SAT CONTROL®

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SIGMA - Solar tracker WEB server with LAN, RS485, DIN rail

User Manual

SAT CONTROL d.o.o., Pozenik 10, SI4207 CERKLJE SLOVENIA – EU
www.solar-motors.com / info@solar-motors.com

1. Introduction

Sigma is the main (master) controller for a tracker network in large-scale solar power plant applications. It directs and supervises the Nano and Pico positioners. The user can control the whole tracker network from an integrated web page server.

1.1 Features

- 24V operation
- Up to 64 slaves (single port or both ports together)
- 2 actuators/slew drives supported per positioner
- 7 operating modes
- 2 coordinate systems (azimuth/elevation, polar mount)
- 3 tracker geometry models
- Up to 10 positioner power-supply lines supported
- Up to 8 channels for actuator/slew drive position control
- Actuator/slew drive license import/export
- HTTP web server
- SMTP mail client
- SNTPv4 client
- Telnet server (console)
- Local weather station (transmitter/receiver)
- Remote firmware upgrade (Sigma and positioners)
- Log file generation
- 2GB SD card support
- 2 x RS485 (Modbus) port
- 1 x Ethernet(LAN) interface
- 3 x open collector output (report status)
- 3 x analog input (multiple input function options)
    - Wind sensor (analog, digital)
    - Radiation sensor
    - Temperature sensor
    - 3 mode options
    - Emergency mode switch
    - Wind mode switch
    - Snow mode switch

2. Before you start

Thank you for buying the Sigma solar server. Before you power up Sigma, you should check that all of the wiring is done correctly and the power-supply voltage is adequate. There should also be a memory card in the SD card slot on the bottom side of Sigma otherwise updating positioners, saving settings, saving positioner configuration as well as saving tab and log reporting won't work.

3. Wiring

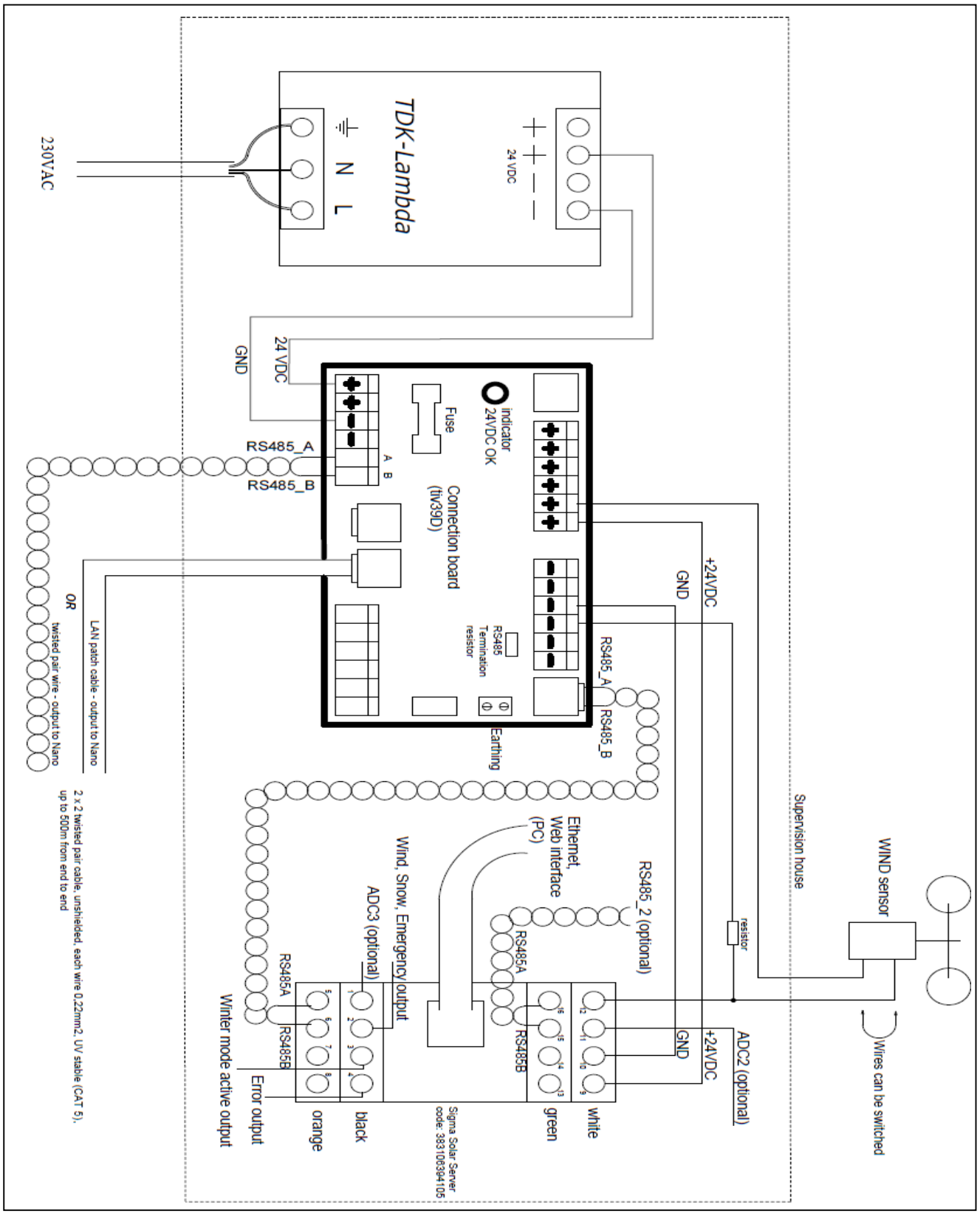

Fig 1. Wiring diagram

3.1 Sigma recommendations

- 24V power supply
- Power supply must be SMPS type (switching mode power supply), 1A capacity
- Galvanically isolated power supply (from the positioner or any other power supply)
- Sigma and positioner power supplies must have the minus terminals connected
- Overvoltage/overcurrent transient protection
- Each Sigma must be galvanically isolated from any other Sigma or power plant (any power or ground cross-connection between power plants is not recommended)
- All input/output power must come from the Sigma power supply

3.2 RS485 recommendations

- 0.22–0.5 mm2 for runs up to 300 meters
- 0.5–0.75 mm2 for runs up to 1200 meters
- 0.75–1.5 mm2 for runs longer than 1200 meters
- Shielded twisted-pair cable
- Cable shield connected to the minus terminal at the first positioner over a 100 ohm resistor
- Run Modbus cable away from high voltage lines and in a separate conduit
- Overvoltage/overcurrent transient protection
- Minus terminal must not contact tracker metal parts (only at the first positioner over a 1kohm 50W resistor)

3.3 Positioner recommendations

- 24V power supply
- Max 0.125ohm power line resistance per line
- Power supply for Pico, ePico and Nano must be the SMPS type (switching mode power supply), 5A capacity per positioner
- Max. 10 positioners per SMPS, 5 positioners per SMPS are recommended, the best is 1 positioner per SMPS
- The last positioner on the line must have a termination resistor (360 ohm)

3.4 Optional inputs

ADC [1…3] are optional inputs working at voltages from 0V to 30V. ADC1 is used for a wind sensor. ADC [2…3] provide additional functionality (**see 6.7 System tab**). If an ADC input is used as a switch, voltages higher than, or equal to, 11V are detected as logic '1'.

OC [1...3] are open-collector status outputs which can tolerate 30V and sink max 50mA.

OC1 goes active when positioners (slaves) report errors.

OC2 outputs a frequency of 2Hz when Sigma enters WINTER mode.

OC3 outputs a frequency of 2Hz when Sigma enters WIND, SNOW, or EMERGENCY mode.

RS485_2 is an optional positioner communication port which works in parallel with the primary RS485 port (**see 6.7 System tab**).

4. Sigma configuration

When you first power up Sigma, the settings are set to factory defaults (Automatic Tracking is disabled).

Before enabling automatic tracking, these steps must be taken:

1. Set GMT time and NTP (optional) (**see 6.7 System tab**).
2. Set the power plant longitude and latitude (**see 6.7 Controller tab**).
3. Set the moving interval to a desired value (**see 6.4 Controller tab**).
4. Set power supply line settings (**see 6.4 Controller tab**). Each power supply line represents one physical power supply powering the positioners.
5. Configure "Installer parameters and tracking geometry" (**see 6.4 Controller tab**) with parameters that match your tracker(s).
6. Connect and configure all positioners on Modbus port(s) (**see 6.5 Trackers tab**).
7. Set the positioner "Power supply line" and "Channel" (**see 6.5 Trackers tab**).
8. Allow 1 minute for Sigma to enable positioner actuators/slew drives.
9. Enable automatic tracking for all positioners by clicking the "Enable all" button (**see 6.5 Trackers tab**).
10. Immediately after enabling automatic tracking click on "Go Home all" so that positioners initialize position sensing (**see 6.5 Trackers tab**).
11. After all positioners finish homing, put them in a table-like position by forcing them into wind mode (**see 6.3.11 Mode Buttons**) and level them mechanically.
12. Put "wind mode" to normal mode (**see 6.3.11 Mode Buttons**). Automatic tracking is now working.

4.1 Changing a positioner

When changing or connecting (a) new positioner(s) to Sigma or when tracker construction is changed, automatic tracking for that positioner should be disabled, and the positioner should be sent to the home position by selecting its ID and clicking on "Home A" and "Home B".

If Sigma does automatic tracking, commands may not be accepted if the active current limit is exceeded for the positioner power supply line.

When homing is done, automatic tracking can be enabled for a specific positioner by selecting the positioner ID and clicking the "Tracking Enable/Disable" button.

5. Connecting Sigma to PC via LAN

You can attach sigma directly to your network card or via network router/switch.

When connecting directly to PC network card you have to manually set IP settings:

- Open Network Connections by clicking the Start button, and then clicking Control Panel. In the search box, type adapter, and then, under Network and Sharing Center, click View network connections.
- Right-click the connection that you want to change, and then click Properties. If you're prompted for an administrator password or confirmation, type the password or provide confirmation.
- Click the Networking tab. Under This connection uses the following items, click Internet Protocol Version 4 (TCP/IPv4) and then click Properties.
- Click on Use following IP address and type in IP address 192.168.3.100 and Subnet mask 255.255.255.0

When connecting sigma to network router Sigma's IP should be in the same network group as router not used by any other network device and Sigma's gateway set to Router IP. (Example: Router's IP=192.168.1.1; Sigma's IP= 192.168.1.100; Sigma's gateway=192.168.1.1)

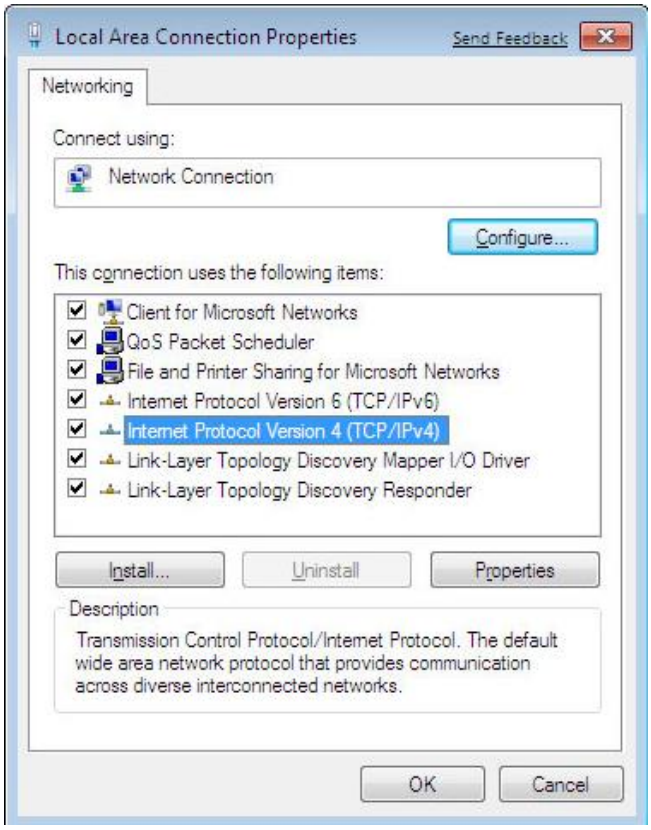

Fig 1.a network

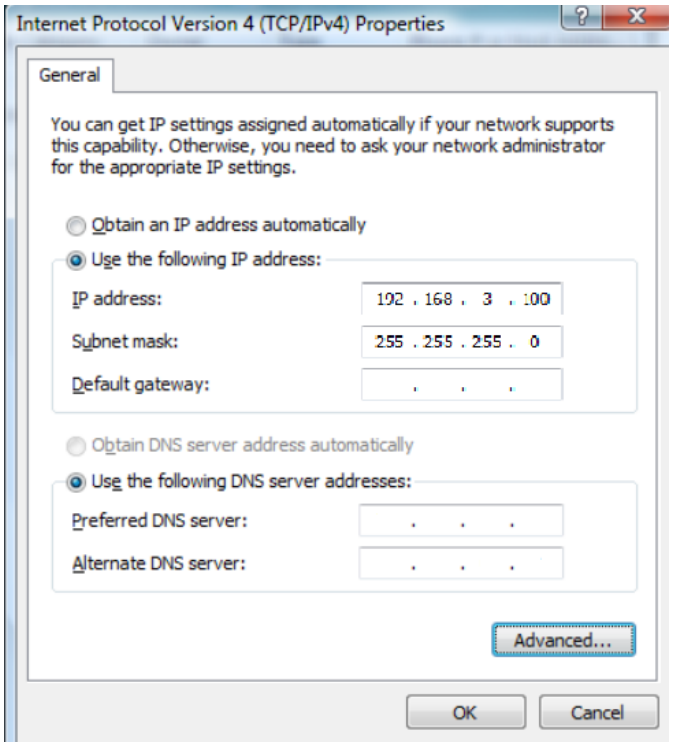

Fig 1.b IP settings

6. Network (LAN) Settings

Network settings are saved on SD Card in the "system.ini" file (**see Fig 2. for default settings**), and backed up on internal storage. The settings can only be changed by disconnecting SD Card from Sigma and editing the "system.ini" file from a PC with a text editing program.

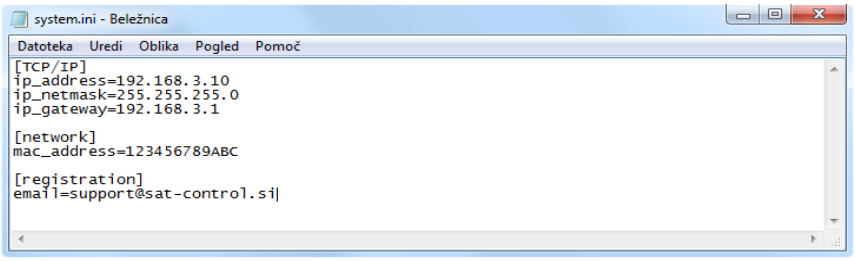

Fig 2. system.ini

7. Web interface

The Sigma server uses standard HTTP protocol on port 80. You can access the web interface with Internet Explorer (Firefox or Google Chrome) by entering Sigma's IP directly in the navigation bar (**see Fig 3.**).

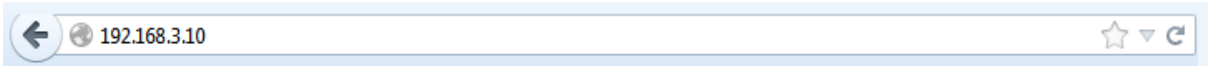

Fig 3. Navigation bar

7.1 No login access

Sigma offers some no login functions by entering a path to the navigation bar (example: "192.168.3.10/log.txt").

- Log files can be accessed (**see 8. Log files**)
- Firmware upgrade files can be accessed ("xxx.ini" and "xxx.bin")
- Two special monitoring commands are available "/monitor_params" and /trackers_params"

7.2 /Monitor_params

Monitor_params outputs a string of parameters separated with ";" displayed on "Monitoring tab"

Format:

1.Hour:Min:Sec

2.Day.Month.Year

3.Sigma's voltage

4.Sum of currents

5.Wind speed

6.Radiation

7.Temperature

8.Azimuth

9.Elevation

10. PM hour angle
11. PM elevation angle
12. Trackers status

Example: "09:10:46;27.09.2013;22.6;0.000;0.0;0;0;-48;30;-40;41;TRACKING OK"

7.3 /Trackers_params

Trackers_params outputs a string of tracker dynamic parameters. Parameters are separated with ";"

If a positioner is not connected, its parameters are "-;-;-;-;-;-;"

Format:

1. X positioner data are the following
2. Positioner data [repeated X times]
    a. Positioner voltage
    b. Positioner current
    c. Position actuator/slew drive A
    d. Position actuator/slew drive B
    e. Positioner status
    f. Extended positioner settings

```
Example: 1;22.4;0.000;0.0;96.7;1073742080;0;22.5;0.000;-3017.3;inf;1073742592;0;
```

7.4 Login (index page)

When connecting with Sigma, the first page that you will get is the login page. To go any further you need to enter a username (default:"admin") and password (default : "admin"), which are stored on SD Card in the "accounts.ini" file (**see Fig 4.**) and backed up on internal storage. The settings have two groups: ("[admin]" and "[user]") with different access rights. The settings can only be changed by disconnecting SD Card from Sigma, and editing this file from a PC with a text editing program.

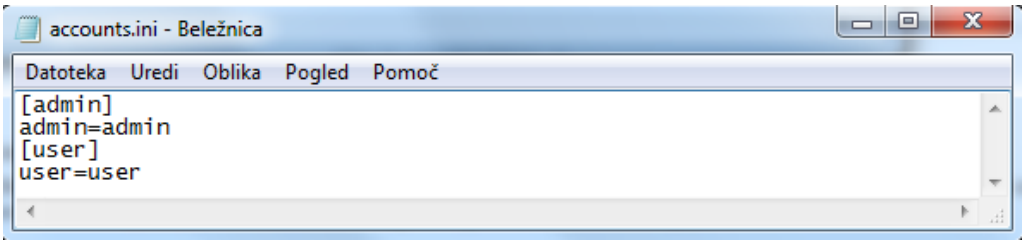

Fig 4. accounts.ini

7.5 Monitoring tab

In the Monitoring tab you have a quick overview of the system variables, system status and connected positioners. You can also change the trackers' operating mode from this tab.

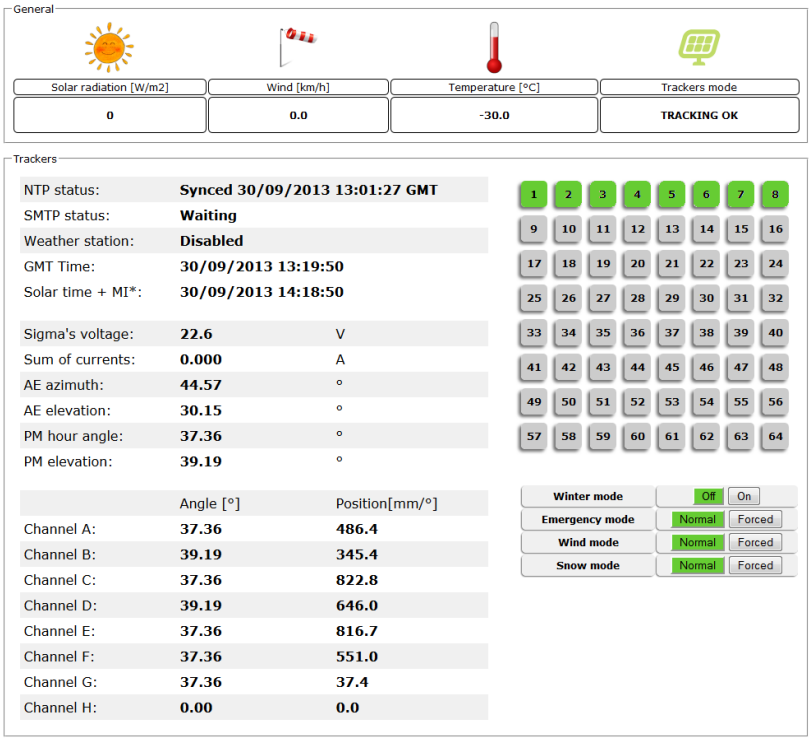

Fig 5. Monitoring tab

7.6 Sensor readings

There are three sensor readings (solar radiation, temperature, and wind) that come from the ADC inputs or from a remote weather station (see the Weather tab).

7.7 Trackers mode (automatic tracking must be enabled)

Sigma has 7 operating modes, which are arranged by priority (highest first):

- **Resistance measurement mode (measures every positioner power line resistance)**
- **Emergency mode (can be any position)**
- **Wind mode (should be a table-like position)**
- **Snow mode (should be a steep angle)**
- **Homing mode (does homing of all positioner actuators/slew drives)**
- **Night mode**
- **Tracking mode (winter sub mode)**

7.8 NTP status

This status shows if the time is synchronized with the NTP server, and when it was last synchronized.

7.9 Weather station

The status of local weather station mode (disabled, receiving and broadcasting).

7.10 GMT time

GMT time, which runs in the local RTC (real-time clock).

7.11 Solar time + MI*

This is GMT time, which has longitude time and one moving time interval added.

7.12 Sigma voltage

The voltage of Sigma's power supply.

7.13 Sum of currents

The sum of all currents flowing through positioners (slaves).

7.14 AE/PM angles

Current angles calculated from the solar time.

7.15 Channel A-F angle/position

The current calculated angle and physical position of a channel.

7.16 Forced mode buttons

You can force Sigma into emergency mode, wind mode, snow mode.
If more than one mode is forced, the one with the highest priority will take place.

7.17 Winter mode

Winter sub mode is used to limit the motor range in winter time.
"Winter Min/Max range" (**see 6.4 Controller**) is used instead of "Motor min/max range" to limit the motor range.
Homing mode is disabled in winter mode.

7.18 Controller

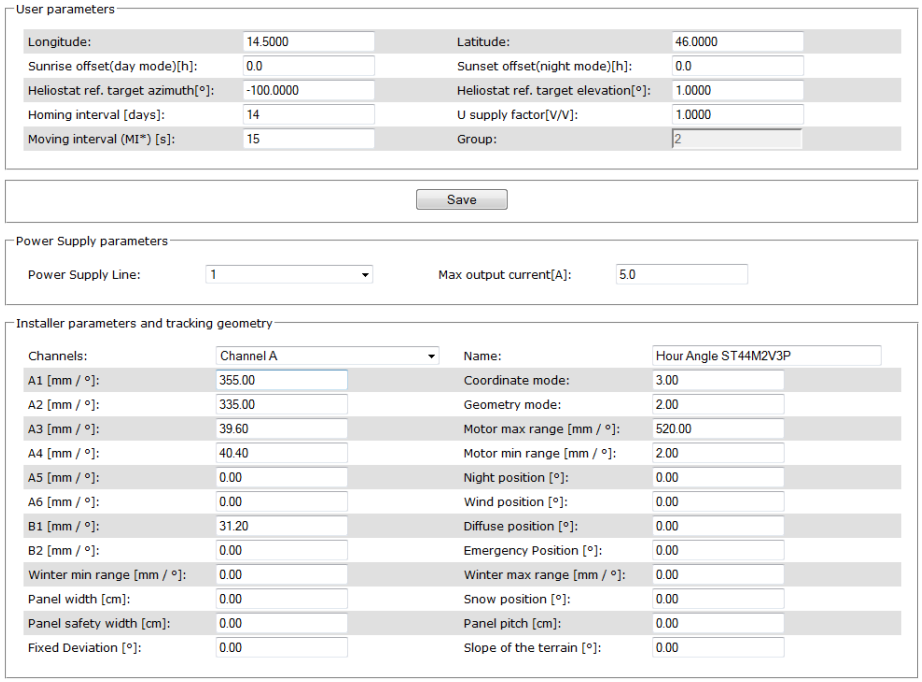

Fig 6. Controller tab

7.19 Longitude/Latitude

These parameters must be set or tracking won't work correctly.

7.20 Sunrise(day mode)/sunset(night mode) offset

Optional offset parameter to alter when sigma starts/stops tracking.

7.21 Heliostat ref. target azimuth/elevation

Target which will be shown in monitoring tab, for channels that have selected coordinate modes 5 or 6.

7.22 Homing interval

On how many days Sigma is put into HOMING mode.

7.23 U supply factor(V/V)

This parameter must be set correctly (default 1), or a reading on the Monitoring tab " Sigma's voltage" will be wrong.

7.24 Moving interval

It tells you how often the positioners (slaves) will be moved to a new position.

7.25 Power supply parameters

There are 10 slave supply lines available. At least one must be set according to the positioner power supply current rating, or the positioners won't move.

7.26 Coordinate mode

Valid values are:

- **1**: AE azimuth
- **2**: AE elevation
- **3**: PM hour angle
- **4**: PM elevation
- **5**: PM hour angle for use with heliostat
- **6**: PM elevation angle for use with heliostat
- **7:** AE azimuth angle for use with heliostat
- **8:** AE elevation for use with heliostat
- **11**: Azimuth or elevation single axis tracking (**see Fig 10.**). For this mode you should also set a fixed deviation and the slope of terrain, and optionally the panel width, panel pitch and panel safety width for backtracking.

7.27 Geometry mode

Valid values are:

- **1**: Slew drive (**see Fig 7**.)
- **11**: Slew drive elevation (**coordinate mode 11 only**)
- **2**: Hour actuator (**see Fig 8**.)
- **3**: Elevation actuator (**see Fig 9**.)
- **13**: Elevation actuator (**coordinate mode 11 only**)

7.28 Motor min/max range (not used when winter mode is active)

Limit for a channel position output.

7.29 Winter min/max range (only used when winter mode is active)

Limit for a channel position output.

7.30 Night, winter, emergency, snow, diffuse mode position

Position for a specific mode.

This position can be disabled for every channel by typing "off" or value greater or equal "10000".

7.31 A1...A6,B1...2

Geometry mode variables (**see 6.4.8 Geometry mode**).

7.32 Panel width/pitch

Panel width and panel pitch are used for backtracking (anti shadowing) calculation.

Both parameters must be set to enable backtracking.

7.33 Panel safety width

This is added to the panel width to take into account the panel thickness and other corrections.

7.34 Fixed deviation (used only by coordinate mode 11)

Rotation of a tracker parallel to the surface from south to west (**see Fig 10. Beta angle**)

Example: (S-N = 0°, W-E = 90°) if for example tracker is slightly turned to west 15 degrees then deviation is -15

7.35 Slope of terrain(used only by coordinate mode 11)

Rotation perpendicular to the surface (**see Fig 10. Alpha angle**)

7.36 Coordinate mode, geometry mode configuration options

Coordinate m.	1	2	3	4	5	6	7	8	11	
Geometry m.										
1	X	X					X	X	X	Slew drive azimuth, elevation tracking(coordinate 11 azimuth only [deviation=0°])
2	X		X		X		X		X	Azimuth tracking or Hour angle tracking (if coordinate 11 deviation=0°)
3		X		X		X		X		Elevation tracking
11									X	Slew drive Elevation tracking (deviation = 90°)
13									X	Elevation tracking (deviation = 90°)

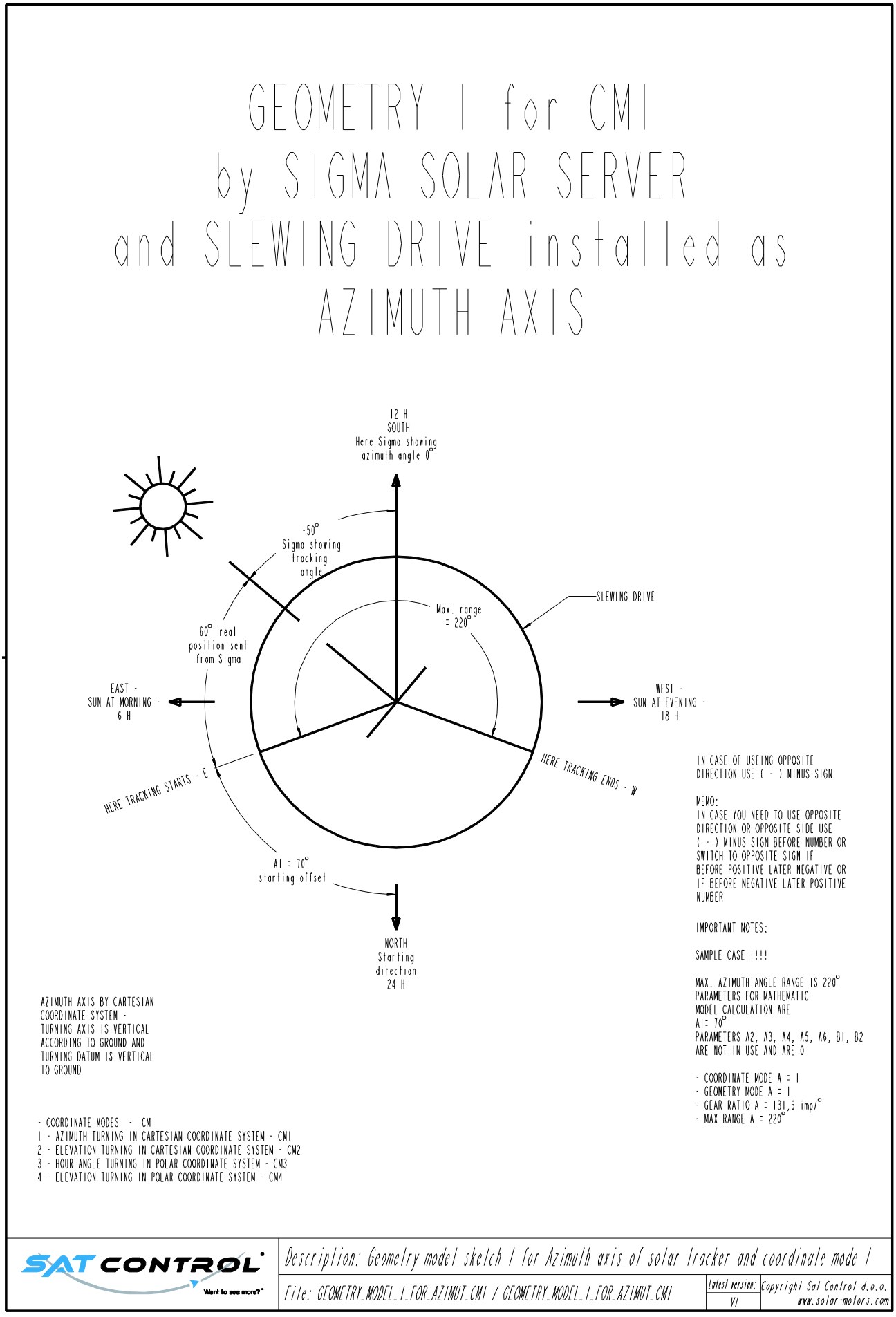

Fig 7. Geometry 1 for AZIMUTH axis

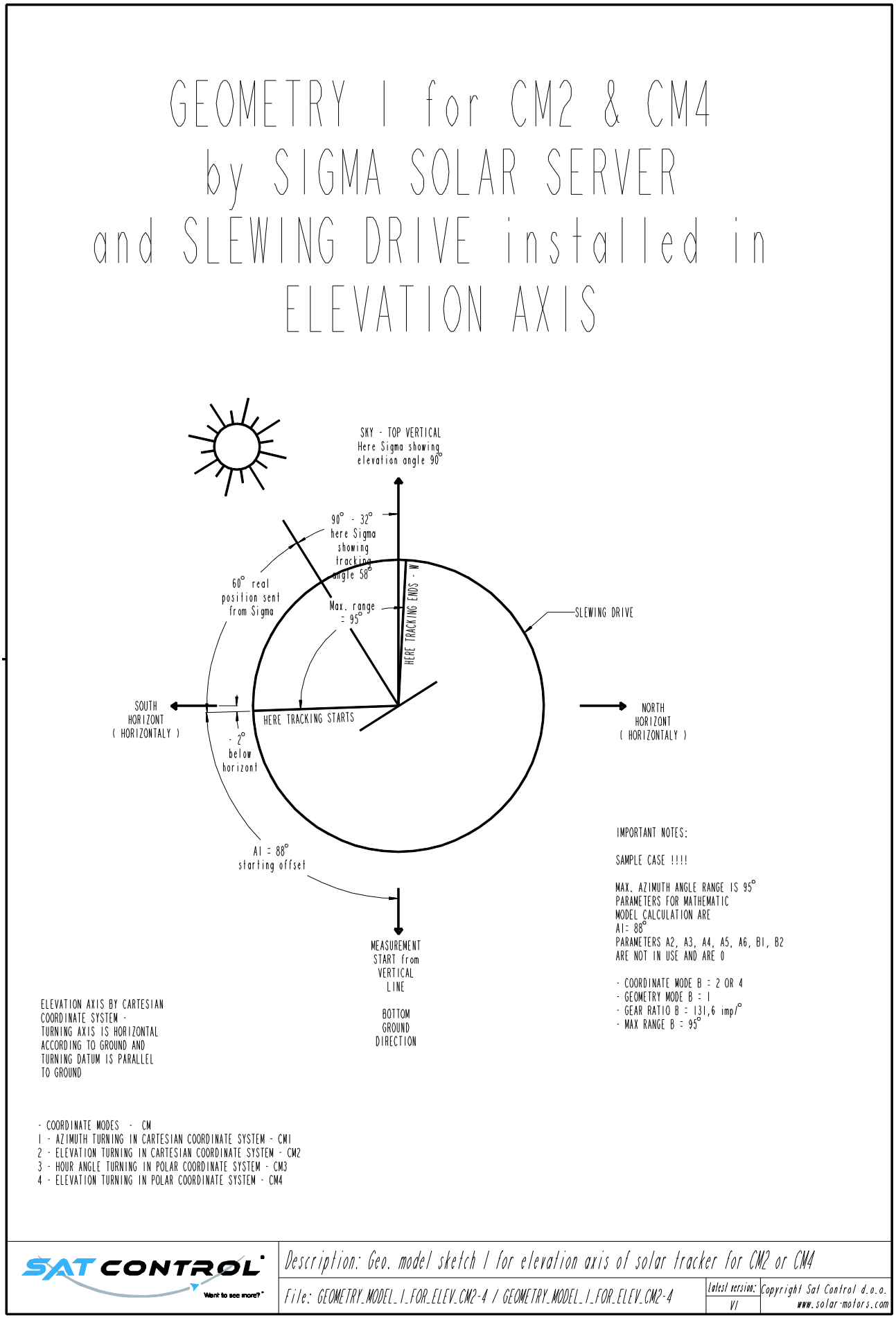

Fig 7a. Geometry 1 for ELEVATION axis

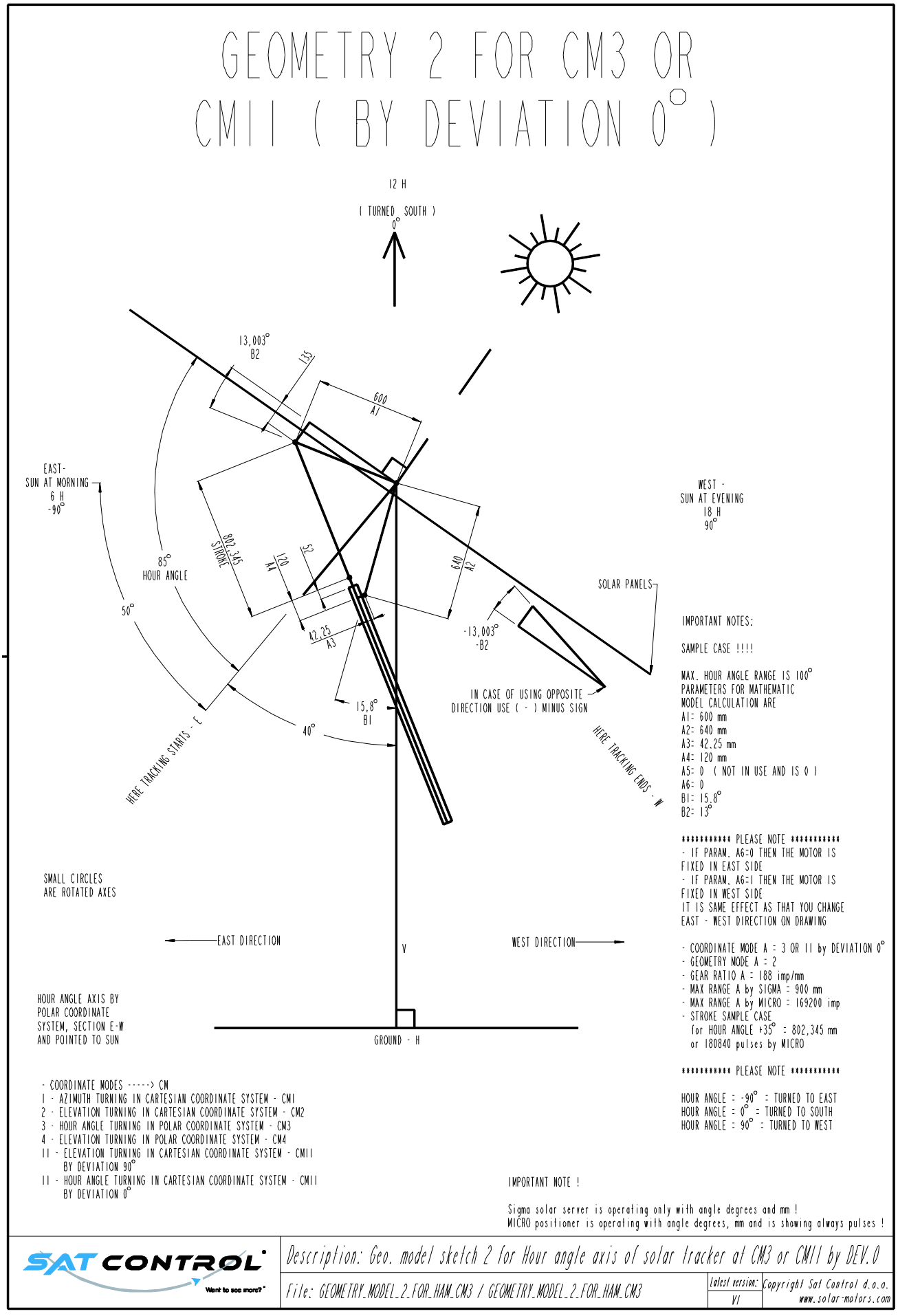

Fig 8. Geometry 2 for Hour angle axis

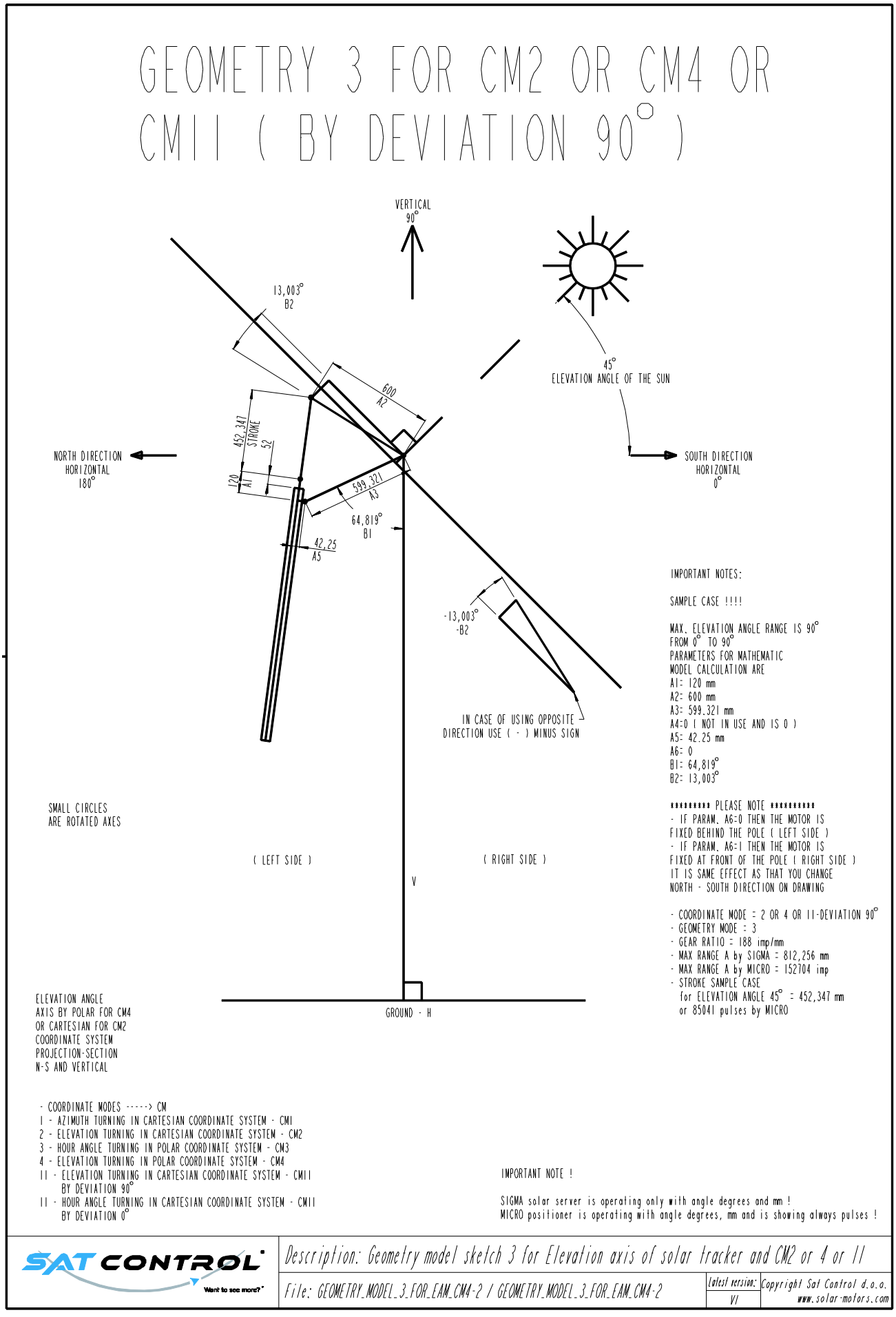

Fig 9.a Geometry 3 for Elevation angle axis

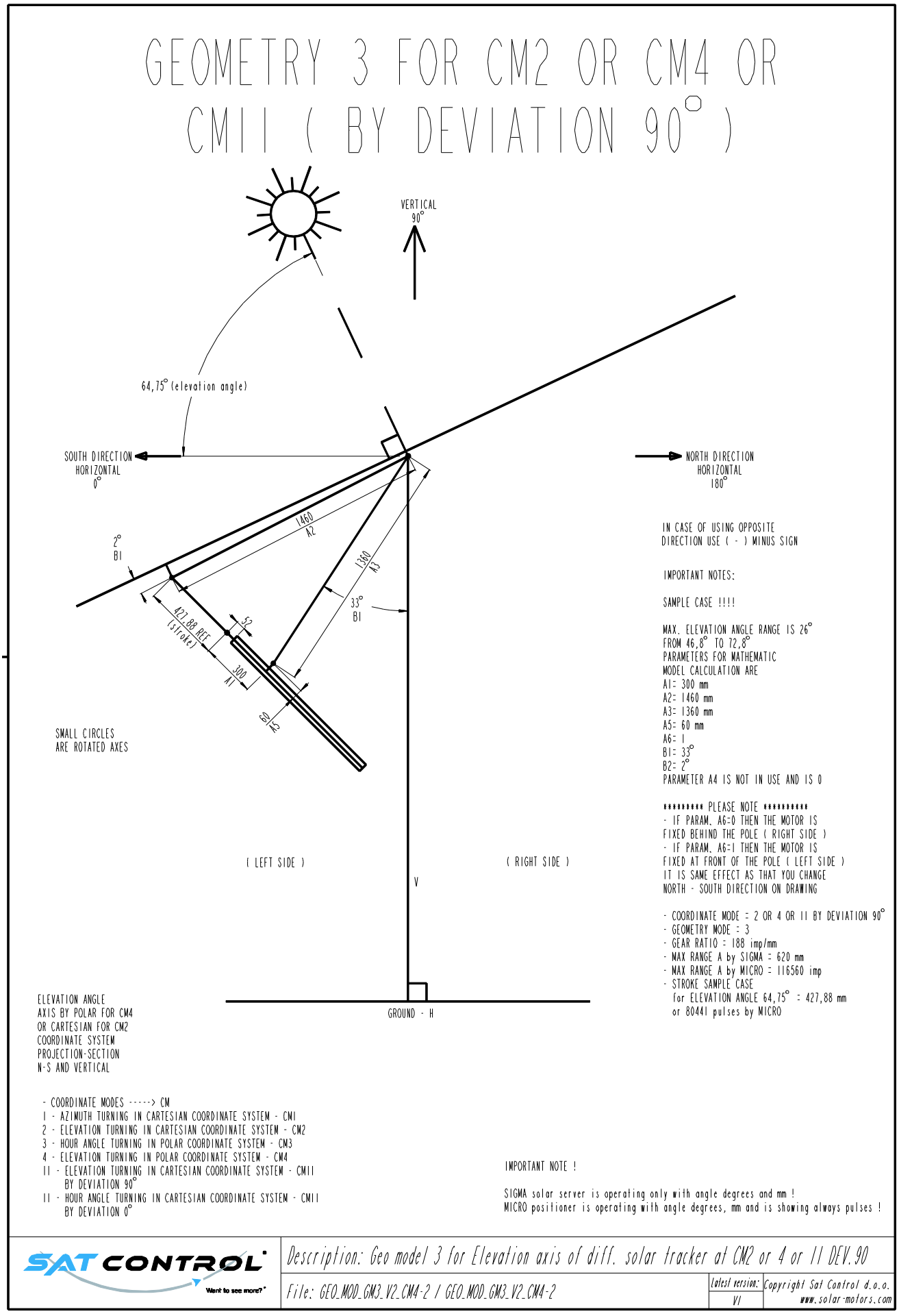

Fig 10 Geometry 3 for different type of solar tracker

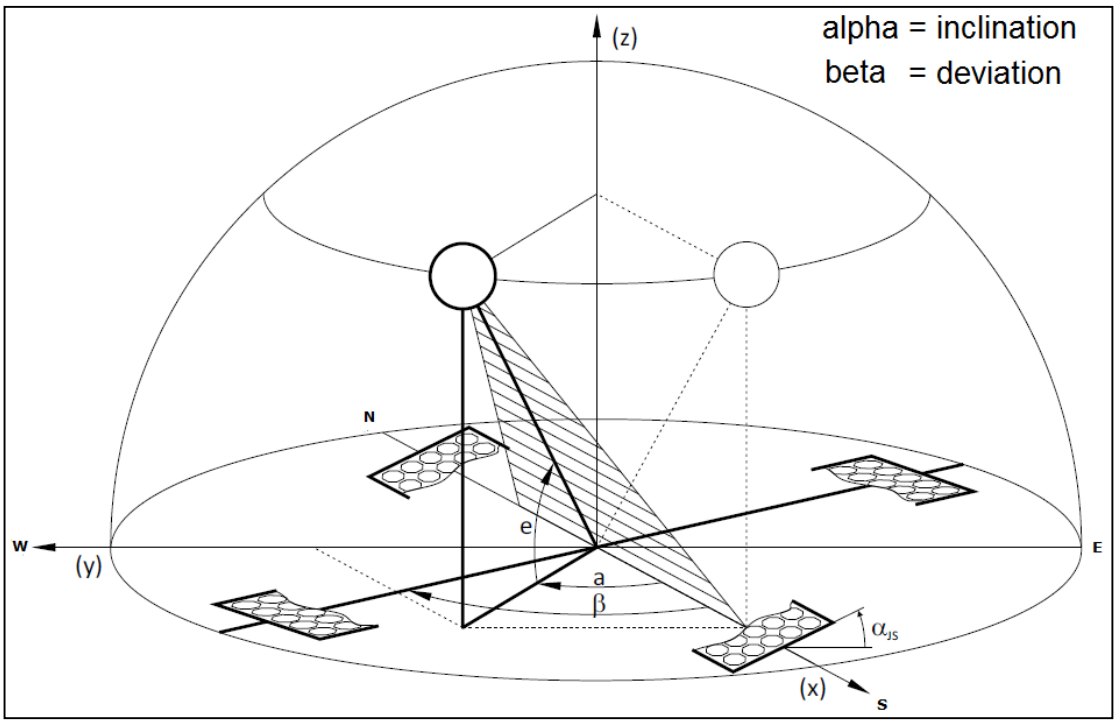

Fig 11. Coordinate mode 11

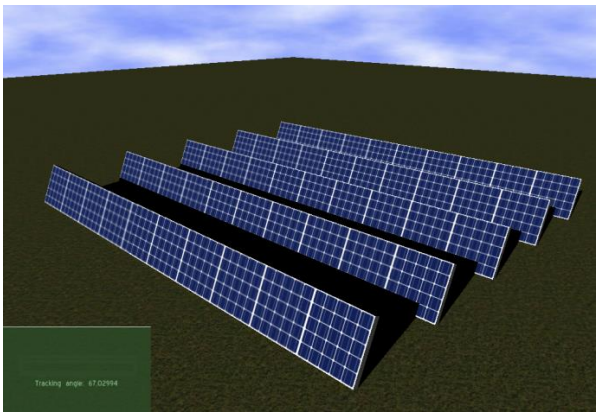

Fig 12. Normal tracking

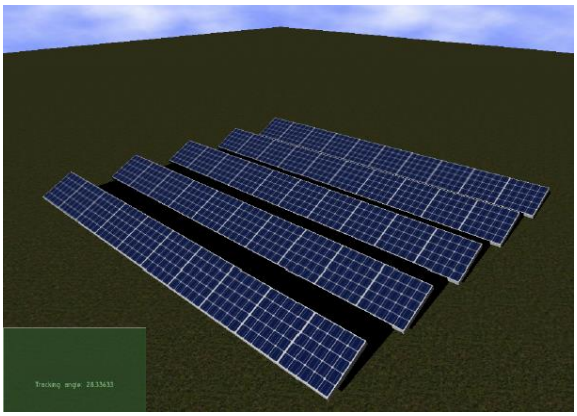

Fig 13. Backtracking

7.37 Trackers tab

This tab is used for positioner (slave) configuration, monitoring and manual control.

7.38 Monitoring positioners

Sigma can have 64 positioners (slaves). Each positioner has its own monitoring line which is sorted in ascending order by the ID number, which is also the Modbus device address.

ID: Version: Force Show remaining counter Clear status range Enable all Disable all

ID	bVer	Ver	Line	U [V]	I [A]	MA Rem.[mm]	MA Pos.[mm]	MA Dest.[mm]	MA Ch.	MB Rem.[mm]	MB Pos.[mm]	MB Dest.[mm]	MB Ch.	Wait [s]	S	M	H	T
01	1.002	3.033	1	22.4	0.000	0.0	0.0	0.0	A	358.2	96.7	96.7	0	0	1			
02	1.002	2.478	1	23.8	0.000	0.0	2.0	2.0	C	na	na	na	0	52	2			
03	1.002	2.478	1	23.8	0.000	0.0	2.0	2.0	C	na	na	na	0	53	3			
04	1.002	2.478	1	23.7	0.000	0.0	2.0	2.0	C	na	na	na	0	53	4			
05	-	-	1	-	-	-	-	-	0	-	-	-	0	5	5			

Fig 14. Monitoring positioners

- **ID**: Modbus device address
- **bVer**: Bootloader version
- **Ver**: Software version
- **Line**: Selected power line (0=disabled)
- **U[V]**: Device voltage measured
- **I[A]**: Device current consumption
- **Mx Rem.[mm]**: Last position when in homing mode, and the end switch was pressed
- **Mx Pos.[mm]**: Current motor position
- **Mx Dest[mm]**: Current destination set point
- **Mx Ch.**: Actuator/slew drive channel (0=disabled, motor will not move)
- **Wait[s]**: When "0" device is waiting to be contacted (or will not be if there is an error condition, or the channel and power line are not set)
- **S**: Status of a positioner. Click to see active status (**see 6.5.2, 6.5.3, 6.5.4**)
    - Gray colour : NO RESPONSE
    - Green colour : OK
    - Orange colour : WARNING
    - Red colour : ERROR (indicated actuator or slew drive will not move)
- **M**: Actuator/slew drive moving flag (green colour)
- **H**: Actuator/slew drive is doing homing (green colour)
- **T**: Automatic tracking enable (green colour)

7.39 Positioner status – OK

- **Power failure:** Positioner has come out of reset
- **Some button was pressed**: Someone has pressed buttons on the positioner
- **MODBUS timeout**: Positioner did not receive commands from Sigma for "**Modbus timeout**"(**see 6.5.6 Positioner parameters**)
- **Motor X is moving out**: Actuator/slew drive is moving outwards
- **Motor X is moving in**: Actuator/slew drive is moving inwards
- **Motor X is homing**: Actuator/slew drive is initializing position sensing
- **End switch pressed X – LO**: Actuator/slew drive lower end switch is pressed (position = 0mm)
- **End switch pressed X – HI**: Actuator/slew drive upper end switch is pressed (position = max range of the actuator/slew drive)
- **Measuring Line Resistance**: Positioner is executing power line resistance measurement with one enabled motor

7.40 Positioner status - warnings

- **Locked**: Sigma has locked the positioner because the actuator/slew drive license timer has expired (**contact Sat-Control d.d.**)
- **Undervoltage**: Positioner voltage was under 20V
- **Overvoltage**: Positioner voltage was over 32V

- **Button Stuck**: Button was pressed for more than 10 minutes. There is a mechanical problem with one of the positioner buttons
- **To low voltage!(motor cannot run)**: Positioner voltage was under 20V when Sigma tried to move the actuator/slew drive
- **Motor cut off**: Voltage dropped under 17V when the motor was running (motor was stopped)
- **Motor A Hall losing impulses**: Counter of the first hall sensor is different from the counter of the second hall sensor
- **Motor B Hall losing impulses**: Counter of first hall sensor is different from the counter of the second hall sensor
- **Flash save error**: Positioner was unable to save variables. Variables are loaded from backup or corrupted (automatic homing is triggered when the move command is received)

7.41 Positioner status - Errors

- **Current limit exceeded in motor X**: Positioner has exceeded current limit (**see 6.5.6 Positioner parameters**)
- **No hall signal in motor X**: One or both halls not detected
- **Error on the cable in motor X**: There is no hall sensor and no current(**see 6.5.6 Detection current Mx**) detected
- **Homing timeout in motor X**: Motor was doing homing too long (**see 6.5.6 Homing timeout**)
- **End switch X failure(check motor cable)**: Motor position was higher than "**End switch error detect Mx**" (**see 6.5.6 Positioner parameters**), and the end switch was still pressed
- **Line resistance too high**: Measured resistance was higher than "Max power line resistance" (**see 6.5.6 Positioner parameters**)

7.42 Positioner configuration

For a positioner to function properly some basic parameters must be set.

First you should select a positioner connected to an RS485 port by entering its Device ID (0 = broadcast address), and click on the Send button so that "Tracker parameters" fields are filed with the selected positioner data.
Each actuator/slew drive or slew drive has its own settings that you must configure. You can enter the values manually, or select a configuration profile from "Load Configuration Mx". Just select your actuator/slew drive or slew drive type, click "load", and parameters will be loaded automatically.

A range of devices can be configured with data from a selected positioner by entering a range (example: "1-5 2") into "Configure range of IDs Mx" and clicking on the Send button. When the page refreshes, the command is completed.

You can save positioner settings ("Save ID defaults" and "Save ID defaults all") on SD Card. When the positioner is changed, Sigma detects a serial number change and loads the settings from SD Card automatically.

In order to move actuator/slew drive or slew drive "Power supply line", its limitation, (**see 6.4 Controller tab**) channel and positioner settings must be set.

7.43 Positioner parameters

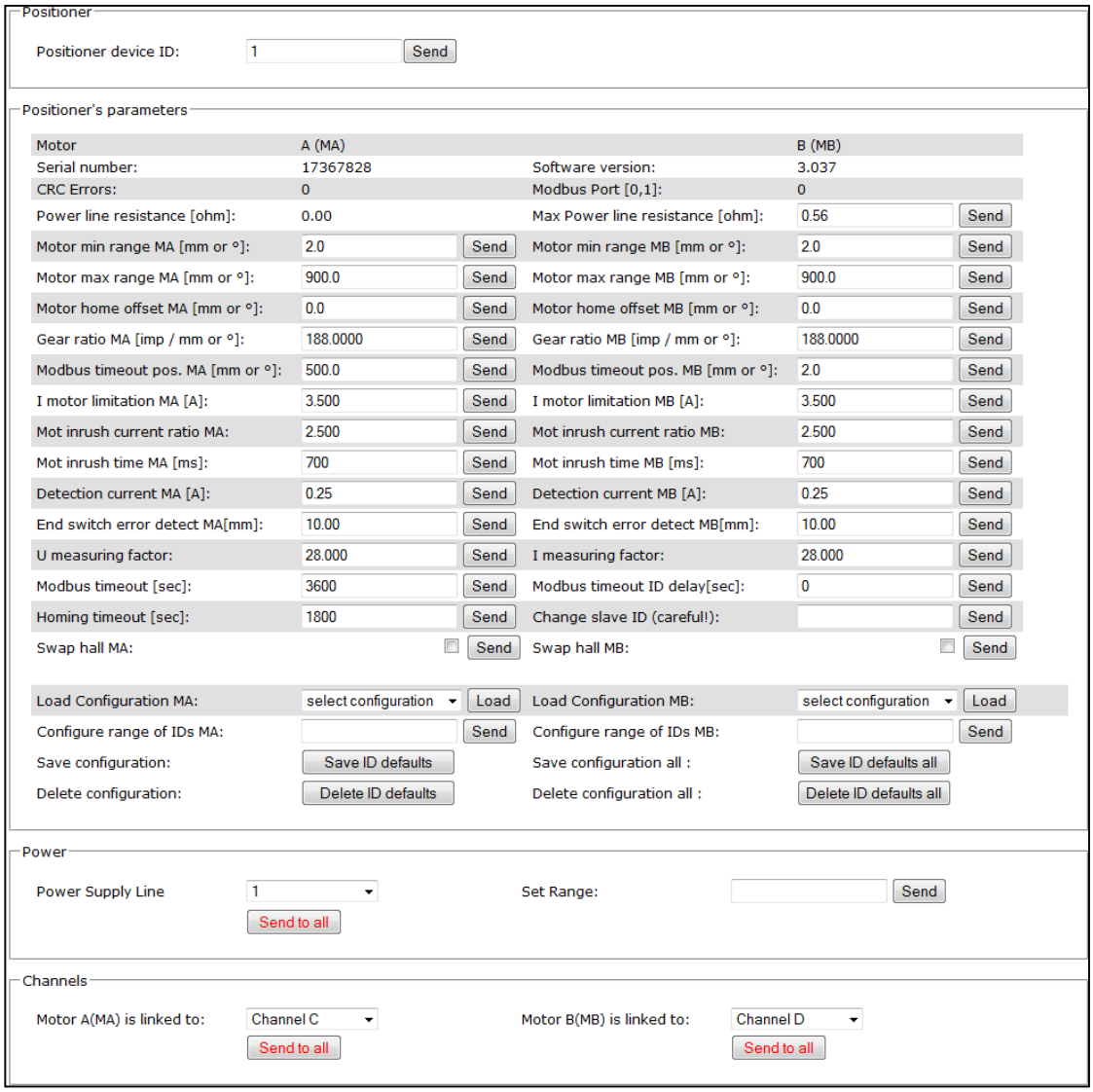

Fig14. Positioner configuration

- **Motor**: Positioner/slew drive motor
- **Serial number**: Unique positioner serial number
- **CRC Errors**: Number of detected CRC errors for a selected positioner
- **Software version**: Positioner software version (2xxx = Pico, 3xxx = Nano, 4xxx = ePico)
- **Modbus Port**: Indicates on which bus a positioner was detected (primary port is set under "system tab")
- **Power line resistance**: When the measured power line resistance exceeds this value, the positioner enters an error state (will not move)
- **Motor min/max range Mx**: Physical limits of a motor
- **Motor home offset**: Correction for tracker angular position
- **Gear ratio Mx**: How many impulses the actuator/slew drive gives per mm
- **I Motor limitation Mx**: Limits the maximum current through the motor
- **Motor inrush current ratio Mx**: is multiplied with "I Motor limitation Mx" and used when the motor is started
- **Motor inrush time Mx:** How long inrush current (I Motor limitation Mx * Motor inrush current ration Mx) will be active after the motor is started
- **Detection current Mx:** How much current needs to flow through the motor to detect it

- **End switch error detect Mx:** When the position is higher, the positioner starts sensing for the end switch error when the actuators/slew drives are stopped
- **U measuring factor:** Factor for onboard positioner voltage sensing (default 28.0)
- **I measuring factor:** Factor for onboard positioner current sensing (default 28.0)
- **Modbus timeout:** When no command is received from Sigma for this period of time, a Modbus timeout event is triggered and the positioner goes to "Modbus timeout position"
- **Modbus timeout position:** Where to go when a Modbus timeout event occurs
- **Modbus timeout ID delay:** This parameter is multiplied with a device (ID-1) and added to "Modbus timeout" so that positioners are sent to a position sequentially (not at once)
- **Swap Hall Mx:** Swaps hall sensor position counting
- **Homing timeout**: How long to run the motor inwards when doing homing before triggering a timeout
- **Change slave ID:** Changes a slave device address (use it with care)

7.44 Positioner commands

When a positioner is configured properly, you can use several command buttons.

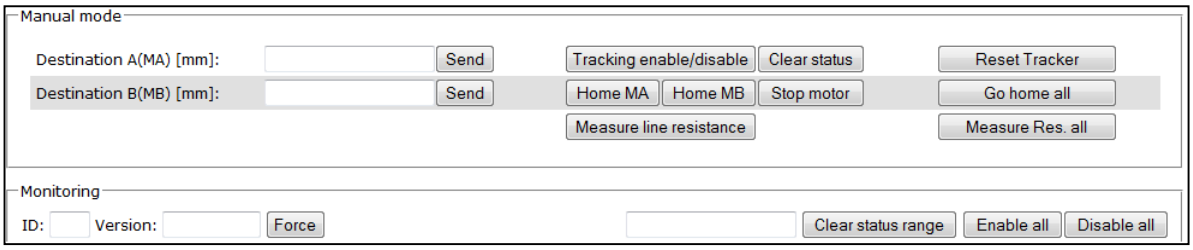

Fig 15. Positioner commands

- **Enter destination X:** Sends the actuator/slew drive to the absolute position
- **Tracking enable/disable:** Toggles automatic tracking for a selected positioner
- **Clear status:** Clears all error, warning states
- **Home MA, Home MB:** Sends a specific actuator/slew drive of the selected positioner to home position 0 (actuator/slew drive runs inwards until the end switch is pressed)
- **Stop motor:** Stops the motor of a selected positioner if moving
- **Measure line resistance:** Measures power line resistance of a selected positioner
- **Reset Tracker:** Resets a selected positioner
- **Go home all:** Puts Sigma in HOMING mode
- **Go home all:** Puts Sigma in RESISTANCE MEASUREMENT mode
- **Clear status range:** Clears a range or a single positioner status without changing the selected "Device ID" (example:"1-5 10")
- **Enable all:** Enables automatic tracking of all positioners
- **Disable all:** Disables automatic tracking of all positioners
- **ID, Version**: This is for saving an old boot loader version positioner. You can force any version of 2000 or 3000 to define a device type. This has no effect on new boot loader devices (if during software upgrade of a positioner something went wrong, then the positioner type was lost)

7.45Weather tab

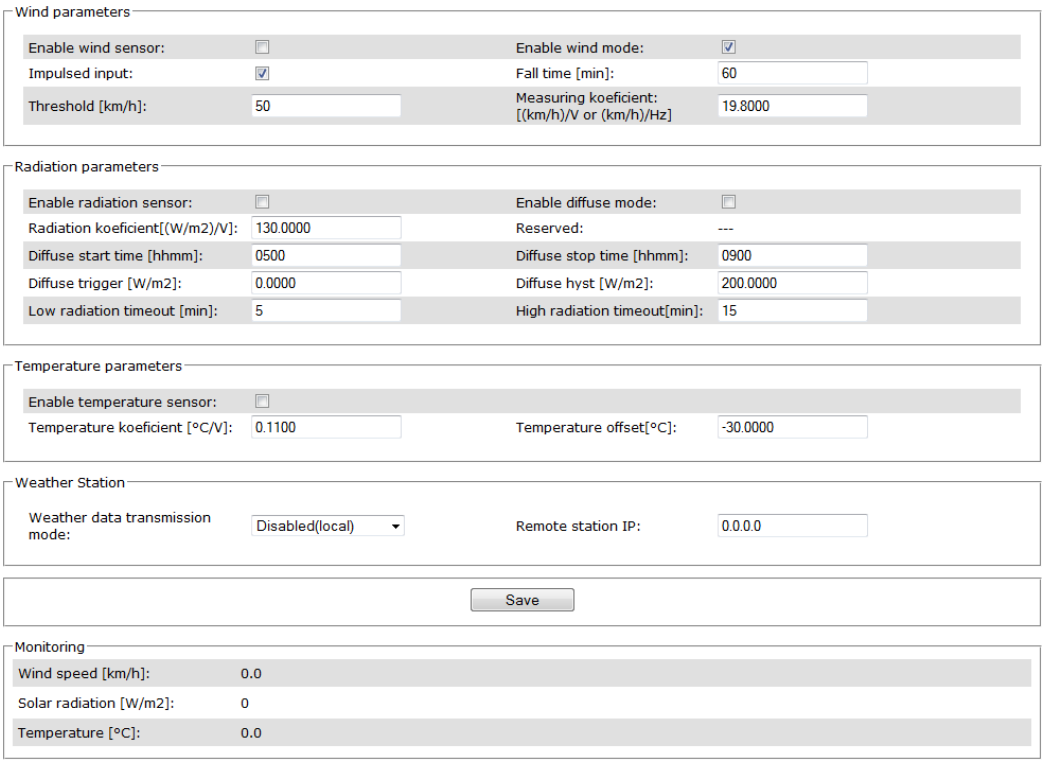

Fig 16. Weather tab

7.46 Wind parameters

- **Enable wind sensor:** Enable wind sensor input / unchecked = get value from weather station
- **Enable wind mode:** Enable wind mode triggering
- **Impulsed input:** If checked, the sensor input signal is digital otherwise analog
- **Fall time:** How long to wait after the wind speed falls under Threshold before removing a WIND mode request (default: 60)
- **Threshold:** When the wind speed is higher, go to WIND mode (default: 50)
- **Measuring coefficient:** Wind sensor conversion coefficient (default: 1.22 for a digital wind sensor and 19.80 for analog sensor)

7.47 Radiation parameters(ADC function must be selected)

- **Radiation sensor enable:** Enable radiation sensor input / unchecked = get value from weather station
- **Diffuse mode enable:** Enable diffuse mode triggering
- **Radiation coefficient:** Radiation sensor conversion coefficient (default: 130)
- **Diffuse start/stop time:** Time when to check if the DIFUSE sub mode should be activated
- **Diffuse Trigger:** When solar radiation is lower, activate DIFUSE sub mode
- **Diffuse hyst:** When DIFUSE sub mode is activated, solar radiation must get over "Diffuse Trigger" + "Diffuse hyst" to deactivate DIFUSE sub mode
- **Low radiation timeout:** How long solar radiation must stay over "Diffuse Trigger" + "Diffuse hyst" to deactivate DIFUSE sub mode
- **High radiation timeout:** How long solar radiation must stay under "Diffuse Trigger" before activating DIFUSE sub mode

7.48 Temperature parameters (ADC function must be selected)

- **Enable temperature sensor:** Enable temperature sensor input / unchecked = get value from weather station
- **Temperature coefficient:** Temperature sensor conversion coefficient (11)
- **Temperature offset:** Offset from 0°C

7.49 Weather station

Weather variables (wind speed, solar radiation and temperature) can be sensed from Sigma local ADC terminals or from a remote Sigma weather station. When in broadcast mode, UDP packets are broadcasted on LAN every second.

- **Weather data transition mode:** Disabled, Broadcast, Receive
- **Remote station IP:** When in receive mode, this IP sets a remote station IP address

7.50 System tab

Here you can manage all system-related parameters.

7.51 System parameters

This is an overview of the system LAN settings, the serial number of Sigma and group number (licenses).
The serial number is used for group number import/export and registration of a group number.
The system parameters are stored on SD Card and backed up on internal storage so that Sigma can operate even without SD Card.

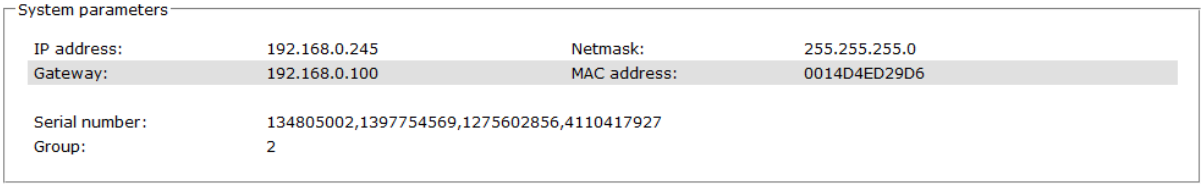

Fig 17. System parameters

7.52 License management

Sigma supports licenses (group) import/export. Licenses are exported for a specific Sigma. Once you register a group number with Sat-Control, export is disabled but you can still import.

To send a registration code by e-mail with an embedded SMTP client ("Send to Sat-Control" button), you should have SD Card connected and "Email reporting" on the "system" tab and "Contact information" on the "about" tab configured.

You can also click the "Get code" button and send us a displayed code. When using Google Chrome, "code" cannot be copied, so you have to open a log file by clicking on "Show today's log" and copy it from there or you can use Firefox browser.
Send the code to support@sat-control.si and you will receive a registration key in response.

Copy the key to "Registration key" (there should be no white spaces) and click the confirm button. If everything went alright, you should get a popup window saying "Registration successful". Press F5 on the keyboard to refresh the page.

Fig 18. Licenses management

7.53 Email reporting

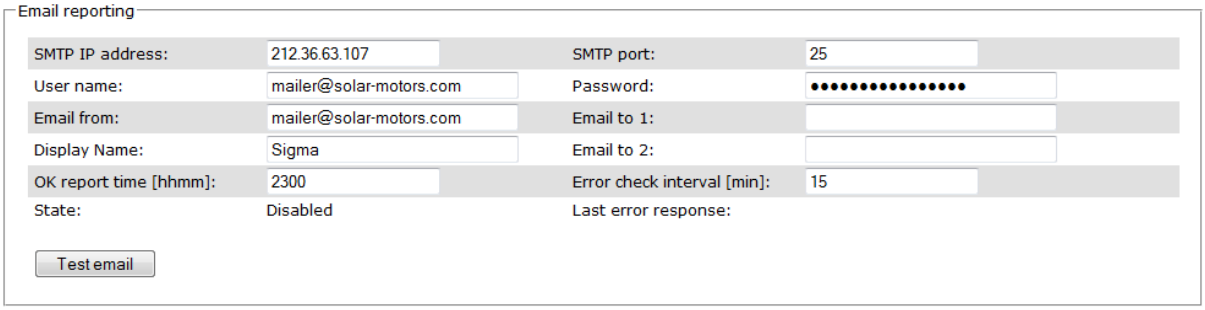

Fig 19. SMTP settings

- **SMTP IP address:** IP address of a remote SMTP server (0.0.0.0=disabled)
- **SMTP port:** SMTP server remote port (default=25)
- **User name, Password:** SMTP username and password used for login
- **Email from:** Your e-mail address
- **Email to 1, 2:** Where to send an ERROR or OK/ALIVE report (if Email to 2 is empty, it will not be used)
- **Display Name:** Name that will be displayed on email when received by the remote end
- **OK report time:** Time of day when to transmit an OK e-mail
- **Error check interval:** How often to check for new errors
- **State:** Displays the last state of the SMTP client
- **Test email:** Sends a test email

7.54 ADC2...3 input function select

ADC supports multiple functions, which can be selected by two drop boxes.

Each ADC channel has one unique and 3 common modes.

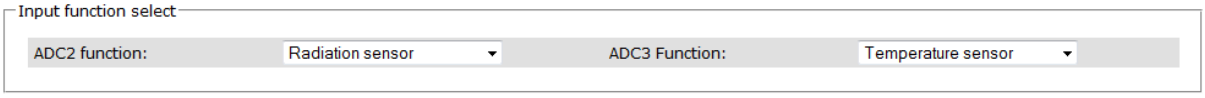

Fig 20. ADC functions

Unique functions:

- **ADC2 :** Radiation sensor
- **ADC3 :** Temperature sensor

Common functions:

- Emergency switch
- Snow mode switch
- Wind mode switch

7.55 Modbus parameters

Sigma has two Modbus ports (**see Fig 1.**), which can be used for slave positioners. There can be two positioners with the same ID on different buses but not on the same bus. From which bus this ID will be picked is selected with the "Primary Port" parameter (default=0)

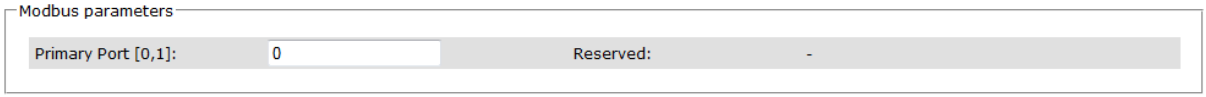

Fig 21. Modbus

7.56 Time

There is an on board RTC (real time clock) with battery backup that handles timekeeping when Sigma is not powered. This timer runs GMT time and is responsible for all timing functions and tracking calculations.

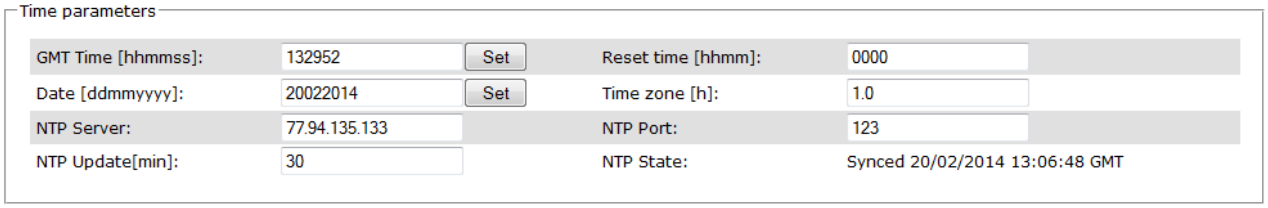

Fig 22. Time

- **GMT Time**: Current RTC timer time
- **Date:** Current date
- **Reset time:** Time when to schedule SIGMA reset
- **NTP Server:** IP address of a remote NTP server
- **NTP Port:** Remote NTP server port
- **NTP Update:** Update interval
- **Time zone:** Set this to your local time zone for sunrise/sunset to work

7.57 User interface

Page Refresh Delay sets how long a web page will wait before auto refreshing the page.

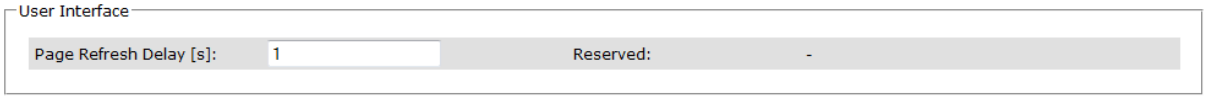

Fig 23. User interface

7.58 Updating parameters

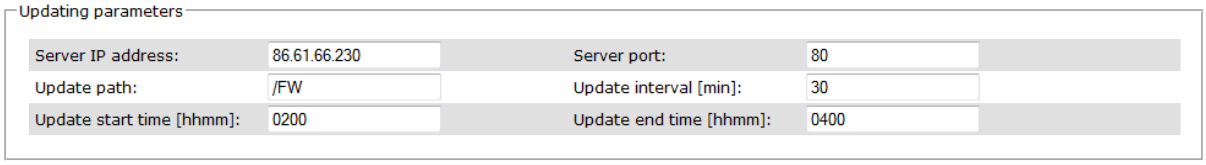

Fig 24. Update settings

These parameters are used when you click on the "Check for updates" button on the "SYSTEM" tab.

- **Server IP address:** Remote HTTP server IP address (can also be another Sigma)
- **Server port:** Remote HTTP server port (default:80)
- **Update path:** Directory on the remote HTTP server (Sigma adds "/" at the end)
- **Update interval:** How often to check for new updates
- **Update start/end time:** When to start and end checking for new updates

7.59 Buttons

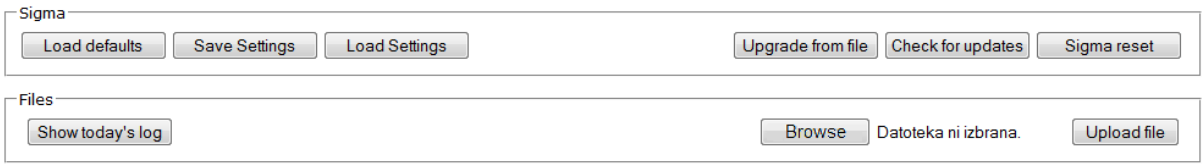

Fig 25. System buttons

- **Load defaults:** Loads factory defaults (except login and system parameters)
- **Save Settings:** Saves all settings to SD Card in the "settings.cfg" file and downloads it. (You can backup a configuration file to a PC).
- **Load Settings:** Load all settings from the "settings.cfg" file on SD Card.
- **Upgrade from file:** This puts SIGMA in firmware flashing mode which works without SD Card (Warning! Sigma settings will be lost)
- **Check for updates:** Check for updates on the remote HTTP server (updating parameters must be set first!)
- **Sigma reset:** Reset Sigma (after 5 seconds)
- **Show today's log:** Downloads today's log file stored on SD Card
- **Upload file:** Manually uploads new firmware or configuration file(when uploading Nano/Pico firmware/bootloader reset Sigma afterwards)

7.60 About tab (stored on SD Card)

About tab is used for the Sigma owner or service person/company contact information.

These fields are also sent when registering a group number with Sat-control using an embedded SMTP client.

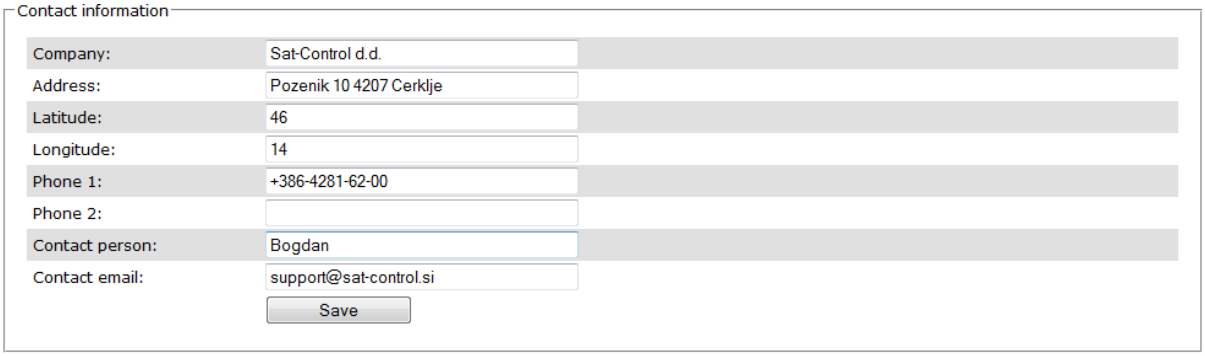

Fig 26. About tab

8. Telnet interface

Telnet is a simple text-based protocol. It shows a more detailed operation of Sigma.

Windows has an inbuilt telnet client or you can use a program like PuTTy.

You can connect to a telnet server using Sigma's IP address and port number 60.

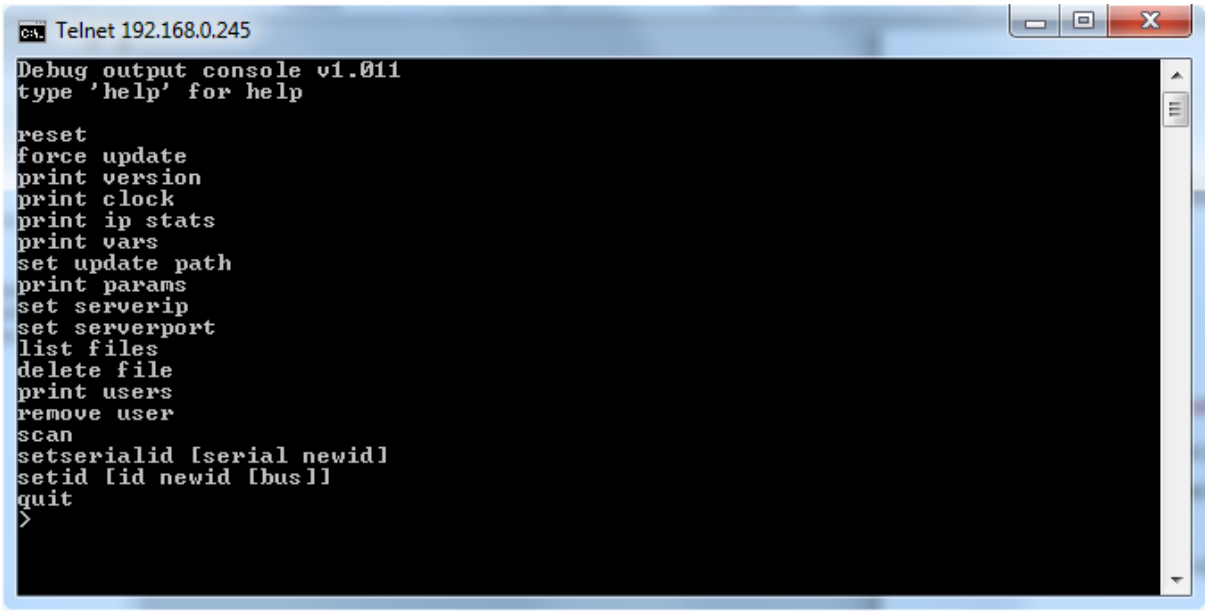

Fig 27. Telnet terminal

Note: Telnet is not protected with a username/password.

8.1 Windows Vista, Windows 7 enabling telnet client

1.Click Start

2.Control Panel

3.Programs and Features

4.Turn Windows features on or off

5.Check Telnet Client

6.Hit OK

8.2 Connect to Telnet from the Windows console

1. Open Command prompt (console)
    - On Windows 7 and Vista click Start, type "cmd" and press Enter.
2. Type telnet [Sigma's IP] [Telnet Port] (example: "telnet 192.168.3.10 60")

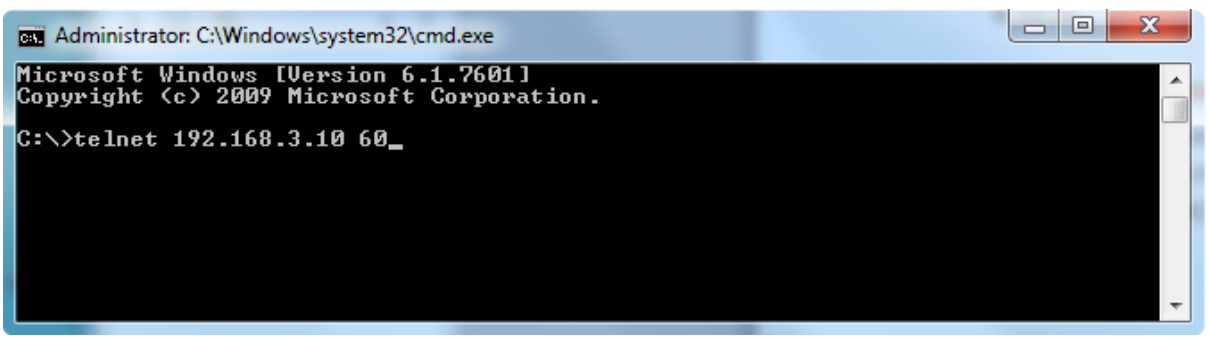

Fig 28. Command prompt

8.3 Connect to Telnet from PuTTy

Putty does not have any installation procedure. Just run it, put in Sigma's IP port (60), select a Telnet connection type and click Open.

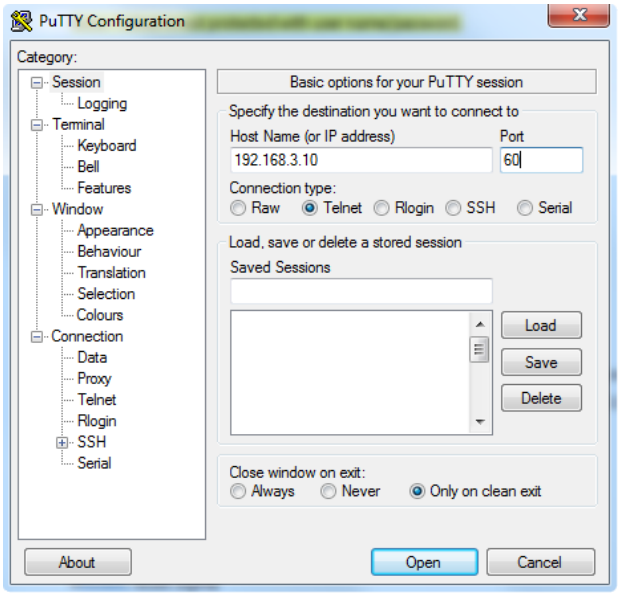

Fig 29. PuTTy

8.4 Commands

- **help**: Shows all commands
- **reset**: Resets Sigma
- **force update**: Checks for updates on a remote HTTP server (**see 6.7 System tab**)
- **print version**: Displays the Sigma boot loader version and software version
- **print clock**: Displays the current system GMT time
- **print ip stats**: Displays network stack statistics
- **set update path**: Sets a search path on a remote update HTTP server
- **print params**: Displays system parameters
- **set serverip:** Sets a remote update HTTP server
- **set serverport:** Sets a remote update HTTP server port
- **list files:** Displays files in the root directory of SD Card
- **delete file:** Deletes a specific file on SD Card
- **print users:** Prints a list of connected users
- **remove user:** Removes a user from a session list
- **scan:** Scans all Modbus ports for connected positioners
- **setserialid:** Sets ID(Modbus address) of a positioner with a specific serial number to ID 10 (example: "setserialid 123456789 10")
- **setid:** Changes ID(Modbus address) of a specific positioner (example: "setid 12 20")
- **quit:** Closes connection

9. Log files

Sigma has a logging system, which records events:

- Sigma startup
- User interface login
- Trackers mode change
- Positioner connected/disconnected
- Positioner warnings/errors
- Changes made to Sigma settings
- Changes made to positioners

9.1 Accessing log files

Log files can be accessed without login.

Log files are arranged by the day of month, and month.

There is a special case where you can select today's log by typing"log.txt" (example: 192.168.1.10/0501log.txt).

To view today's log file go to "System tab" and click on ""Show today's log"

To view past log files, type a desired log file name in the navigation bar (**see Figure 3. Navigation bar**).

Format: 0501log.txt (select a log file of the fifth of January)

```
#[Info]
#Sigma log file (by Sigma solar server)
#Date: 27.09.2013
GMT 27/09/2013 00:00:00 SYS | *** Scheduled Reset ***
GMT 27/09/2013 00:00:06 SYS | Sigma Startup ver:1242
GMT 27/09/2013 00:00:16 INT | MODE CHANGE : NIGHT MODE
GMT 27/09/2013 00:00:16 INT | id:01 connected / port:0 / serial:17364999 / version:2478
GMT 27/09/2013 00:00:17 INT | id:02 connected / port:0 / serial:17237308 / version:2478
GMT 27/09/2013 00:00:17 INT | id:03 connected / port:0 / serial:17363983 / version:2478
GMT 27/09/2013 00:00:17 INT | id:04 connected / port:0 / serial:17304838 / version:2478
GMT 27/09/2013 00:00:18 INT | id:06 connected / port:0 / serial:17236540 / version:2478
GMT 27/09/2013 00:00:18 INT | id:07 connected / port:0 / serial:17425949 / version:3034
GMT 27/09/2013 00:00:19 INT | id:08 connected / port:0 / serial:17427228 / version:3034
GMT 27/09/2013 04:03:00 INT | MODE CHANGE : TRACKING MODE
```

Fig 30. Log file

10. Upgrading

Sigma is able to upgrade itself and the positioners connected to Modbus ports.

The positioners are upgraded automatically when a version change is detected.

When Sigma starts from a new firmware:

1. Settings are set to defaults
2. Settings are loaded from the SD Card "settings.cfg" file
3. Forced modes are reset to normal operation

There are two Sigma upgrade options:

- Update Sigma and the positioners from a file on SD Card
- Update Sigma directly from a file sent via a web page

10.1 Firmware file names

- **mware.bin :** Sigma firmware upgrade
- **sigma_bw.bin**: Sigma boot loader upgrade
- **nano_fw.bin:** Nano firmware upgrade
- **nano_bw.bin:** Nano boot loader upgrade

- **pico_fw.bin:** Pico firmware upgrade
- **pico_bw.bin:** Pico boot loader upgrade
- **epico_fw.bin:** ePico firmware upgrade
- **epico_bw.bin:** ePico boot loader upgrade

If upgrading using the "Check for updates" button, each file on the server should have a matching file with the ".ini" suffix.

10.2 Upgrade from SD Card

To update from SD Card you must first transfer new firmware files.

This can be done in three ways:

- Turn off Sigma and plug out SD Card. Put it in your PC and copy the firmware.
- On the "system" tab under the "files" group click the "browse" button and select the firmware file, then click the "Upload file" button. If everything went OK, click on the "Sigma reset" button.
- On the "system" tab click on the "Check for updates" button. Sigma will automatically look for firmware updates on a remote HTTP server. If the Sigma firmware upgrade file is found, Sigma will save the settings on SD Card and trigger system reset (updating parameters must be set).

10.3 Upgrade Sigma directly from a firmware file

Warning: Settings will be lost!

This option only applies to Sigma (not the positioners).

On the "system" tab click on the "Upgrade from file" button and wait while Sigma switches to firmware flashing mode. When Sigma is in this mode, the green LED (light emitting diode) on Sigma will blink fast. When the upgrade window opens, click on the "browse" button and select the Sigma firmware upgrade file, then click on the "Send" button and wait for upgrade to finish.

11. Troubleshooting

Automatic tracking does not move:

- Check the power supply parameters (**6.4 see the Controller tab**).
- Check that the positioner power supply line and channel are set (**6.5 see the Trackers tab**).
- Automatic tracking must be enabled (**6.5 see the Trackers tab**).
- Check the positioner active status (there should be no errors) (**6.5 see the Trackers tab**).
- The positioner power supply should be greater than 20V.

A positioner is showing weird data in:

- Check the positioner settings.

There is no about tab text:

- SD Card not in the memory card slot.
- SD Card file system corrupted.

12. Changes history

Ver. 1.252:

- New parameter home offset A/B in trackers tab
- New version of Pico(2.482) and Nano(3.037) firmware that support new parameter

Ver. 1.256:

- New coordinate mode 11 and geometry modes 11,13
- Improved input sensor sampling
- Wind, radiation, temperature coefficient change for factor of 100
- New control flags for wind, radiation, temperature inputs

Ver. 1.257:

- Fixed mode position "off" handling (tracker position changed after sigma reset)
- Changed sensor input handling:
    - When input sensor is enabled value is read locally, otherwise from weather station

Ver. 1.258:

- Improved tracking accuracy
- Added sunrise/sunset for day mode/night mode switching(replacing day/night mode time)
- Added "time zone" parameter (must be set correctly for sunrise/sunset to work)
- Added sunrise/sunset offset parameters

Ver. 1.259:

- Added heliostat coordinate systems (5, 6, 7, 8).
- Added parameters "Heliostat ref. target azimuth/elevation" on controller tab
- Added option box to show positioner "remaining counter" or "heliostat target" of individual positioner on trackers tab
- Moving interval changed from minutes to seconds

Ver. 1.260:

- Minor heliostat internal changes

Ver. 1.261:

- Minor internal changes

Ver. 1.262:

- Added solar sunrise/sunset (tracking end by solar sunset and start night mode).