CSEQ technologies ltd

Quick Start Guide

B301 Autosteer System

Introduction

This document will guide you through the initial steps required to calibrate your autosteer system and covers basic usage of AgOpenGPS version 6.6.2.

Please refer to the installation guide for instructions on mounting the components on your specific type of machine, hydraulic schematics etc. This guide assumes the kit is fully assembled and ready for testing / calibration.

Powering up the system

The Box3 unit will only switch on once it has a stable source of 12 V power and is also connected via USB cable to a computer. The Box3 monitors the source voltage; to protect itself and prevent draining the vehicle battery, it will automatically switch itself off below 10 V.

To switch on, ensure all connections to the Box3 are made, ensure the E-stop switch is depressed and turn on your tractor. Depress the power button on the top left edge of the tablet PC for 3 seconds to turn it on.

The tablet PC will start and after approximately 1 minute will automatically open AgOpenGPS and AgIO.

AgOpenGPS and AgIO

AgIO (IO: Input/Output) handles connections with the Box3 and other modules, such as a section controller or an interface with a third-party control box. It is also responsible for receiving RTK corrections. The data is then transferred to AgOpenGPS which is responsible for mapping and guidance.

AgOpenGPS is the main mapping interface that you will interact with. It is responsible for field management, section control, navigation and autosteer.

In normal operation, both applications will be running. AgIO will be in the background behind the AgOpenGPS window. It is easy to switch between the two by pressing or .

Setting up AgIO

The majority of settings in AgIO are pre-configured prior to delivery. Once the system is powered on, verify that the *IMU*, *Steer* and *GPS* icons are shaded green, per Fig 1.

Figure 1: AgIO display

Selecting an RTK base station
This will usually come pre-set. Assuming you have a working internet connection, in the main AgIO window you should see the *kb* value increasing in the top left corner of the window.

   If this is not the case, you will need to select a nearby base station. Press and select *NTRIP*. Input your organisation's username and password (supplied separately). Press *Get Source Table* and select your nearest *Mount Point* from the list. Press to return.

Setting up AgOpenGPS

Initial steer setup
To calibrate the steering, open the Steer Wizard by pressing > *Wizards* > *Steer Wizard*. Press *Start Wizard*. You will be presented with the following window:

DO NOT PRESS *Load Defaults*. Many settings relevant to the Box3 have been pre-loaded. Press to move to the next stage.

1. In the next few steps, input your machine's wheelbase, track width, antenna distance forward from rear axle, antenna height, antenna offset (input a negative number if the antenna is placed to the left of centre). Press each time to save and move on.

2. The following steps should be skipped: *Steer Enable Mode*, *A/D Converter*, *Motor Driver*, *Invert Relay*, *Danfoss Valve*.

3. Drive the vehicle across a side slope, so it is leaning to the right. The roll indicator should be indicating a positive roll angle: If not, *Invert Roll*:

4. Press , drive the vehicle onto a level pad and press *Zero Roll*.

5. Press and turn the steering wheel to the right. The steer angle must increase, as shown by the WAS (Wheel Angle Sensor) angle. If not, press *Invert WAS*. The green bar gives a visual indication of your steer angle:
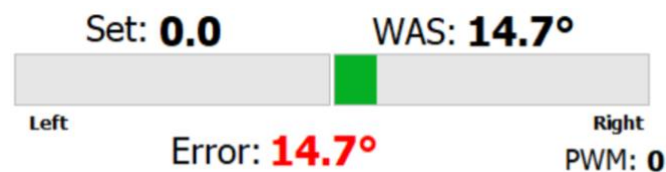
6. Press , drive forward manually in as straight a line as possible then press to set the zero point.

7. Release the red E-Stop switch and press the steer enable pushbutton. The LED in the pushbutton should light up red. Drive slowly forward and press to increase the 'Set:' value to approximately 10 degrees right. The tractor should turn to the right. If it turns left, press to invert direction. Do not worry if the response is weak or overshoots at this time. Tuning will occur later.

8. Press twice to begin calibration. Drive in an approximately 30 m circle at about 5 km/h to the right. Do not press until you are driving a steady circle.

9. The Wizard will record the radius once you have completed a semicircle and derive the true steering angle. For Box3 hydraulic units this is usually around 180 sensor counts per degree. CANbus units vary by brand but are usually between 20 and 40.

10. Only complete the left-hand calibration if you have installed your WAS on one side of a push/pull steering arrangement (where there is one small ram attached to each wheel). Users with centrally-mounted steering rams and CANbus systems should skip this step.

11. Set the maximum angle the system will steer. Set the angle to just before the steering hits the end-stops or any lower value. U-turn or line acquisition may be impaired if this value is below 30.

12. Skip through *Automatic Canceling* and *Panic Stop Speed*.

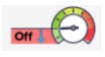13. Follow the on-screen instructions for *Minimum Movement Setting*. Enable autosteer. You are aiming to send just enough voltage to the valve to move the wheels slowly. Setting this too high will lead to imprecise steering, as it will be unable to make fine adjustments.

14. *Gain Setting*: increase *Proportional Gain* until the wheels steer quickly to the setpoint and very slightly overshoot before coming back to the setpoint. For hydraulic systems, this is usually around 80–100.

    o Move the steering to an arbitrary angle then enable autosteer and observe the response when returning to centre.
    o Pull the steering around with the steering wheel while autosteer is engaged. The autosteer should keep the wheels pointing straight ahead.
    o Using the *Left* and *Right* buttons, nudge the steering in increments of 1 degree. The wheels should track these small adjustments and the error value should be low (< 0.3).
    o If the steering moves too quickly, reduce *PWM Maximum* to cap the speed.

15. Press ✅ to save and return.

Implement setup

Press ⚙ > *Configuration* to enter the main settings window. On the main display, you will see a list of saved vehicles. For a new system, only *cseq_base* will be visible.

In the *Save As* box, type the name of your tractor and implement e.g. *fendt820-subsoiler*. Press 💾 to save.

Implement dimensions

1. Press 🛩 to access the implement settings page.

2. Select the image that corresponds to your implement: mounted, front mounted, tow-between or trailed.

3. Press ↤→ and enter the distance from axle to the working part of the implement.

4. For trailed implements, press ⊩ and enter the distance from the toolbar to the wheels then select the forward or behind icon.

5. Press 🔧 and enter any offsets or overlaps required.

6. Press ⊤⊤⊤ to set up the tool width and sections.
   o Enter the section width in cm then under the *Sections* dropdown, select the number of sections.
   o Use ⟋ to choose whether the section turns off immediately upon touching the boundary or once the coverage % has been reached.
   o Set the percentage of a section that must be covered before it switches off with the % *Coverage* box.
   o Use 🕑 to set the minimum speed, below which sections switch off.
   o Use the advanced section configuration 🎛 if you require more than 16 sections or the sections are not equally sized. In this window, set zones along the machine width, corresponding to your different section sizes.

7. Press 🕐 to add compensation for any section on/off delays.

8. Press ⬤ to set whether section control is activated by the work switch (see page 10) or autosteer.

Starting work

Press 🌱 to open the *Field* menu. From here you have several options:

ISO-XML
      Import fields created in another GPS system, which have been exported to the ISO-XML format.

From KML
      It is possible to draw boundaries in Google Earth and import them to AgOpenGPS as a KML file using this function. Beware Google Earth imagery is often inaccurate by several metres.

New
      Create a new field.

Open
      Open any previously saved field.

Resume
      Open the last used field.

From Existing
      Make a copy of an existing field, keeping the boundaries, tramlines etc. but resetting the coverage map.

Drive In
      Opens a list of the nearest fields, sorted by distance.

Suggested workflow

Instead of creating a new field each time, it is best to carefully drive and map your field boundaries and AB lines at a convenient time of year (e.g. after harvest) and create a set of 'master' fields. These can be called up using the *From Existing* function for each subsequent job. Investing a day or two in this can save time and effort for many years after.

Creating a new field

Press *New* and enter the name of the field. Use 📅 and 🕐 to add today's date and time.

For small or one-off jobs, it is often not necessary to set a boundary. Simply create AB lines or use Contour mode to informally work the field (see page 9).

Creating a boundary

1. Press 📐 and select *Boundary* to enter the window.

2. Press + to create a boundary by driving, use 🌐 to select a KML file or press ▶ to use Bing Maps inside AgOpenGPS.

3. Press 🎯 to record a boundary by driving.

4. The boundary recording window will appear. Enter the offset distance from the vehicle.

5. Press 🚜 to toggle which side the boundary is recorded.

6. Press 🚜← to toggle whether the boundary is recorded from the axle or the toolbar position.

7. Press 🏭 to switch on recording when sections are on

8. Press ⬡➕ and ⬡✖ to manually add and remove points (useful for making sharp corners).

9. Press ⏺ REC to begin recording the boundary. Press it again to pause recording (e.g. for manoeuvring).

10. When the boundary is complete, press ✅ to save and exit. The area is displayed below.

Creating a headland

Headland lines are useful if you wish to work the inner part of a field before the boundary.

1. Press ▨ > *Headland*.

2. Enter the width of the headland in metres or use the dropdown box to select the number of tool widths.

3. Press ▨ to build the headland line. It will be represented as a yellow line on the map. Press ▨ to start again if desired.

4. It is possible to edit the headland by selecting any two points on the map, to create a line across the headland. Use ▨ to truncate the shape (e.g. to cut off a narrow corner).

Creating an AB line

Press ▨ to load the AB menu. Press ▨ to record a new AB by driving or press ▨ to draw one from the boundary map.

Driving an AB

There are three options for driving AB lines:

A+: ▨   Straight AB: ▨   Curved AB: ▨

A+ lines use your current position and heading to create a line quickly. You can also enter a heading manually if desired.

Straight AB lines require you to place an A point, drive manually and enter a B point to create the line.

Curved AB lines record your entire path between points A and B. It is possible to pause recording and manually add points if required.

Drawing an AB

An AB line can be created from a boundary by pressing ✏️ . You can select any two points on the map then press 📏 or 〰️ to create a line between those two points. Use |◄◄ and ►►| to scroll through the available lines.

Boundary curve

By pressing ⬜ a boundary curve is made. This creates concentric guidance lines based upon the boundary. Note that boundary curves must be re-created each time a field is opened using 'from existing', as the tool width may be different.

Recording work

Pressing 🚜 will switch on automatic coverage mapping. Once above the set minimum speed and inside the boundary (or headland), sections will turn on. To work outside the headland (if you have set one), press ⬜ to disable it.

Manual work recording is achieved using 🚜 and is useful for tasks such as rolling where it is not possible to raise the tool. In this mode, the sections are always on.

Reversing into corners

Using trailed implements, the angle of the tool may not match reality when manoeuvring into corners. Press 🔧 to straighten the drawbar before pulling away.

Workswitch

A work recording switch is included with the Box3 kit. By default, when plugged in and active, it will switch on manual recording. Its behaviour can be changed to enable automatic recording in the tool settings.

Tuning Autosteer

Once you have created a field and a straight AB line, it is possible to fine-tune the system's parameters to achieve perfect steering. Drive slowly, arm the system by releasing the E-stop switch and engage autosteer using the button. Ensure the tractor is warm, as cold hydraulic oil can cause the steering to behave differently.
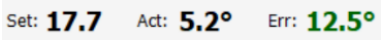
Take note of the cross-track error value at the top of the display: `73 ▶` where 73 is the distance from the line in centimetres and > indicates the direction.

Line following

Press `-15.6 -2.0` on the left-hand panel to open the steer settings window. The top number in the icon indicates the requested steer value from AgOpenGPS and the bottom number is the actual steer angle.

1. In the Pure Pursuit tab:

   a. Set *Integral* to 0 for now.

   b. Adjust the *Steer Response* value until the vehicle holds the line well but is not too sharp when turning onto the line (line acquisition). This value controls the **lookahead point**, which is denoted by a yellow dot in front of the vehicle in the main navigation window. If the lookahead point is too far away, it will not request enough steer angle to move the vehicle to the line, thus acting 'lazy'. Move the lookahead point too close and the vehicle will 'follow its nose' and oscillate over the line.

2. Press 🎛 to enter the *Gain* tab - these settings concern the hydraulic valve and will have been set roughly using the Steer Wizard (page 3). At the bottom of the window, note the steer angle set point, actual steer angle and the resulting error: `Set: 17.7   Act: 5.2°   Err: 12.5°`

   a. If the steering initially does not react but reaches the setpoint when moving, increase *Minimum to Move*.

    b. Increase *Proportional Gain* until just before the wheels oscillate. Ideally the steering will respond quickly but not overshoot.

    c. If the steering is moving too quickly to the setpoint, consider reducing *Maximum Limit*.

3. Press 🛞 to enter the *Steering Geometry* tab. These settings will also have been set roughly in the Steer Wizard.

    a. If the vehicle is consistently driving to one side of the line, adjust *WAS Zero*. If the vehicle is to the **left,** adjust *WAS Zero* in the **positive (right)** direction.

    b. *Counts per Degree* can be adjusted if the wheels are over- or under-steering.

4. Advanced settings can be accessed through the *Nerd* tab 🤓 Proceed with caution!

Automatic disengagement

The system can be set to switch off automatically if user input to the steering wheel is detected. Press ▥➡ to expand the steer settings window and ensure the 🕐 is selected. Two algorithms are available and can be chosen by selecting *Current Sensor* or *Pressure Sensor*.

    Current sensor

    Preferred option. This algorithm compares the voltage sent to the hydraulic valve against the measured movement of the steering system.

    If the valve is active but the steering is not moving or vice versa, we know either the operator has introduced oil into the system via the steering wheel or there is an issue (burst hose, broken wire etc). In either case, the autosteer should be shut down.

    1. Press the *Current Sensor* button to activate the feature then *Send + Save* ⚙➡ in the bottom right.

2. The green bar shows the amount of 'slippage' in the system and will disable steering if it goes above 80%. When driving normally, the value should be below 20%.

3. The slider adjusts a multiplication factor in the algorithm, to match steer angle to valve actuation. While autosteering, adjust the slider in increments of 10%, pressing ⚙️➡️ after each adjustment. There should be a point where a fast, deliberate 1/4 turn of the steering wheel will cause the green bar to spike and autosteering to cut out.

4. Finely adjust the percentage to get the best possible response.

Pressure sensor
This algorithm is simpler and evaluates whether steer angle error is increasing, once the error has gone above 1°.

1. Press the *Pressure Sensor* button to activate the feature then *Send + Save* ⚙️➡️ in the bottom right.

2. The green bar represents the amount of times this condition has occurred. It will reduce when driving steadily on a line and increase when steering errors are common.

3. Set the threshold to a level that reliably switches off autosteering when the wheel is turned but does not spuriously cut out while driving the line. Remember to press ⚙️➡️ after each adjustment.

Other Adjustments
In the expanded steer settings window, there are various options for advanced tuning.

🛞 **tab:**
   UTurn Compensation increases or reduces steer angle in U-turns. Useful if the vehicle understeers around a U-turn.

Sidehill compensation adds a small amount of steer angle in the uphill direction, per degree of roll angle. Useful if the vehicle or implement pulls low on sidehills.

Steer In Reverse can be disabled here if not required. By default, the steering can be engaged while reversing.

Stanley/Pure Pursuit toggles between the *Stanley* or *Pure Pursuit* steering algorithms. *Pure Pursuit* is the default and is recommended for almost all applications.

🔔 tab:

Manual Turns selects the max speed to perform a manual U-turn (manual turns must be enabled in main settings).

Min Speed switches off autosteer below this value.

Max Speed switches off autosteer above this value.

⚙️ Main configuration window

Press 🖳 to enter the IMU fusion settings.

IMU/GPS fusion weight can be increased if the vehicle is slow to react to ground features such as bumps The default is 70% IMU. For high-speed jobs this should be set to 75 or 80%. *Minimum GPS Step* can also be increased to 10 cm in high-speed applications.

Reverse Detection is enabled by default but can be disabled here.

UTurn

The UTurn feature will create guidance lines to turn the vehicle around at the boundary to the next AB line automatically. It goes without saying that this feature has the potential to be incredibly dangerous and is used entirely at the owner's risk. Remain alert at all times and be ready for any eventuality. If you have any doubts as to its function, test it in simulator mode first.

1. Enter the main configuration window and select

   a. Set the turn radius to a suitable value but ensure it is not equal to or an exact multiple of the tool width (e.g. set it to 8.1 m).

   b. Set the distance to boundary . For tools with a solid boom, ensure this distance is at least half the tool width (e.g. for a 24 m sprayer, set it to at least 12 m). For trailed implements such as drills, this value can be much lower.

   c. Set *Smoothing* and *extension length* according to the guidance on screen using the arrows.

2. In the bottom left-hand corner of the main navigation display, a box showing 0 is present. Press this to select the number of AB lines to skip (0 means it will skip none and return to the next line).

3. When autosteering down an AB line, press to switch on UTurn. Note the green turn line which has been created at the end of the field.

4. Press to swap the direction of the U-turn line left or right. The value will count down the distance until the turn is executed.

5. Press to switch modes between 3-point turn and normal mode.