna tracking system with the ***sat-nms*** ACU-ODU. For this it is possible to integrate a ***sat-nms*** L-Band beacon receiver (LBRX) into the ***sat-nms*** ACU-ODU. In this case it is necessary to integrate the optional Ethernet switch into the ***sat-nms*** ACU-ODU. As the level information is in this case transferred via Ethernet (by UDP packets) between the beacon receiver and the antenna step track system the ***sat-nms*** LBRX beacon receiver not necessarily has to be at the same place as the antenna controller. It can be at a completely different location. The only requirement is that it is connected to the same Ethernet. Please refer to the documentation of the ***sat-nms*** LBRX how to setup the parameters of this unit and how to connect it. A short version of the documentation could be found on the internal website of the ***sat-nms*** ACU-ODM. Just enter the IP-address of the unit (standard-IP is: 192.168.2.65) into the Webbrowser of a connected computer and press the **HELP** button on the left side.

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 a hot ambient. **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, what 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.

3.1 Frequency inverter operation

The following chapters give a short overview of the frequency-inverters operation. As there are used two different manufacturers (Siemens and OMRON) the following chapter is split. If you need more detailed informations, please refer to the manual of the delivered frequency inverter.

3.1.1 Siemens frequency inverter operation

if your ***sat-nms*** ACU-ODU is equipped with Siemens frequency inverters, use this chapter to get a short overview of the basic operation of this unit. If an OMRON type is installed, please refer to chapter 3.1.2 OMRON frequency inverter operation .

3.1.1.1 Display and function of the buttons

The frequency inverters used in the ***sat-nms*** ACU-ODM are equipped with a basic operation panel (BOP) that shows you all of the parameters set to the frequency inverter. It also is able to show you the actual values of frequency, voltage and output voltage. The following picture shows how the BOP looks like:

origin: Siemens user Documentation ,6SE6400-5AA00-0BP0'

After start-up of the inverter the display of the BOP shows you the following values:

- If the motor is running, the display shows you the actual motor frequency and the direction (with or without a **-** as prefix of the shown frequency what represents the rotation-direction)
- If the motor is not running, the display is alternating between the pre- selected frequency with prefix for the direction and the actual frequency 0.00Hz.

If you like to get some other parameters, press and hold the button **Fn** longer than 2s. By pressing the button **Fn** once you can change between the following parameters:

- DC link voltage (indicated by d - units V).
- output current. (A)
- output frequency (Hz)
- output voltage (indicated by o - units V)

To return to the start-up display mode, press and hold the button **Fn** for longer than 2s. The following Table shows the function of the frequency-inverters buttons.

- **Panel/ Button.** --- **Function****Effect.**
- 

 --- indicates statusThe LCD displays the settings and values currently used by the converter.
- 

 --- start converterpressing the button starts the converter. This button is **disabled by default** . To enable this button set P0700 = 1.
- 

 --- stop converter**OFF1** Pressing the button causes the motor to come to a standstill at the selected ramp down rate. **Disabled by default** , to enable set P0700 =1. **OFF2** Pressing the button twice (or once long) causes the motor to coast to a standstill. This function is always enabled.
- --- change directionpress this button to change the direction of rotation of the motor. Reverse is indicated by a minus (-) sign or a flashing decimal point. **Disabled by default** , to enable set P0700 = 1.
- 

 --- jog motorPressing this button while the inverter has no output causes the motor to start and run at the preset jog frequency. The motor stops when the button is released. Pressing this button when the motor is running has no effect.

- 

--- functionsthis button can be used to view additional information. It works by pressing and holding the button. It shows the following, starting from any parameter during operation:
    1. DC link voltage (indicated by d - units V).
    2. output current. (A)
    3. output frequency (Hz)
    4. output voltage (indicated by o - units V).
    5. The value selected in P0005 (If P0005 is set to show any of the above (3, 4, or 5) then this will not be shown again).

Additional presses will toggle around the above displays.**Jump Function** From any parameter (rXXXX or PXXXX) a short press of the Fn button will immediately jump to r0000, you can then change another parameter, if required. Upon returning to r0000, pressing the Fn button will return you to your starting point.

- 

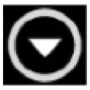
--- access parameterspressing this button allows access to the parameters
-  --- increase valuepressing this button increases the displayed value. To change the Frequency Setpoint via the BOP set P1000 = 1.
-  --- decrease valuepressing this button decreases the displayed value. To change the Frequency Setpoint via the BOP set P1000 = 1.

Table 1 *origin: Siemens user Documentation 6SE6400-5AA00-0BP0*

3.1.1.2 Changing Parameters of the Frequency Inverter

On Table 4 and Table 5 you can see the test-settings that are programmed in the delivery state.

To change the parameters press button **P** once, now you can change the parameter-number with the arrow-buttons up and down. To change the chosen parameter press button **P** once again. Now you can change the parameter with the arrow-buttons to the desired value. To save the new parameter value, press button **P** once. To go back to the parameter choice, without saving, press button **Fn**

The Parameters that you can find in row Value 1 have to be set as written in the following tables.

When you are finished with setting the parameters, you have to set parameter 971 to value 1 (transfer Data from RAM to EEPROM) and press button **P** . Otherwise the settings are deleted with the next power-down of the frequency inverter.

When you have changed the parameters in {i quick commissioning mode} (Parameter No. 10 = 1), the changed parameters have to be saved with setting Parameter No. 3900 = 3. **ATTENTION!** If you save the quick commissioning changes with Parameter No. 3900 = 1, all of the interface parameters are set to factory defaults, and have to bet set to the desired values for the ***sat-nms*** ACU-RMU to ensure proper function.

ATTENTION! Change the frequency inverters motor-parameters only when the corresponding motor is connected. This is because while changing the motor parameters the frequency inverter makes some measures to define the power that is needed to make the motor run. In normal cases it suffices to change the following Parameters of the frequency-inverters:

Setting of the motor parameters

Param. No.:	Value 1	Value 2	Remark	Setting Description
-	-	-	connect Motor as Triangle	
3	3		User access level	Expert
4	0		Parameter filter	All parameters
10	1		Quick commissioning	Start
304			--> Motor voltage rating	see Motor Plate
305			--> Motor current rating	see Motor Plate
307			--> Motor power rating	see Motor Plate
310			--> Motor frequency rating	see Motor Plate
311			--> Motor speed rating	see Motor Plate
1080			--> Min. speed	Value verify by testing
1082			--> Max. speed	see Motor Plate
1120			--> Ramp-up time	Value verify by testing
1121			--> Ramp-down time	Value verify by testing
1135			--> OFF3 ramp-down time	= 1121
3900	3		End of quick commissioning	3: Save param, keep I/O settings

Table 2

Setting of the interface parameters

Param. No.:	Value 1	Value 2	Remark	Setting Description
3	3		User access level	Expert
1001			Fixed frequency 1	Low speed >= 1080
1003			Fixed frequency 3	High speed <= 1082
1058			JOG frequency CW	= 1080
1059			JOG frequency CW	= 1080
1060			JOG ramp-up time	= 1120
1061			JOG ramp-down time	= 1121
1080			Min. frequency	Value verify by testing
1082			Max. frequency	see Motoplate
1120			Ramp-up time	Value verify by testing
1121			Ramp-down time	Value verify by testing
1135			OFF3 ramp-down time	= 1121
1310			Continuous boost	Value verify by testing, increase this value to start the motor with lowest frequency, decrease it if the motor is overloaded
1312			Starting boost	Value verify by testing, increase this value to start the motor with lowest frequency, decrease it if the motor is overloaded
2000			Reference frequency	= 1003
971	1		Transfer data from RAM to EEPROM	-

Table 3

3.1.1.3 Parameter settings in delivery state

Setting of the motor parameters in delivery state

Param. No.:	Value 1	Value 2	Remark	Setting Description
-	-	-	connect Motor as Triangle	
3	3		User access level	Expert
4	0		Parameter filter	All parameters
10	1		Quick commissioning	Start
100	0		--> Europe / North America	
300	1		--> Select motor type	Asynchronous
304	**208**		--> Motor voltage rating	see Motor Plate
305	**6,4**		--> Motor current rating	see Motor Plate
307	**1,3**		--> Motor power rating	see Motor Plate
308	0		--> Motor cosPhi rating	internal calculation
309	0		--> Motor efficiency rating	internal calculation
310	**60**		--> Motor frequency rating	see Motor Plate
311	**3280**		--> Motor speed rating	see Motor Plate
320	0		--> Motor magnetizing current	internal calculation
335	0		--> Motor cooling	Self-cooled
640	150		--> Motor overload factor [%]	see Motor Plate
700	2		--> Selection of command source	Terminal
1000	3		--> Selection of frequency setpoint	Fixed frequency
1080	**10**		--> Min. speed	Value verify by testing
1082	**60**		--> Max. speed	see Motor Plate
1120	**1**		--> Ramp-up time	Value verify by testing
1121	**0,3**		--> Ramp-down time	Value verify by testing
1135	**0,3**		--> OFF3 ramp-down time	= 1121
1300	0		--> Control mode	V/f linear
3900	1 or 3		End of quick commissioning	1: Save param, reset all others to factory defaults 3: Save param, keep I/O settings

Table 4

Setting of the interface parameters in delivery state

Param. No.:	Value 1	Value 2	Remark	Setting Description
3	3		User access level	Expert
700	2		Selection of command source	Terminal
701	99		Function of digital input 1	Enable BICO parameterization
702	12		Function of digital input 2	Reverse
703	15		Function of digital input 3	Fixed setpoint
704	9		Function of digital input 4	Fault acknowledge
719	0	3	Selection of cmd. & freq. setp.	Cmd = BICO parameter, Seeting = Fixed frequency
731	52.3		Function of digital output 1	Drive fault active
748	0		Invert digital outputs	NO
840	722.0		BI: ON/OFF1	Digital input 1
844	1.0		BI: 1. OFF2	default
845	19.1		BI: 2. OFF2	default
1000	3		--> Selection of frequency setpoint	Fixed frequency
1001	**10**		Fixed frequency 1	Low speed >= 1080
1003	**60**		Fixed frequency 3	High speed <= 1082
1022	722.2		BI: Fixed freq. selection Bit 2	Digital input 3
1035	19.13		BI: Enable MOP	default
1036	19.14		BI: Enable MOP (DOWN-command)	default
1040	10		Setpoint of the MOP	= 1001
1058	**10**		JOG frequency CW	= 1080
1059	**10**		JOG frequency CW	= 1080
1060	**1**		JOG ramp-up time	= 1120
1061	**0,3**		JOG ramp-down time	= 1121
1070	1024		CI: Main setpoint	Fixed frequency setpoint
1080	**10**		Min. frequency	Value verify by testing
1082	**60**		Max. frequency	see Motoplate
1113	722.1		BI: Reverse	Digital input 2
1120	**1**		Ramp-up time	Value verify by testing
1121	**0,3**		Ramp-down time	Value verify by testing
1124	722.0		BI: Enable JOG ramp times	Digital input 1
1135	**0,3**		OFF3 ramp-down time	= 1121
1210	5		Automatic restart	Restart after mains blackout and fault
1310	**75**		Continuous boost	Value verify by testing, increase this value to start the motor with lowest frequency, decrease it if the motor is overloaded
1312	**75**		Starting boost	Value verify by testing, increase this value to start the motor with lowest frequency, decrease it if the motor is overloaded
2000	**50**		Reference frequency	= 1003
971	1		Transfer data from RAM to EEPROM	-

Table 5

3.1.1.4 Fault states overview

The following tables give you a short overview over the fault states, the frequency inverter is able to display.

Fault	Possible Causes	Diagnose & Remedy	Reaction
F0001 Overcurrent	➢ Motor power does not correspond to the inverter power ➢ Motor lead short circuit ➢ Earth fault	Check the following: 1. Motor power (P0307) must correspond to inverter power (P0206) 2. Cable length limits must not be exceeded 3. Motor cable and motor must have no short-circuits or earth faults 4. Motor parameters must match the motor in use 5. Value of stator resistance (P0350) must be correct 6. Motor must not be obstructed or overloaded ➢ Increase the ramp time ➢ Reduce the boost level	OFF2
F0002 Overvoltage	➢ DC-link voltage (r0026) exceeds trip level (P2172) ➢ Overvoltage can be caused either by too high main supply voltage or if motor is in regenerative mode ➢ Regenerative mode can be cause by fast ramp downs or if the motor is driven from an active load	Check the following: 1. Supply voltage (P0210) must lie within limits indicated on rating plate 2. DC-link voltage controller must be enabled (P1240) and parameterized properly 3. Ramp-down time (P1121) must match inertia of load	OFF2
F0003 Undervoltage	➢ Main supply failed ➢ Shock load outside specified limits	Check the following: 1. Supply voltage (P0210) must lie within limits indicated on rating plate 2. Supply must not be susceptible to temporary failures or voltage reductions	OFF2
F0004 Inverter Over-temperature	➢ Ambient temperature outside of limits, ➢ Fan failure	Check the following: 1. Fan must turn when inverter is running 2. Pulse frequency must be set to default value 3. Air inlet and outlet points are not obstructed Ambient temperature could be higher than specified for the inverter	OFF2
F0005 Inverter I^2t	➢ Inverter overloaded ➢ Duty cycle too demanding ➢ Motor power (P0307) exceeds inverter power capability (P0206)	Check the following: 1. Load duty cycle must lie within specified limits 2. Motor power (P0307) must match inverter power (P0206)	OFF2
F0011 Motor Over-temperature I^2t	➢ Motor overloaded ➢ Motor data incorrect ➢ Long time period operating at low speeds	1. Check motor data 2. Check loading on motor 3. Boost settings too high (P1310,P1311, P1312) 4. Check parameter for motor thermal time constant 5. Check parameter for motor I^2t warning level	OFF1
F0041 Stator resistance measurement failure	Stator resistance measurement failure	1. Check if the motor is connected to the inverter 2. Check that the motor data has been entered correctly	OFF2

Table 6 *origin: Siemens user Documentation 6SE6400-5AA00-0BP0*

Fault	Possible Causes	Diagnose & Remedy	Reac-tion
F0051 Parameter EEPROM Fault	Reading or writing of the non-volatile parameter storage has failed	1. Factory reset and new parameterization 2. Change inverter	OFF2
F0052 Powerstack Fault	Reading of the powerstack information has failed or the data is invalid	Change inverter	OFF2
F0060 Asic Timeout	Internal communications failure	1. Acknowledge fault 2. Change inverter if repeated	OFF2
F0070 Communications board setpoint error	No setpoint received from communications board during telegram off time	1. Check connections to the communications board 2. Check the master	OFF2
F0071 No Data for USS (RS232 link) during Telegramm Off Time	No response during telegram off time via USS (BOP link)	1. Check connections to the communications board 2. Check the master	OFF2
F0072 No Data from USS (RS485 link) during Telegram Off Time	No response during telegram off time via USS (COM link)	1. Check connections to the communications board 2. Check the master	OFF2
F0080 Analogue input - lost input signal	➢ Broken wire ➢ Signal out of limits	Check connection to analogue input	OFF2
F0085 External Fault	External fault is triggered via terminal inputs	Disable terminal input for fault trigger	OFF2
F0101 Stack Overflow	Software error or processor failure	1. Run self test routines 2. Change inverter	OFF2
F0221 PI Feedback below mini-mum value	PID Feedback below minimum value P2268	1. Change value of P2268 2. Adjust feedback gain	OFF2
F0222 PI Feedback above maximum value	PID Feedback above maximum value P2267	1. Change value of P2267 2. Adjust feedback gain	OFF2
F0450 (Service mode only) **BIST Tests Failure**	Fault value 1 Some of the power section tests have failed 2 Some of the control board tests have failed 4 Some of the functional tests have failed 8 Some of the IO module tests have failed 16 The Internal RAM has failed its check on power-up	1. Inverter may run but certain actions will not function correctly 2. Replace inverter	OFF2

Table 7 *origin: Siemens user Documentation 6SE6400-5AA00-0BP0*

Fault	Possible Causes	Diagnose & Remedy	Reac-tion
A0501 Current Limit	➢ Motor power does not correspond to the inverter power ➢ Motor leads are too short ➢ Earth faults	1. Check whether the motor power corresponds to the inverter power 2. Check that the cable length limits have not been exceeded 3. Check motor cable and motor for short-circuits and earth faults 4. Check whether the motor parameters correspond with the motor being used 5. Check the stator resistance 6. Increase the ramp-up-time 7. Reduce the boost 8. Check whether the motor is obstructed or overloaded	--
A0502 Overvoltage limit	➢ Mains supply too high ➢ Load regenerative ➢ Ramp-down time too short	1. Check that mains supply voltage is within allowable range 2. Increase ramp down times **Note**: Vdc-max controller is active, ramp-down times will be automatically increased	--
A0503 Undervoltage Limit	➢ Mains supply too low ➢ Short mains interruption	Check main supply voltage (P0210)	--
A0504 Inverter Over-temperature	Warning level of inverter heat-sink temperature (P0614) is exceeded, resulting in pulse frequency reduction and/or output frequency reduction (depending on parametrization in (P0610)	1. Check if ambient temperature is within specified limits 2. Check load conditions and duty cycle 3. Check if fan is turning when drive is running	--
A0505 Inverter I^2t	Warning level is exceeded; current will be reduced if parameterized (P0610 = 1)	Check if duty cycle is within specified limits	--
A0506 Inverter Duty Cycle	Heatsink temperature and thermal junction model are outside of allowable range	Check if duty cycle are within specified limits	--
A0511 Motor Over-temperature I^2t	Motor overloaded	Check the following: 1. P0611 (motor I^2t time constant) should be set to appropriate value 2. P0614 (Motor I^2t overload warning level) should be set to suitable level 3. Are long periods of operation at low speed occuring 4. Check that boost settings are not too high	--
A0541 Motor Data Identification Active	Motor data identification (P1910) selected or running	Wait until motor identification is finished	--
A0600 RTOS Overrun Warning	Software error		
A0700 CB warning 1	CB (communication board) specific	See CB user manual	--
A0701 CB warning 2	CB (communication board) specific	See CB user manual	--
A0702 CB warning 3	CB (communication board) specific	See CB user manual	--
A0703 CB warning 4	CB (communication board) specific	See CB user manual	--
A0704 CB warning 5	CB (communication board) specific	See CB user manual	--
A0705 CB warning 6	CB (communication board) specific	See CB user manual	--

Table 8 *origin: Siemens user Documentation 6SE6400-5AA00-0BP0*

Fault	Possible Causes	Diagnose & Remedy	Reaction
A0706 CB warning 7	CB (communication board) specific	See CB user manual	--
A0707 CB warning 8	CB (communication board) specific	See CB user manual	--
A0708 CB warning 9	CB (communication board) specific	See CB user manual	--
A0709 CB warning 10	CB (communication board) specific	See CB user manual	--
A0710 CB communication error	Communication with CB (communication board) is lost	Check CB hardware	--
A0711 CB configuration error	CB (communication board) reports a configuration error	Check CB parameters	--
A0910 Vdc-max controller de-activated	Vdc max controller has been de-activated, since controller is not capable of keeping DC-link voltage (r0026) within limits (P2172) ➢ Occurs if main supply voltage (P0210) is permanently too high ➢ Occurs if motor is driven by an active load, causing motor to goes into regenerative mode ➢ Occurs at very high load inertias, when ramping down	Check the following: 1. Input voltage (P0756) lies within range? 2. Load must match In certain cases apply braking resistor	--
A0911 Vdc-max controller active	Vdc max controller is active; so ramp-down times will be increased automatically to keep DC-link voltage (r0026) within limits (P2172)	1. Check parameter inverter input voltage 2. Check ramp-down times	--
A0912 Vdc-min controller active	Vdc min controller will be activated if DC-link voltage (r0026) falls below minimum level (P2172) ➢ The kinetic energy of the motor is used to buffer the DC-link voltage, thus causing deceleration of the drive! ➢ So short mains failures do not necessarily lead to an undervoltage trip		--
A0920 ADC parameters not set properly	ADC parameters should not be set to identical values, since this would produce illogical results. ➢ Index 0: Parameter settings for output identical ➢ Index 1: Parameter settings for input identical ➢ Index 2: Parameter settings for input do not correspond to ADC type	Analogue input parameters should not be set to the same value as each other	--
A0921 DAC parameters not set properly	DAC parameters should not be set to identical values, since this would produce illogical results. ➢ Index 0: Parameter settings for output identical ➢ Index 1: Parameter settings for input identical ➢ Index 2: Parameter settings for output do not correspond to DAC type	Analogue Output parameters should not be set to the same value as each other	--
A0922 No load applied to inverter	➢ No Load is applied to the inverter ➢ As a result, some functions may not work as under normal load conditions Low output voltage eg when 0 boost applied at 0 Hz	1. Check that load is applied to the inverter 2. Check motor parameters correspond to motor attached 3. As a result, some functions may not work correctly, because there is no normal load condition	--

Table 9 *origin: Siemens user Documentation 6SE6400-5AA00-0BP0*

Fault	Possible Causes	Diagnose & Remedy	Reaction
A0923 Both JOG Left and JOG Right are requested	Both JOG right and JOG left (P1055/P1056) have been requested. This freezes the RFG output frequency at its current value. JOG right and JOG left signals active together	Make sure that JOG right and JOG left signals are not applied simultaneously	--

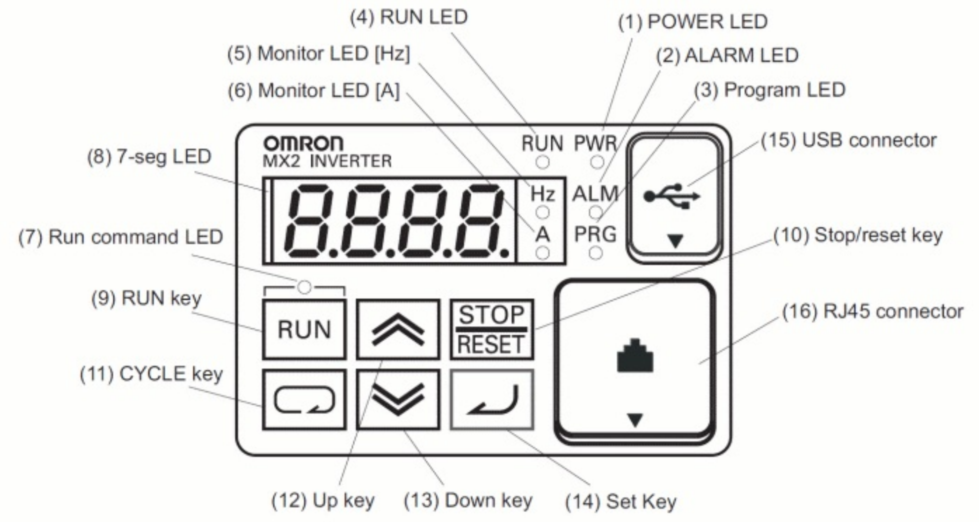
Table 10 *origin: Siemens user Documentation 6SE6400-5AA00-0BP0*

3.1.2 OMRON frequency inverter operation

If your ***sat-nms*** ACU-ODU is equipped with OMRON frequency inverters, use this chapter to get a short overview of the basic operation of this unit. If a Siemens type is installed, please refer to chapter 3.1.1 Siemens frequency inverter operation .

3.1.2.1 Display and function of the buttons

The frequency inverters used in the ***sat-nms*** ACU-ODU have an integrated display that shows you all of the parameters set to the frequency inverter. It also is able to show you the actual values of e.g. output frequency, voltage and output voltage. The following picture shows how the frontpanel looks like:



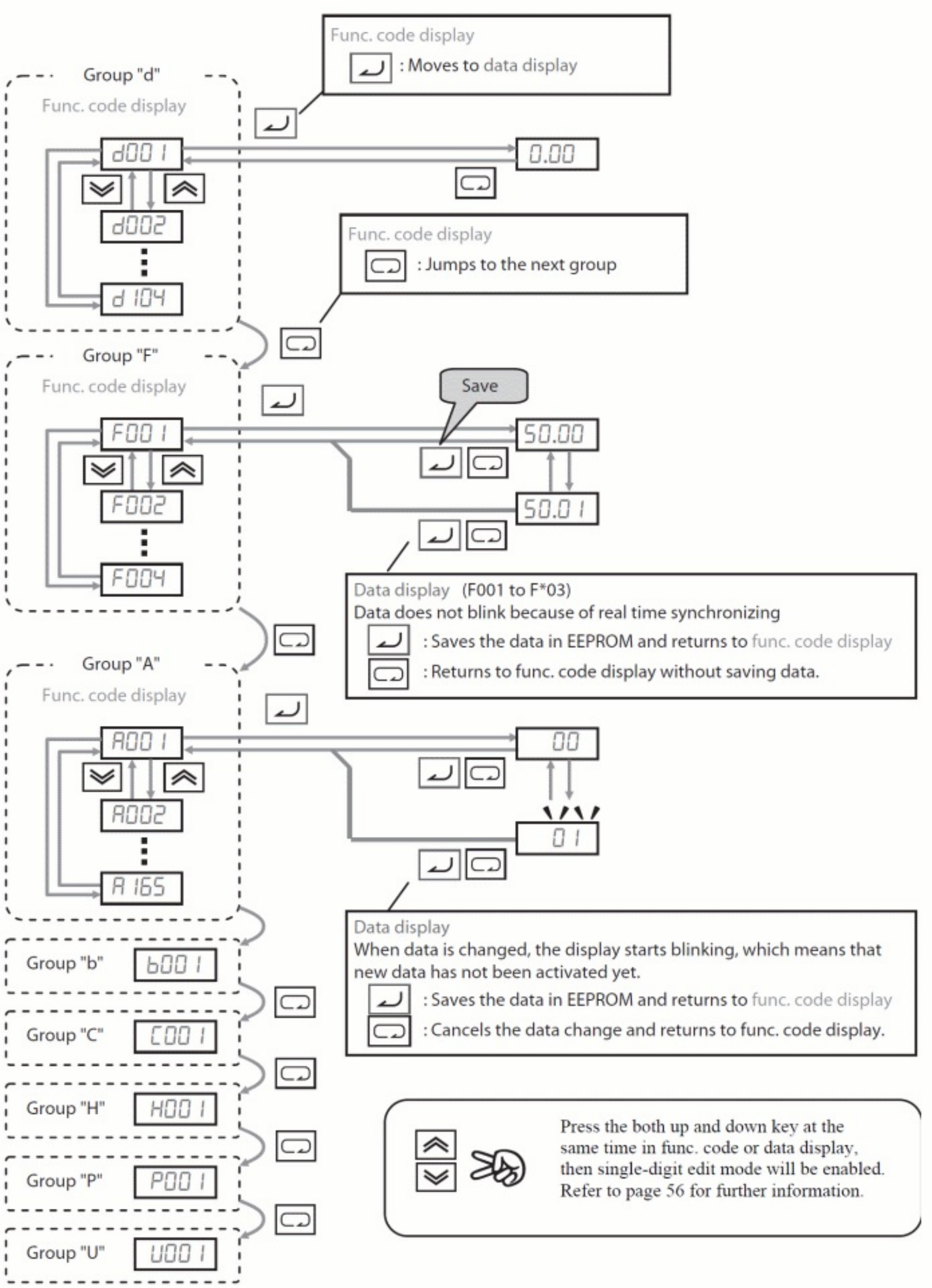
The following table shows the function of the frequency inverter's buttons:

item	***content***
(1) POWER LED	Turns ON (green) while the inverter is powered up
(2) ALARM LED	Turns ON (red) when the inverter trips
(3) Program LED	Turns ON (green) when the display shows changeable parameter. Blinks when there is a mismatch in setting
(4) RUN LED	Turns ON (green) when the inverter is drivin the motor
(5) Monitor LED [Hz]	Turns ON (green) when the displayed data is frequency related
(6) Monitor	Turns ON (green) when the displayed data is current related

LED [A]	
(7) Run command LED	Turns ON (green) when a Run command is set to the operator
(8) 7-seg LED	Shows each parameter , monitors etc.
(9) Run key	Makes inverter run
(19) Stop/reset key	Makes inverter decelerates to a stop. Reset the inverter when it is in trip situation
(11) CYCLE key	Go to the top of next function group, when a function mode is shown. Cancel the setting and return to the function code, when a data is shown. Moves the cursor to a digit left, when it is in digit-to-digit setting mode. Pressing for 1 second leads display data of *d001* , regardless of current display.
(12) Up key (13) Down key	Increase or decrease data. Pressing both keys at the same time gives you the digit-to-digit edit.
(14) SET key	Go to the data display mode when a function code is shown. Stores the data and go back to show the function code, when data is shown. Moves the cursor to a digit right, when it is in digit-to-digit display mode.
(15) USB connector	Connect USB connector (mini-B) fur using PC communication
(16) RJ45 connector	Connect RJ45 jack for remote operator (this is not an Ethernet interface!)

origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual.pdf

3.1.2.2 Menu structure of frequency inverter



origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual.pdf

3.1.2.3 Changing value display

After startup the display of the frequency inverter shows a value depending on setting of parameter B038 (value 001...104 corresponds to display values d001...d104 shown on next table) If you like to view some other parameters, press Set Key (14). By pressing the Up and Down Key (13) and (14) select desired parameter. By pressing Set Key (14) this selected parameter is displayed. The following table gives you the possible values to display:

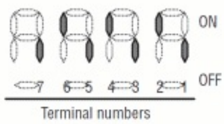
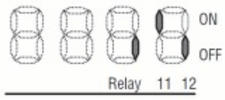
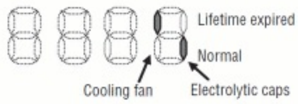
"D" Function			Run Mode Edit	Units
Func. Code	Name	Description		
d001	Output frequency monitor	Real time display of output frequency to motor from 0.0 to 400.0Hz*1 If b163 is set high, output frequency (F001) can be changed by up/ down key with d001 monitoring.	–	Hz
d002	Output current monitor	Filtered display of output current to motor, range is 0 to 655.3 ampere (~99.9 ampere for 1.5kW and less)	–	A
d003	Rotation direction monitor	Three different indications: "F" ...Forward "o" ...Stop "r" ...Reverse	–	–
d004	Process variable (PV), PID feed-back monitor	Displays the scaled PID process variable (feedback) value (A075 is scale factor), 0.00 to 10000	–	-
d005	Intelligent input terminal status	Displays the state of the intelligent input terminals: 	–	–
d006	Intelligent output terminal status	Displays the state of the intelligent output terminals: 	–	–
d007	Scaled output frequency monitor	Displays the output frequency scaled by the constant in b086. Decimal point indicates range: 0 to 40000	–	-
d008	Actual frequency monitor	Displays the actual frequency, range is -400 to 400 Hz*2	–	Hz
d009	Torque command monitor	Displays the torque command, range is -200 to 200%	–	%
d010	Torque bias monitor	Displays the torque bias value, range is -200 to 200%	–	%
d012	Output torque monitor	Displays the output torque, range is -200 to 200%	–	%
d013	Output voltage monitor	Voltage of output to motor, Range is 0.0 to 600.0 V	–	V
d014	Input power monitor	Displays the input power, range is 0 to 100 kW	–	KW
d015	Watt-hour monitor	Displays watt-hour of the inverter, range is 0 to 9999000	–	–
d016	Elapsed RUN time monitor	Displays total time the inverter has been in RUN mode in hours. Range is 0 to 9999 / 1000 to 9999 / 100 to 999 (10,000 to 99,900)	–	hours

Table 1 *origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual*

"D" Function			Run Mode Edit	Units
Func. Code	Name	Description		
d017	Elapsed power-on time monitor	Displays total time the inverter has been powered up in hours. Range is 0 to 9999 / 1000 to 9999 / 100 to 999 (10,000 to 99,900)	–	hours
d018	Heat sink temperature monitor	Temperature of the cooling fin, range is -20~150	–	C
d022	Life check monitor	Displays the state of lifetime of electrolytic capacitors on the PWB and cooling fan. 	–	–
d023	Program counter monitor [EzSQ]	Range is 0 to 1024	–	–
d024	Program number monitor [EzSQ]	Range is 0 to 9999	–	–
d025	User monitor 0 [EzSQ]	Result of EzSQ execution, range is -2147483647~2147483647	–	–
d026	User monitor 1 [EzSQ]	Result of EzSQ execution, range is -2147483647~2147483647	–	–
d027	User monitor 2 [EzSQ]	Result of EzSQ execution, range is -2147483647~2147483647	–	–
d029	Positioning command monitor	Displays the positioning command, range is -268435455~+268435455	–	–
d030	Current position monitor	Displays the current position, range is -268435455~+268435455	–	–
d050	Dual monitor	Displays two different data configured in b160 and b161.	–	–
d060	Inverter mode monitor	Displays currently selected inverter mode : IM, IM-high-FQ	–	–
d102	DC bus voltage monitor	Voltage of inverter internal DC bus, Range is 0.0 to 999.9	–	V
d103	BRD load ratio monitor	Usage ratio of integrated brake chopper, range is 0.0~100.0%	–	%
d104	Electronic thermal monitor	Accumulated value of electronic thermal detection, range is from 0.0~100.0%	–	%

*1 Up to 1000Hz for High frequency mode (d060 set to "2")
*2 Up to 1000Hz for High frequency mode (d060 set to "2")

Table 2 *origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual*

3.1.2.4 Changing Parameters of the Frequency Inverter

On following Tables 3 to 6 and you can see the test-settings that are programmed in the delivery state. To change the parameters press Cycle Key (11) as soon as you have reached the right group (A...U), now you can change the parameter-number with the up- and down Key (12)+(13). To change the chosen parameter press button Set Key (14). Now you can change the parameter with the up and down Keys to the desired value. To save the new parameter value, press Set Key (14) once. To go back to the parameter choice, without saving, press Cycle Key (11)

In normal cases it suffices to change the following Parameters of the frequency-inverters: in row **value** the ACU-ODU standard setting is given, **standard** represents the OMRON delivery state value. Please refer to the OMRON manual for more detailed parameter informations.

Table 3: Parameters to be configured to the motor parameters

Index	Description	Value	Standard	unit	Remark
A003	Base frequency setting	50.0	50.0	Hz	[30-50]
A004	Maximum frequency setting	50.0	50.0	Hz	[50-400]
A021	Multi-speed 1 setting	10.00	0.00	Hz	Low speed [0-50]
A022	Multi-speed 2 setting	50.00	0.00	Hz	High speed [0-50]
A042	Manual torque boost value	5.0	1.0	%	min. 1 max. 10 [0-20]
A045	V/f gain setting	100	100	%	optimising max Voltage if A082 is too high [20-100]
A082	AVR voltage select	400	400	V	Motor maximum voltage [380-480]
B001	Selection of automatic restart mode	01	00		[00-04]
B008	Restart mode on over voltage / over current trip	01	00		[00-04]
B012	Level of electronic thermal setting	7.2	7.2	A	Set to motor maximum current [depending on power class]
B083	Carrier frequency setting	10.0	10.0	kHz	[2.0-15.0]
C102	Reset function	02	00		Cancel trip state at input ON transition, no effect if in Run Mode [00-03]
F002	Acceleration (1) time setting	2	10.00	Sek	[0.01-3600.0]
F003	Deceleration (1) time setting	0,5	10.00	Sek	[0.01-3600.0]

Table 4: Interface parameters, these normally do not have to be changed.

Index	Description	Value	Standard	unit	Remark
B090	Dynamic braking usage ratio	0.0	0.0	%	Selects the rate of use of the regenerative braking resistor [0.0-10.0]
B095	Dynamic braking control (BRD) selection	00	00		Off [00-02]
B096	BRD activation level	720	720	V	[660-760]
B097	BRD resistor value	100	100	Ohm	Ohmic value of the braking resistor connected to the drive [100.0-600.0]

Table 5: If you use an external brake resistor, you have to adjust the following parameters:

Index	Description	Value	Standard	unit	Remark
A001	Frequency source setting	01	01		Terminal aktiv [00-10]
A002	Run command source setting	01	01		Terminal aktiv [01-04]
A019	Multi-speed operation selection	00	00		A21-A35 aktiv [00-01]
A041	Torque boost select	00	00		Manual Boost [00-01]
A043	Manual torque boost frequency adjustment	5.0	5.0	%	Freq. Setting für Boost [0.0-50.0]
A044	V/f characteristic curve selection	00	00		constant torque [00-03]
A081	AVR function select	02	02		Inverter On [00-02]
A097	Acceleration curve selection	01	01		linear ramp [00-04]
A098	Deceleration curve selection	01	01		linear ramp [00-04]
B013	Electronic thermal characteristic	01	01		constant torque [00-02]
B021	Overload restriction operation mode	01	01		overload protection on [00-03]
B049	Dual Rating Selection	00	00		constant torque [00-01]
B091	Stop mode selection	00	00		decceleration ramp enable [00-01]
B171	Inverter mode selection	00	00		no selection [00-03]
C001	Terminal [1] function	00	00		FWD [00-no]
C002	Terminal [2] function	01	01		REV [00-no]
C004	Terminal [4] function	18	18		RS [00-no]
C005	Terminal [5] function	02	02		CF1 [00-no]
C006	Terminal [6] function	03	03		CF2 [00-no]
C026	Alarm relay terminal function	05	05		AL [00-no]

Table 6: To Reset Frequency inverters parameters to OMRON factory default settings, refer to following table

Index	Description	Value	Standard	unit	Remark
B038	Initial-screen selection	001	001		InverterData: Display Value: [000-202]
B084	Initialization mode (parameters or trip history)	03	00		reset to factory default, delete fault memory [00-04]
B085	Country for initialization	01	01		InverterData: EU [00-01]
B094	Initialization target data setting	00	00		all parameters [00-03]
B180	Initialization trigger	01	00		perform inizialisation [00-01]

The following tables give you a short overview over the fault states, the frequency inverter is able to display.

Erro Code	Name	Cause(s)
E01	Over-current event while at constant speed	The inverter output was short-circuited, or the motor shaft is locked or has a heavy load. These conditions cause excessive current for the inverter, so the inverter output is turned OFF. The dual-voltage motor is wired incorrectly.
E02	Over-current event during deceleration	
E03	Over-current event during acceleration	
E04	Over-current event during other conditions	
E05	Overload protection	When a motor overload is detected by the electronic thermal function, the inverter trips and turns OFF its output. Check if the application can accept softer acceleration rates to minimize peak currents F002/F202/A092/A292). Check if motor parameters are not correctly set (H020 to H034), depending in motor control method (A044/A244).
E06	Braking resistor overload protection	When the BRD operation rate exceeds the setting of "b090", this protective function shuts off the inverter output and displays the error code.
E07	Over-voltage protection	When the DC bus voltage exceeds a threshold, due to regenerative energy from the motor.
E08	EEPROM error	When the built-in EEPROM memory has problems due to noise or excessive temperature, the inverter trips and turns OFF its output to the motor.
E09	Under-voltage error	A decrease of internal DC bus voltage below a threshold results in a control circuit fault. This condition can also generate excessive motor heat or cause low torque. The inverter trips and turns OFF its output.
E10	Current detection error	If an error occurs in the internal current detection system, the inverter will shut off its output and display the error code.
E11	CPU error	A malfunction in the built-in CPU has occurred, so the inverter trips and turns OFF its output to the motor.
E12	External trip	A signal on an intelligent input terminal configured as EXT has occurred. The inverter trips and turns OFF the output to the motor.
E13	USP	When the Unattended Start Protection (USP) is enabled, an error occurred when power is applied while a Run signal is present. The inverter trips and does not go into Run Mode until the error is cleared.
E14	Ground fault	The inverter is protected by the detection of ground faults between the inverter output and the motor upon during powerup tests. This feature protects the inverter, and does not protect humans.
E15	Input over-voltage	The inverter tests for input over-voltage after the inverter has been in Stop Mode for 100 seconds. If an over-voltage condition exists, the inverter enters a fault state. After the fault is cleared, the inverter can enter Run Mode again.

Table 7 *origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual*

Erro Code	Name	Cause(s)
E21	Inverter thermal trip	When the inverter internal temperature is above the threshold, the thermal sensor in the inverter module detects the excessive temperature of the power devices and trips, turning the inverter output OFF.
E22	CPU communication error	When communication between two CPU fails, inverter trips and displays the error code.
E25	Main circuit error (*3)	The inverter will trip if the power supply establishment is not recognized because of a malfunction due to noise or damage to the main circuit element.
E30	Driver error	An internal inverter error has occurred at the safety protection circuit between the CPU and main driver unit. Excessive electrical noise may be the cause. The inverter has turned OFF the IGBT module output.
E35	Thermistor	When a thermistor is connected to terminals [5] and [L] and the inverter has sensed the temperature is too high, the inverter trips and turns OFF the output.
E36	Braking error	When "01" has been specified for the Brake Control Enable (b120), the inverter will trip if it cannot receive the braking confirmation signal within the Brake Wait Time for Confirmation (b124) after the output of the brake release signal. Or when the output current doesn't reach the brake release current (b126) during the brake release time (b121)
E37	Safe Stop	Safe stop signal is given.
E38	Low-speed overload protection	If overload occurs during the motor operation at a very low speed, the inverter will detect the overload and shut off the inverter output.
E40	Operator connection	When the connection between inverter and operator keypad failed, inverter trips and displays the error code.
E41	Modbus communication error	When "trip" is selected (C076=00) as a behavior in case of communication error, inverter trips when timeout happens.
E43	EzSQ invalid instruction	The program stored in inverter memory has been destroyed, or the PRG terminal was turned on without a program downloaded to the inverter.
E44	EzSQ nesting count error	Subroutines, if-statement, or for-next loop are nested in more than eight layers
E45	EzSQ instruction error	Inverter found the command which cannot be executed.
E50 to E59	EzSQ user trip (0 to 9)	When user -defined trip happens, inverter trips and displays the error code.
E60 to E69	Option errors (error in connected option board, the meanings change upon the connected option).	These errors are reserved for the option board. Each option board can show the errors for a different meaning .. To check the specific meaning, please refer to the corresponding option board user manual and documentation.
E80	Encoder disconnection	If the encoder wiring is disconnected, an

		encoder connection error is detected, the encoder fails, or an encoder that does not support line driver output is used, the inverter will shut off its output and display the error code shown on the right.

Table 8 *origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual*

Erro Code	Name	Cause(s)
E81	Excessive speed	If the motor speed rises to "maximum frequency (A004) x over-speed error detection level (P026)" or more, the inverter will shut off its output and display the error code shown on the right.
E83	Positioning range error	If current position exceeds the position range (P072-P073), the inverter will shut off its output and display the error code.

Table 9 *origin: OMRON user Documentation I570-E2-01-X+MX2+UsersManual*

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.

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 have to be connected directly at the ***sat-nms*** ACU-ODM core module. The Motors have to be connected directly to the frequency inverters. Please refer to the schematic of the ***sat-nms*** ACU-ODU that has been delivered to you. It shows you where to connect Limit switches, motors and mains.

4.2.1 Angle encoder connection

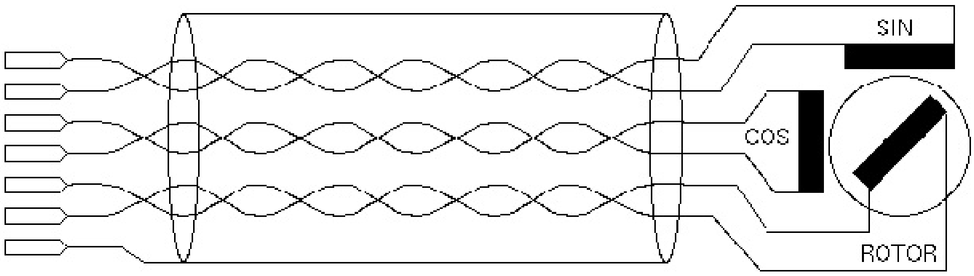
The angle encoders have to be connected directly to the core module of the ***sat-nms*** ACU-ODU, which is called ***sat-nms*** ACU-ODM. Inside, the ***sat-nms*** ACU-ODM consists of a main board and two or three interface boards with the circuitry for the position sensors. These boards are different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



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 and emergency switch have to be connected to the terminals bottom right of the cabinet. Please refer to the schematics for the exact cabling. 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' or 'emergency stop' condition. Opening the emergency stop contact disconnects the frequency inverters, motor drivers or conductors from mains supply immediately.

4.2.3 Motors connection

Connect the azimuth and elevation motors directly to the frequency inverters. Use shielded cable only. Take care, that the shield is connected to the PE terminal of the frequency inverter and is NOT connected to the crankcase. If your ACU-ODU is equipped with a polarisation drive, the terminals are located at the rail where the other terminals are mounted at. Here it is not necessarily needed to use a shielded cable. If you nevertheless use a shielded one, take care, that the shield is connected to the PE terminal of the terminals 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 DIR-START for AZ and EL and as DUAL-START for POL if you have Siemens frequency inverters installed. If your ***sat-nms*** ACU-ODU is equipped with OMRON frequency inverters, all axis have to be configured as DUAL-START.

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. If your ***sat-nms*** ACU-ODU is equipped with an optional ethernet switch, connect your LAN here. 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.
6. As last step connect the power supply of the motors and start them up as described below.

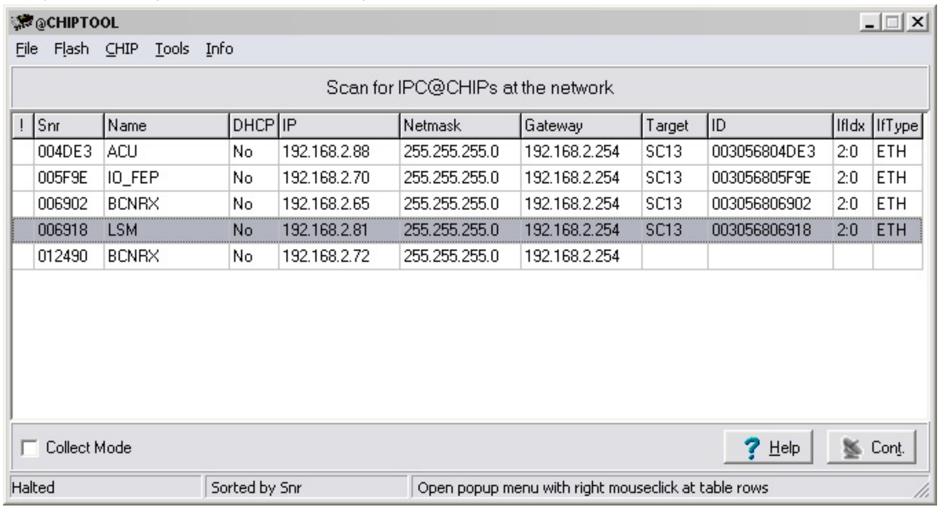
4.3.1 Setting the IP Address

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.

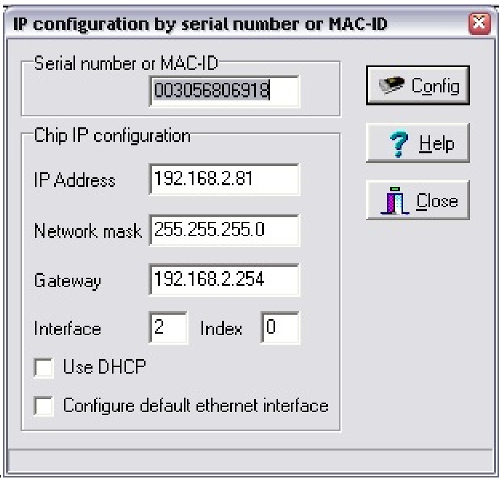
1. First install a network cable between the ACU and your computer. If you have a crossover cable available, this is very easy: simply put the cable into the network connectors of computer and ACU. Without a crossover cable, you need to connect both, the computer and the ACU to the same network hub using 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.



!	Snr	Name	DHCP	IP	Netmask	Gateway	Target	ID	IfIdx	IfType
	004DE3	ACU	No	192.168.2.88	255.255.255.0	192.168.2.254	SC13	003056804DE3	2:0	ETH
	005F9E	IO_FEP	No	192.168.2.70	255.255.255.0	192.168.2.254	SC13	003056805F9E	2:0	ETH
	006902	BCNRX	No	192.168.2.65	255.255.255.0	192.168.2.254	SC13	003056806902	2:0	ETH
	006918	LSM	No	192.168.2.81	255.255.255.0	192.168.2.254	SC13	003056806918	2:0	ETH
	012490	BCNRX	No	192.168.2.72	255.255.255.0	192.168.2.254				

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-RMU 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 Angle encoder connection .

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 shure 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. Set the motor parameters to the frequency inverters as written in chapter 3.1.1 or 3.1.2 to the desired values.
6. Check the motor rotating directions, if necessary change it by interchanging 2 phase-wires of the motor cable.
7. If available, turn on POL motor circuit breaker now and check the rotational direction of the POL Motor. If necessary, change pin 1 and 2 at POL motor terminals to reverse the direction.
8. 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!
9. 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 frequency inverters (parameter settings, fault states etc.), please refer to chapter 3.1 Frequency Inverters .

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.

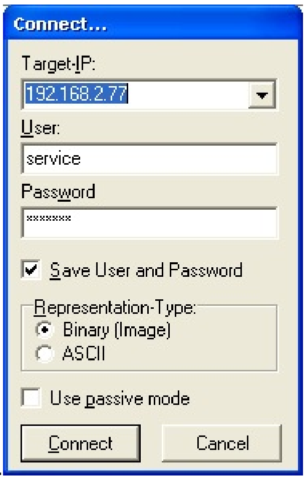
In chapter 5 Operation you find a detailed description of the pointing and tracking parameters.

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

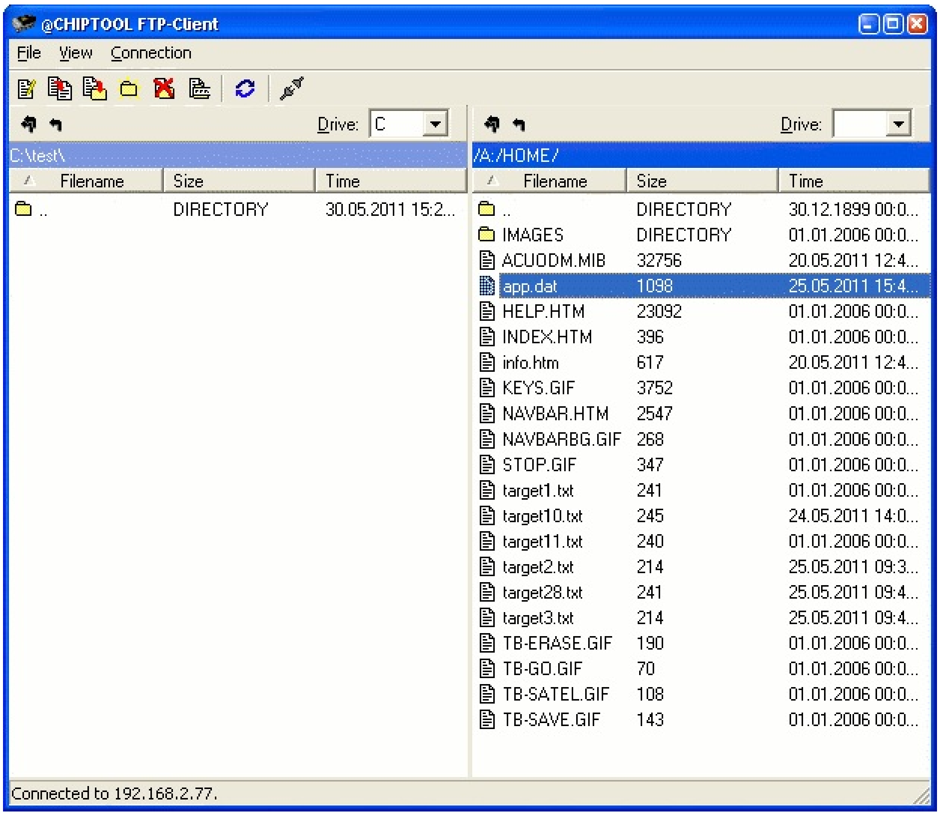
The last step that is recommended to be done is the backup of ACU settings. By this way an easy replacement of the ACU-ODM could be performed. The following step-by step description shows how to do this.

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 will be opened. 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. The refresh-rate may be adjusted on the setup-page from software version 2.1.007 or higher.

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

- --- 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 eight satellites.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 manualStep 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 antenne 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 from software version 2.1.007 or higher. The table below describes the information shown by this page:

- *Parameter Name --- Description*

- 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.

- 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 stopps 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).

Antenna Pointing Page Example:

Azimuth	Elevation	Polarization
219.089°	27.471°	-70.049°
Target value 219.080 °	Target value 27.461 °	Target value -70.082 °

Target name	SES4 22°W RX 11451M003
Tracking mode	ADAPTIVE (SLEEPING) (sleep=317s fill=111.1h age=0.0h)
Beacon level	-82.54 dBm (var 0.00 dB)
Temperature	36.8 °C
ACU Faults	
Tracking Faults	
AZ Tracking State	M=SMALL A=11% J=1% B=0.496° S=0.056°
EL Tracking State	M=SMALL A=15% J=2% B=0.496° S=0.050°
Time	2012-11-27 12:42:37
GPS State	DISABLED

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 99 satellites. Managing these memories is done with the 'Targets' page.

The page displays a table with all pointings actually stored. 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 and moves the antenna to the stored pointing. 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.
- Save --- For each memory location the table shows a floppy disk icon in the 'Save' column. Clicking to this icon saves the actual pointing (and tracking parameters if applicable) to the selected memory location. Again, there is a confirmation dialog page before the data actually is saved.
- 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.

The first target location, labeled 'adaptive tracking memory', is reserved for special purposes: If you store to this target location, 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. 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.

You should not use the first target location for general purposes in order to keep it available for the short time storage described above.

Targets Page Example:

#	Target	Go	Save	Delete
0	ADAPTIVE TRACKING MEMORY			
1	19.2 °E/1G 11698_8 (166.029/34.152/-9.131)			
2	-8 °E AB2 11703982 (202.275/32.979/12.300)			
3	Intelsat 901 -18 ° (214.430/29.924/30.152)			
19	-8 °E AB2 Tracking (202.266/32.960/25.000)			
	Numeric orbit position			

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.

- **Trackingmode** --- 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.
  - **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.

.ts **CLEARMEMORY** Clicking to this mark clear 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.

- **Trackingstepsize** --- 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.
- **Trackingcycletime** --- 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.
- **Measurementdelay** --- 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 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.
- **Recoverydelay** --- 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.
- **Levelaveraging** --- 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.
- **Levelthreshold** --- 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)

- **Smoothinginterval** --- 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'
- **Peakjitterthreshold** --- 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.
- **AZMaximummodeltype ELMaximummodeltype** --- 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.

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

Tracking Parameters Page Example:

Tracking mode	OFF		CLEAR MEMORY	
Tracking step size	15 %		Tracking cycle time	180 sec
Measurement delay	1500 msec		Recovery delay	4000 msec
Level averaging	5 samples		Level threshold	-75.00 dBm
Smoothing interval	6 h		Peak jitter threshold	0 %
AZ Maximum model type	LARGE		EL Maximum model type	LARGE

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. 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 theshold, the antenna movement is calculated from these coefficients using the formulas shown below:

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

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

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

Hardware Test Page Example:

```
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    LO          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   HI          Cabinet door open    HI

Flags:                           Analog:
AZ moving            LO          Temperature          36.7 °C
EL moving            LO          Beacon level         -82.53 dBm
POL moving           LO          Nick                 -81.2 °
                                 Roll                 -90.0 °
AZ motor timeout     LO          AZ raw pointing      1D1A0000
EL motor timeout     LO          EL raw pointing      84660000
POL motor timeout    LO          POL raw pointing     E3840000

AZ coefficients       2.19094E+02 -1.21731E-02 -2.26467E-02
EL coefficients       2.75028E+01 -4.54165E-02  2.37250E-02
```

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.

The table below lists the settings provided by this page.

General

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

Parameter Name	***Description***
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.

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.
RS485 address	With this parameter you select the device address used control the ACU through a serial interface. See chapter 7.3 The RS232 remote control interface for more information about this. 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.
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.
Display refresh	With this parameter you select the refresh-rate of the ACU's main window. This parameter is available from software version 2.1.007 or higher.
Note	The ACU's pointing page by default shows the title 'Antenna pointing'. By entering a different text here, you can make the ACU show a customized title.

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.

- *Parameter Name* --- *Description*
- 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).
- Pre scale 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

Parameter Name	***Description***
Beacon RX type	Selects the source of the beacon level the ACU shall use. Available options are SATNMS and VOLTAGE. In SATNMS 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 SATNMS 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 SATNMS 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

- *Parameter Name --- Description*
- 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

Parameter Name	***Description***
Compass type	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.

Parameter Name	***Description***
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.

General				
Note	3.7m Antenna		Date / time	2011-05-16 12:30:56
Display refresh	1 sec			
Axes control mode	PARALLEL		RS485 address	TERM
Azimuth				
AZ Antenna diameter	3.7 m		Az. step delta	0.020 °
AZ Position sensor type	RESOLVER		AZ Motor driver type	DIR-START
AZ Sense invert	NORMAL		AZ Motor timeout	4000 msec
AZ Pre scale offset	FE9CE38F	calc.	AZ Post scale offset	180.000 °
AZ Calibration scale	0.000000		AZ Pointing hysteresis	0.025 °
			AZ Low speed threshold	2.0 °
AZ Lower limit	148.000 °		AZ Upper limit	230.000 °
Elevation				
EL Antenna diameter	3.7 m		El. step delta	0.100 °
EL Position sensor type	RESOLVER		EL Motor driver type	DIR-START
EL Sense invert	INVERTED		EL Motor timeout	4000 msec
EL Pre scale offset	AF29E38F	calc.	EL Post scale offset	45.000 °
EL Calibration scale	0.000000		EL Pointing hysteresis	0.025 °
			EL Low speed threshold	2.0 °
EL Lower limit	8.000 °		EL Upper limit	77.000 °
Polarization				
PO Position sensor type	RESOLVER		PO Motor driver type	DUAL-START
PO Sense invert	NORMAL		PO Motor timeout	4000 msec
PO Pre scale offset	00000000	calc.	PO Post scale offset	20.026 °
PO Calibration scale	0.000000		PO Pointing hysteresis	0.100 °
			PO Low speed threshold	2.0 °
PO Lower limit	-80.000 °		PO Upper limit	111.000 °
Beacon Receiver				
Beacon RX type	SATNMS		Beacon RX IP address	192.168.2.78
Beacon RX voltage scale	n/a		Beacon RX 0V level	n/a
Beacon RX frequency	11450.529 MHz			
Location				
GPS receiver type	NONE		Antenna longitude	8.915 °E
Antenna course	180.000 °		Antenna latitude	47.782 °N
			Antenna abs. altitude	450 m
Orientation				
Compass type	NONE		Inclinometer type	NONE
Nick offset	n/a		Roll offset	n/a
SNMP Control				
SNMP read community	public		SNMP system name	ACU24
SNMP write community	private		SNMP system location	Default
SNMP trap community	public		SNMP system contact	SatService GmbH
SNMP traps	ENABLED		MIB File	ACUODM.MIB
SNMP trap IP 1	192.168.2.18		SNMP trap IP 2	192.168.2.14
SNMP trap IP 3	0.0.0.0		SNMP trap IP 4	0.0.0.0
Access Control				
User password	******		Admin password	******

Setup Page Example

5.7 Handheld Terminal

The antenna may be moved by means of the optional handheld controller. The Handheld function is not yet available at ACU-RMU and ACU19 Version.

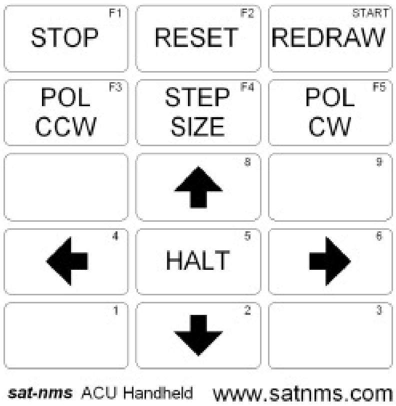
Startup

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



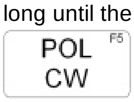
- 

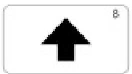
--- Emergency STOP, stops all Motors immediately, it has to be released by pushing the -button
- 

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

--- Back to start screen
- 

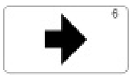
--- Turns the polarisation counterclockwise
- 

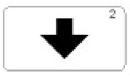
--- Selects the step-size: small steps: x°/keypress (x is the value that was set on the setup-screen), large steps: 10*x°/keypress, continuous mode: the antenna moves as long until the -button is pushed or a limit switch or limit value is reached.
- 

--- 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)
- 

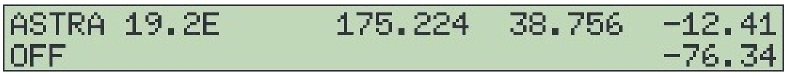
--- Moves the antenna down (EL)

6 Frontpanel operation

The rack mountable version of the ***sat-nms*** ACU provides a LCD and a small keyboard at the front panel for operating the device locally as an option. The capabilities of the front panel operation are designed to operate the ACU locally. It is possible to select a new target, move the antenna incremental, set new pointing angles or select another step track mode. Advanced configuration parameters are available over the web interface. Please start reading at chapter 5.1 for more information.

Display

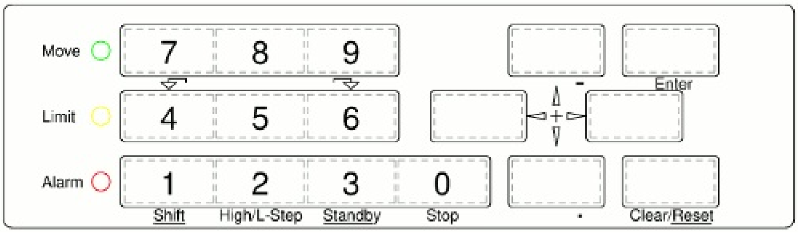
The 2-line display normally shows the actual target name, the angle of the three axes, the step track mode and the beacon level. During menu operation it is used to view and edit some parameter of the ACU.



LEDs

Three LEDs at the front panel signal the summary state of the ACU.

- The 'Move' LED is on while a motor is on.
- The 'Limit' LED is on while an end switch of the antenna is activated. If so, the 'Alarm' LED is also on.
- The 'Alarm' LED is on while the ACU19 is in alarm state.



Keys

The front panel keyboard provides beside the numeric keys four arrow keys and two keys named ENTER and CLEAR. Some keys have a second meaning. The first meaning of the keys remains constant through most levels of the menu:

- ENTER --- The ENTER key descends in the menu tree, accepts and stores changed values
- CLEAR --- The CLEAR key leaves to higher menu levels, abandons changes when editing parameters. It also resets the alarm buzzer when in display mode.
- ◄ ► ▲ ▼ --- The arrow keys navigate in the menu.
- **0..9** --- The number keys are to enter numeric parameters.

If STEP MOVE or JOG MODE is selected in the menu the following keys have a new function.

- **7** --- Move the polarization counterclockwise
- **9** --- Move the polarization clockwise
- **2** --- Select large step or high speed
- ▲ ▼ --- Move the elevation up/down
- ◄ ► --- Move the elevation east/west
- **1** and **3** --- Select the STANDBY Operation Mode

For all directions: view from behind antenna. 'Large steps' normally are 10 times the step size configured for this axis. Pressing **2** together with an arrow key changes to 10x steps or high speed. The step size is configured on the 'Setup'-page on the ***sat-nms*** ACU-ODMs Website.

If one or all motors are moving, they can stop with the following key:

- **0** --- Stop every motor Postion regulation is off. An Alarm will displayed
- **1** and **3** --- Select the STANDBY Operation Mode. No Alarm will displayed
- **1** and CLEAR --- Stop every motor Postion regulation is on

6.1 Display mode

The display mode shows the actual reading and some additional information in the display. This is the default mode, the ACU enters it automatically after power on. Depending on the selected tracking mode, the default display looks like this:

```
ASTRA 19.2E        175.224  38.756   -12.41
OFF                                  -76.34
```

```
ASTRA 19.2E        175.224  38.756   -12.41
ADAP   81.3h         12/5%     8/5%  -76.34
```

or alternative

```
ASTRA 19.2E        175.224  38.756   -12.41
40s    81.3h         12/5%     8/5%  -76.34
```

The upper display line shows the actual target name and the three axes angles. The lower line shows the selected tracking mode or alternative the remaining time between the tracking steps (selected with arrow up/down), depending on tracking mode, the size of the tracking memory and the model data or nothing, and the beacon level.

While the ACU is not in a regular state, the display shows a message. The ordinary contents of the display and the message are shown alternately, the message blinks on the display. The following messages may be displayed at the corresponding position in the display.

At the corresponding angle position:

- FAULT --- General ACU Fault
- TIMEOUT --- Motor moves, but the position encoder does not react
- HI-LIMIT --- High limit switch is activated
- LOW-LIMIT --- Low limit switch is activated
- STOPPED --- Motor stopped, over Web interface or with the STOP-Button on front panel
- BEAC FLT --- If the ACU reads the beacon level via TCP/IP from ***sat-nms*** LBRX and the beacon receiver does not respond
- LOW BEAC --- Low beacon signal

If more than one of the above conditions occurs, only that one with the highest precedence is shown. This means for example that the HI-LIMIT state precedes over the LO-LIMIT state.

6.2 The main menu

The menu mode lets you view and change some ACU settings. From the display mode, you enter the menu by pressing the key ENTER . To leave the menu, repeatedly press the key CLEAR until the display screen appears again. If there are no keystrokes for 30 minute, the ACU automatically leaves the menu and returns to display mode. The menu structure is shown below:

- MENU
- SELECT TARGET
- SET TRACKING MODE
- STEP MOVE
- JOG MODE
- STANDBY
- SET AZIMUTH
- SET ELEVATION
- SET POLARIZATION

To navigate in the menu, use . To select a menu press . Pressing once returns to the main menu level, pressing it twice returns to display mode.

6.3 Select targets

In the SELECT TARGET menu, it is possible to select a saved target. To navigate between the targets use . Press to recall a selected target.

```
ASTRA 19.2E       175.224  38.756  -12.41
MENU: SELECT TARGET
```

```
ASTRA 19.2E       175.224  38.756  -12.41
22 ASTRA 19.2E (175.224/38.756/-12.410)
```

After a target recall, the display returns to the main menu. Press to return to the default display or wait about a 30 minute for automatically return.

6.4 Set tracking mode

In the SELECT TRACKING MODE menu, you can change the tracking mode as shown below:

- OFF
- STEP
- ADAPTIVE
- PROGRAM

For detailed information about tracking please refer to chapter 8.3 Step Tracking , chapter 8.4 Adaptive Tracking and chapter 8.5 Program Tracking .

6.5 Step move

The antenna can be moved over the front panel with the STEP MOVE menu. The corresponding keys are listed below:

- **7** --- Move the polarization counterclockwise
- **9** --- Move the polarization clockwise
- **2** --- Select large step (pressed together with an arrow key)
- --- Move the elevation up/down
- --- Move the elevation east/west

```
ASTRA 19.2E       175.224  38.756  -12.41
STEP MOVE: (PRESS CLR to leave)
```

Press a key one time, moves the antenna one step in the corresponding direction. The step size is defined at the Web interface.

6.6 Jog mode

The antenna can be moved over the front panel with the JOG MODE menu. The corresponding keys are listed below:

- **7** --- Move the polarization counterclockwise
- **9** --- Move the polarization clockwise
- **2** --- Select high speed (pressed together with an arrow key)
- ▲ ▼ --- Move the elevation up/down
- ◄ ► --- Move the elevation east/west

```
ASTRA 19.2E        175.224  38.756  -12.41
JOG MODE: (PRESS CLR to leave)
```

The antenna will as long move as longe a key is pressed in the corresponding direction.

6.7 Standby

The antenna will stop the position keeping, the status will be displayed in the main screen with --- Standby --- blinking in the second line.

```
ASTRA 19.2E        175.224  38.756  -12.41
Press ENTER to enable STANDBY
```

```
ASTRA 19.2E        175.224  38.756  -12.41
OFF               --STANDBY--       -76.34
```

Choose the Menu entry a second time or press **2** (shift) and CLEAR together to leave this Mode.

```
ASTRA 19.2E        175.224  38.756  -12.41
Press ENTER to terminate STANDBY
```

6.8 Set az, el, pl by editing Numeric Parameters

To change a numeric parameter like Azimuth, Elevation or Polarization. Here an example for the azimuth axis: select SET AZIMUTH from the main menu.

```
ASTRA 19.2E        175.224  38.756  -12.41
MENU: SET AZIMUTH
```

The lower display line shows the actual value. You enter the new value, using the number keys. The arrow up key adds a (-) in front of the numeric value and the arrow down adds a (.). The key CLEAR clears the entered value.

```
ASTRA 19.2E        175.224  38.756  -12.41
SET AZIMUTH            175.224 ->
```

To accept the edited value, press ENTER . This checks the entered value against its limits and executes the parameter change. Pressing CLEAR twice (the first key press clears the display) leaves the editing mode without changing anything.

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?levl=?`

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

levl=-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:

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

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	-
acou		-180.000 .. 180.000	°	Antenna course
addr		A B C D E F G NONE	-	RS485 address
ahys		0.000 .. 2.000	°	AZ Pointing hysteresis
ainv		NORMAL INVERTED	-	AZ Sense invert
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
autr		DISABLED 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		SATNMS,VOLTAGE	-	Beacon RX type
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
coty		NONE	-	Compass type 2)
cpos	r/o	LINEAR CIRCULAR SWITCHING INVALID	-	Lin/Crc switch position
ctar		LINEAR CIRCULAR UNKNOWN	-	Linear / circular switch
decl		-90.000 .. 90.000	°	Antenna declination
dele		0 .. 99	-	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
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
goto		0 .. 99	-	Goto target
gper	r/o	#	-	GPS error status

gpsa	r/o	#	-	GPS satellites
gpty		NONE	-	GPS receiver type 3)
ibit		00000000 .. FFFFFFFF	-	Input bits (described below)
icty		NONE	-	Inclinometer type 4)
ipt1			-	SNMP trap IP 1
ipt2			-	SNMP trap IP 2
ipt3			-	SNMP trap IP 3
ipt4			-	SNMP trap IP 4
ivpr			-	Invalid parameter value
jtrh		0 .. 100	%	Peak jitter threshold
mdly		0 .. 9999	msec	Measurement delay
mstp		0 .. 1	-	1 stops all motors (STOP at the Web UI) 0 releases the stop (RESET at the Web UI)
nick	r/o	-90.0 .. 90.0	°	Nick angle
niko		-90.0 .. 90.0	°	Nick offset
note		character string	-	Note
obit		00000000 .. FFFFFFFF	-	Output 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
phys		0.000 .. 10.000	°	PO Pointing hysteresis
pinv		NORMAL INVERTED	-	PO Sense invert

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
praw	r/o	00000000 .. FFFFFFFF	-	PO raw pointing
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	°	Pol. target value
ptot		0 .. 32000	msec	PO Motor timeout
roll	r/o	-90.0 .. 90.0	°	Roll angle
rolo		-90.0 .. 90.0	°	Roll offset
save		0 .. 99	-	Save target
scnt	r/o	0 .. 65535	-	Save count
scon			-	SNMP system contact
slee	r/o	0 .. 65535	sec	Sleep time up to the next tracking action
sloc			-	SNMP system location
smth		0 .. 6	h	Smoothing interval
snam			-	SNMP system name
srno	r/o	character string	-	Device serial no
step		command	-	Step move 5)

stim		character string	-	Date / time 6)
sver	r/o	character string	-	Software version
tage	r/o	#.#	h	Tracking model age
tcyc		1 .. 1638	sec	Tracking cycle time
tdly		100 .. 9999	msec	Recovery delay
tdsc		0..99 / character string	-	Target description 7)
temp	r/o	#.#	°C	Temperature
tflt	r/o	00 .. FF	-	Tracking fault bits (described below)
thrs	r/o	#.#	h	Tracking memory
time	r/o	character string	-	Date / time 6)
tmod		OFF STEP ADAPTIVE MEMORY PROGRAM	-	Tracking mode 8)
tnam		character string	-	Target name
trst		1 .. 1	-	Reset tracking memory
trty		NEVER ONCE FOREVER	-	Tracking retry on fault
trty		NEVER ONCE FOREVER	-	Tracking retry on fault
tsta	r/o	character string	-	Tracking state
tstp		1 .. 100	%	Tracking step size
wdog		OFF ON	-	ON Sends a heatbeat to the AUX 8 output

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

2) ACU variants with compass support provide other choices beside NONE for this parameter. **3)** ACU variants with GPS support provide other choices beside NONE for this parameter. **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)** ACU variants without tracking support only accept NONE for this parameter.

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 '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.

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..8), 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 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	APEAKFLT	azimuth peaking fault
1	EPEAKFLT	elevation peaking fault
2	MODELFLT	model match fault
3	JITTRFLT	jitter fault
4	-/-	not used
5	-/-	not used
6	-/-	not used
7	-/-	not used

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 o f 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:

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

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

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

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&

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.

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.

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° |

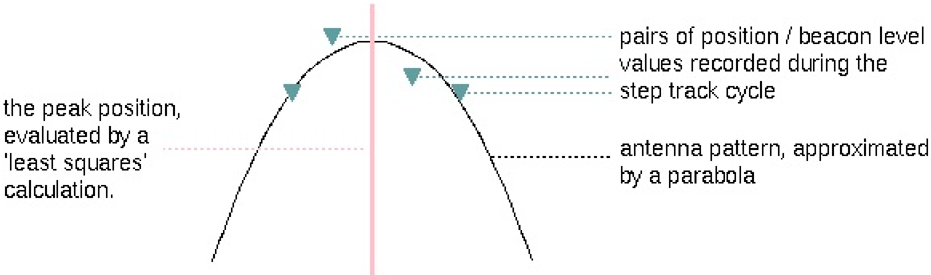
8.3 Steptrack

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

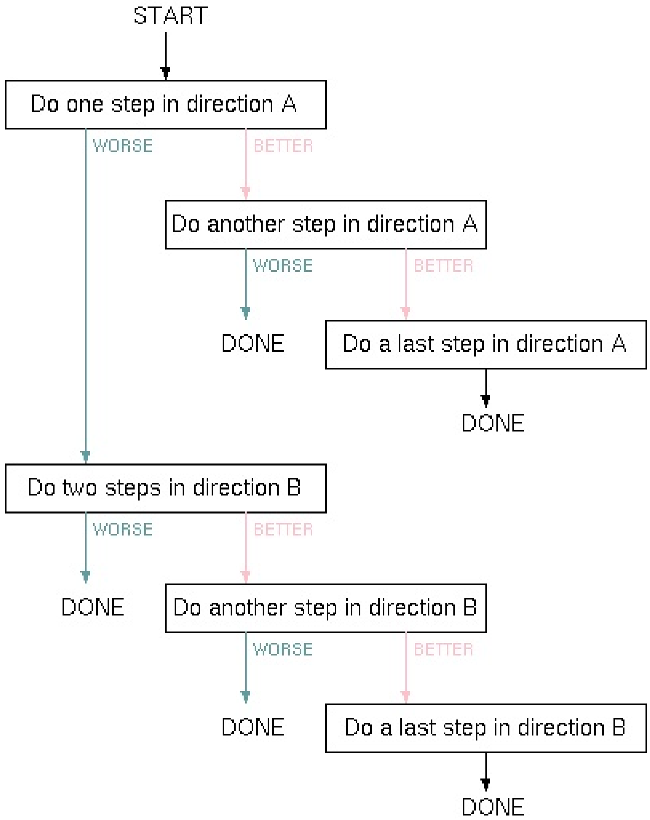
The principle of satellite step tracking is quite simple: For each axis, move the antenna a small amount away from the satellite, move it a small amount to the other site and finally point the antenna to that position where the signal is the strongest. The ***sat-nms*** ACU uses an optimized variant 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.



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.



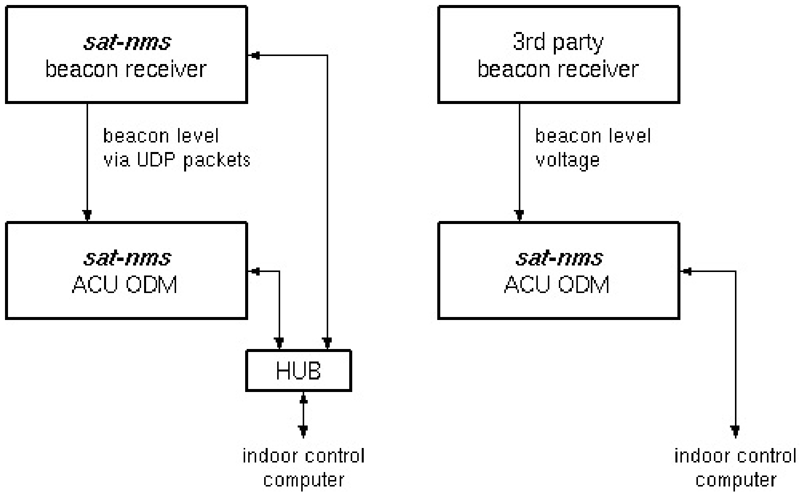
The diagram above shows the sequence of steps the tracking algorithm performs in one cycle on one axis. It starts with a depointing step in one direction (A). If this step lets the signal level decrease, the antenna makes a double step in the opposite direction. It the first step leads to a better receive 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 enought to rech the maximum within the 3dB bandwith within in the entered cycle time. This meas for an inclient 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.



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.

- **AZAntennadiameter ELAntennadiameter** --- 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.
- **BeaconRXtype** --- 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 SATNMS 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.

- **BeaconRXIPaddress** --- You need to enter the beacon receiver's IP address in 'dotted quad' notation here if the receiver tape is set to 'SATNMS'.
- **BeaconRXvoltagescale BeaconRX0Vlevel** --- 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.

- **BeaconRXfrequency** --- 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.

- **Trackingcycletime** --- 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).
- **Trackingstepsize** --- 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.
- **Trackingmode** --- The tracking mode parameter switches the steptrack on or off. With the operation modes 'STEP' and 'ADAPTIVE' the ACU performs steptrack.
- **Levelaveraging** --- 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.
- **Levelthreshold** --- 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.
- **Recoverydelay** --- 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.
- **Measurementdelay** --- 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.
- **Smoothinginterval** --- 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

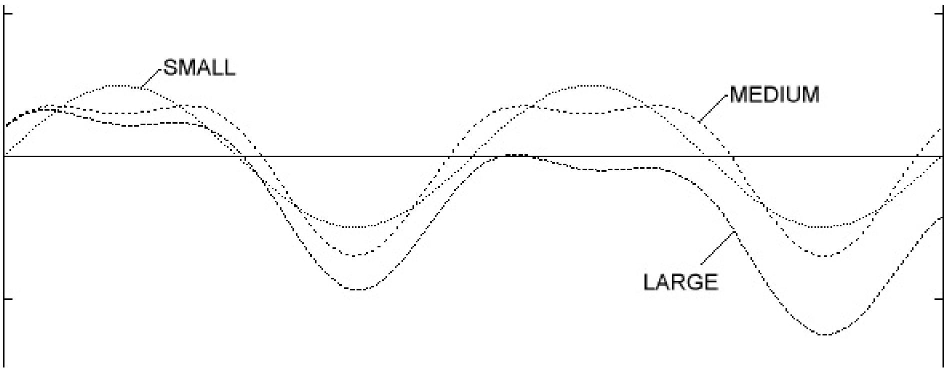
The motion of a geostationary satellite at the sky mainly is caused by an inclination of the satellite's orbit with respect to the earth's equatorial plane, sometimes also by the fact, that satellites decelerate in orbit. The motion seen from the antenna's point of view can be described as the sum of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



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.

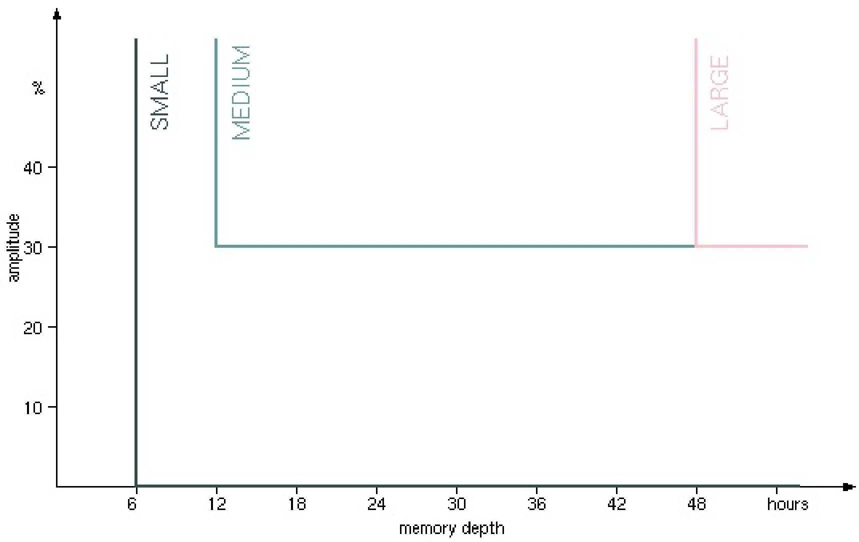
Unfortunately the SMALL model does not fit optimally for all satellites. The MEDIUM model superposes a second sine wave with the double frequency (two cycles for one sidereal day). The model matches very good for almost all stationary satellites. It however requires more and also more precisely measured 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.



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

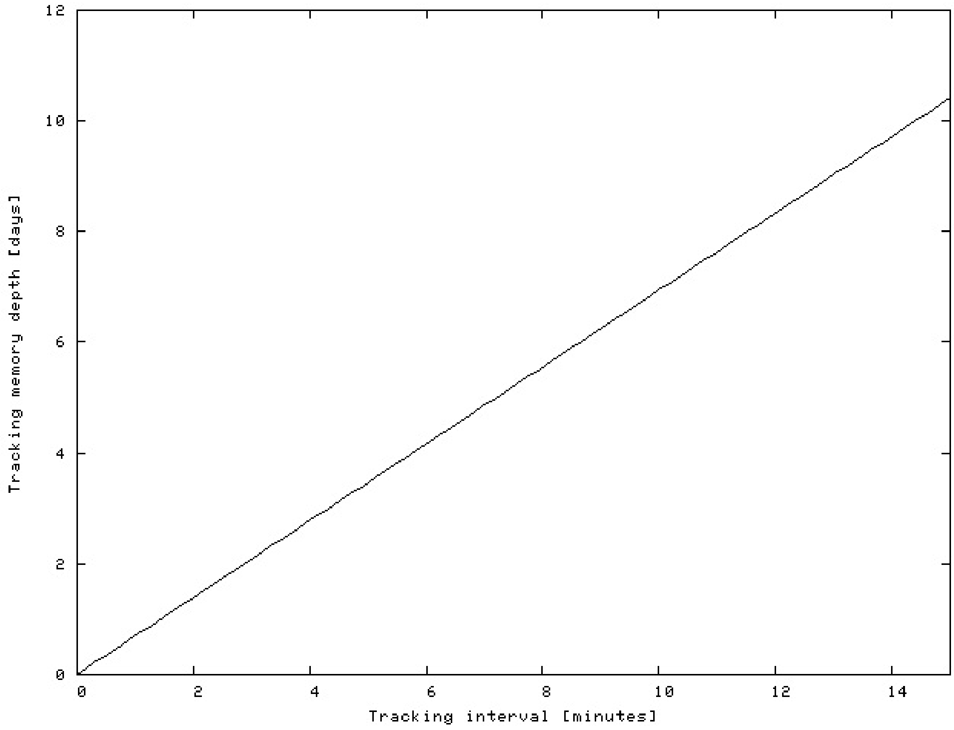
As mentioned above, the amplitude of the satellite's movement is used as a measure of the step track quality. This is because the step track measurement uncertainty is an constant angle which primarily depends on the antenna size.

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.



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 behaviour 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.

- **AZMaximummodeltype ELMaximummodeltype** --- 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.
- **Levelthreshold** --- 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)

- **Peakjitterthreshold** --- 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.

8.5 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 stampThe 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 (1970-01-0100:00:00) is 2440587.5
- 2 --- azimuth angleThe azimuth angle in degrees
- 3 --- elevation angleThe elevation angle in degrees
- 4 --- polarization angleThe polarization angle in degrees. This column is optional, no polarization pointing is commanded if this column is missing.

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 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 polarisation ('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 polarisation 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 --- Frequency inverter for AZ and EL, solid state relays for POL drive
- 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 UPS mains (core module) --- 230V AC, 1A
- Supply Voltage Mains (Motors) --- 380V three-phase alternating current, current depends of motor power.
- Temperature range Humidity --- -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 --- 600x240x800mm (width x depth x height including roof)
- Weight --- depending on frequency inverter type, approx. 50kg