NAVIQ

Navigation Intelligence

MTS160

Magnetic Track Sensor with Position and Angle Reporting

Installation and Operation Manual

Product Overview

Description

The MTS160 is a magnetic guide sensor for mobile robots that provides track position and incidence angle measurements for precise magnetic-path following. Its patented sensing method detects the angular incidence of the magnetic track and its lateral position relative to the sensor, enabling improved tracking accuracy and smoother navigation through bends.

The MTS160 can be used as the primary guidance sensor in robots that follow fixed magnetic paths. It can also be used together with laser- or vision-based navigation systems when high-precision final positioning is required.

The sensor is optimized for use with 25 mm and 50 mm adhesive magnetic tape, as well as other suitable magnetic sources installed in or on the floor. It provides a sensing width of 160 mm with 1 mm position resolution and operates at mounting heights from 10 mm to 50 mm.

The MTS160 supports selectable track polarity, allowing operation with either North-up or South-up magnetic tape. It also supports detection of two-way forks and merges, and can detect opposite-polarity magnetic markers located to the left or right of the main track. For communication, the MTS160 includes an M8 4-pin connector for power and data and supports CANopen and RS232 interfaces. A software-selectable 120-ohm CAN termination resistor is built in. The sensor updates measurements at up to 200 Hz.

The unit includes RGB status LEDs for local indication of track and marker detection, and a PC/web utility for configuration, testing, and monitoring. Firmware can be updated in the field. Internal self-test functions help verify correct operation of the magnetic sensing elements.

With dimensions of 165 mm × 35 mm × 25 mm and an IP54-rated enclosure, the MTS160 is designed for use in industrial environments over a temperature range of –40°C to +65°C.

Key Features

- Detects and measures the position of up to two magnetic tracks across the sensing width
- Reports the incidence angle of each detected track
- Optimized for 25 mm and 50 mm adhesive magnetic tape
- Operating height: 10 mm to 50 mm
- Sensing width: 160 mm
- Position resolution: 1 mm
- Angular resolution: 1°
- Selectable track polarity: North-up or South-up
- Supports detection and handling of two-way forks and merges
- Detects opposite-polarity markers on either side of the main track
- Detects one or two magnetic point sources and reports X/Y position
- M8 4-pin watertight connector for power and communications
- CANopen interface up to 1 Mbit/s
- Built-in, software-selectable 120-ohm termination resistor

- RS232 interface
- Compatible with PLCs, embedded controllers, and industrial computers
- Measurement update rate up to 200 Hz
- RGB status LEDs for track and marker indication
- USB port for configuration, testing, and monitoring through a web app on a PC or smartphone
- Field-upgradeable firmware
- Automatic self-test of internal magnetic sensor ICs
- Wide input voltage range: 7V to 28V DC
- Power consumption: < 1 W
- Dimensions: 165 mm × 35 mm × 25 mm
- Operating temperature: –40°C to +65°C
- IP54-rated enclosure, protected against dust ingress and water splashes
- CE, RoHS compliant

Applications

- Automated Guided Vehicles (AGVs)
- Material handling systems
- Automated manufacturing lines
- Inventory management robots
- Personal mobility shuttles
- VNA (Very Narrow Aisle) truck guidance
- Last-millimeter positioning for laser- or vision-guided robots
- Theatrical props
- Robotic camera dollies
- Smart agriculture systems
- Automated parking systems
- Interactive exhibits

Important Safety Information

Intended Use

The MTS160 is a non-contact magnetic guide sensor for AGVs and mobile robots. It detects the position of a magnetic tape track to support navigation along a defined path.

Improper Use

The sensor is not classified as a safety device under Machinery Directive 2006/42/EC and must not be used for safety-related functions. It must not be used in hazardous or explosive atmospheres unless expressly approved for such use. Any use outside the specified intended purpose, or use with unauthorized accessories or modifications, is considered improper use and is at the user's own risk. Improper use may lead to hazardous situations. All installation and operating instructions must be followed.

Limitation of Liability

The system integrator, machine builder, and operator are responsible for ensuring that the overall robot or machine operates safely and complies with applicable laws, regulations, and safety standards. The MTS160 is a guidance sensor only and is not a safety-rated device. NAVIQ shall not be liable for damage, injury, or loss resulting from improper installation, misuse, operation outside the specified limits, unauthorized modifications, or the use of unauthorized spare parts, consumables, or accessories.

Hazard Warnings and Operational Safety

Always follow the safety notes, warnings, and installation instructions in this manual to reduce risk and avoid hazardous situations.

Repairs

Repairs to the sensor may only be performed by authorized and qualified Naviq personnel. Unauthorized repairs or modifications will void the warranty and may compromise safe operation.

Technical Specifications

Sensor	
Sensing Width	160mm
Sensing Height	10-50mm
Number of Internal Sensing Elements	32
Field Measuring Range	0 – 4 militesla
Sensing Refresh Rate	200 Hz
Number of Simultaneous Tracks	2
Track Position Sense Resolution	1mm
Track Angle Sense Resolution	1 Degree
Number of Simultaneous Markers	2
Marker Position Resolution	0.5mm X and Y
Communication	
USB	Yes
RS232	Yes
RS485	Contact Naviq
RS232 Bit rates	9.6, 19.2, 38.4, 57.6 or 115.2 kbps
CANBus	Yes - CANopen
CAN Bit rates	125, 250, 500 or 1000kbits/
Bus Termination Resistor	120-ohm internal. Software selectable
Communication	
LEDs	Two RGB LEDs
Power-on Selftest	Physical verification on internal Sense ICs
Selftest	Full Hardware Diagnostics
Electrical	
Power Consumption	800mW
Supply Voltage	7V to 28V
Reverse Polarity Protection	Yes
Inrush Current Limiting	Yes
Surge Protection on Com Lines	Yes
Electromechanical	
Power & Signal Connector	M8, 4-pin, Male Connector
Dust and Water Protection	IP54
Operating Temperature Range	-40 oC to +65 oC
Certification	Compliant EN IEC 60947-5-2-2020. CE Marked
Dimensions	165mm x 35mm x25mm
Housing Material	ABS
Weight	80g

Connector and LED Identification

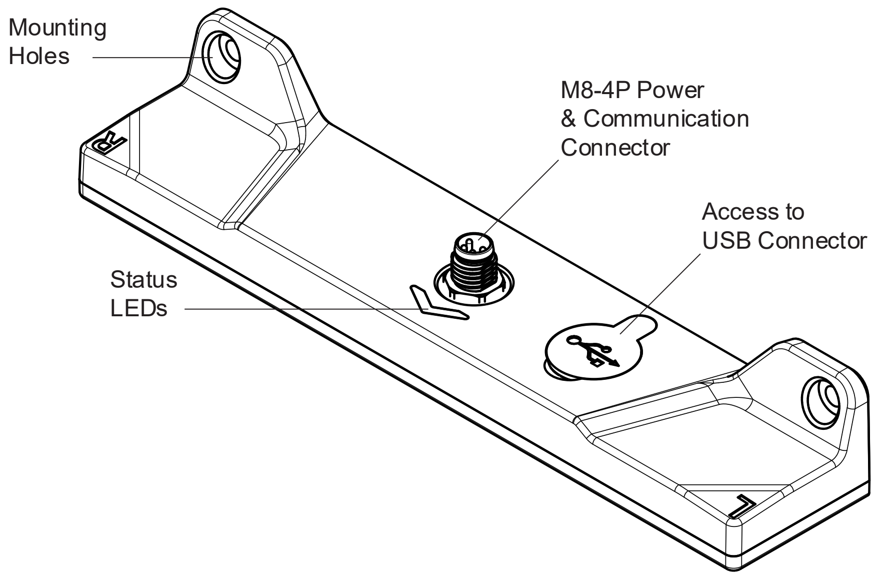

Figure 1 MTS160 external features identification and location

Suitable magnetic materials

The sensor is designed for use with magnetic tape that has unipolar magnetization, with either the North or South pole on the top surface. It supports different tape widths and operating heights within the specified sensing range.

The sensor will not work with materials that use alternating-pole magnetization.

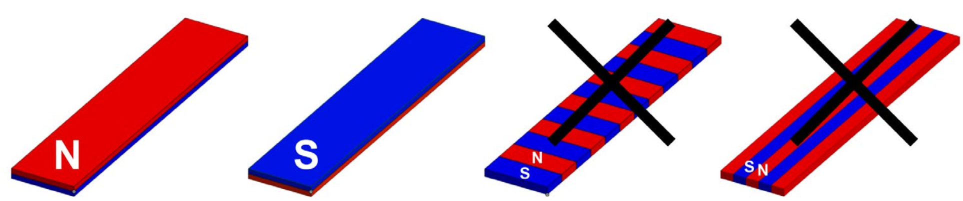

Figure 2: Suitable magnetization

Figure 3 shows examples of magnetic components compatible with the sensor. The graph above each example illustrates the relative field strength and polarity profile.

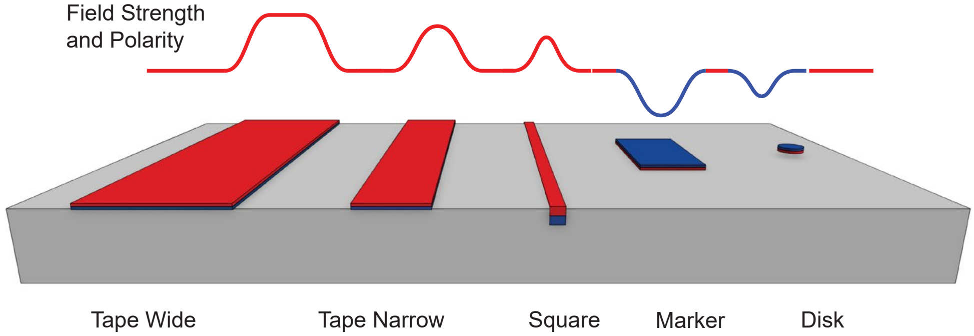

Figure 3: Usable Magnetic Components

Tracking Tape

Use magnetic tape to define the path for the robot to follow. Tape is commonly available in narrow (25 mm) and wide (50 mm) versions. Wider tape generally produces a stronger magnetic field and has higher adhesion to the floor. The narrow tapes are more economical.

Square Profile

For high-traffic areas or harsh environments, a magnetic square profile embedded in the floor may provide better durability.

Position Markers

Position markers are made from magnetic material with polarity opposite to that of the main tracking tape. They are used to provide location reference points along the track.

Point Source Disks

For precise end-position alignment, 20 mm magnetic disks can be used as localized magnetic point sources. These allow the sensor to determine X and Y position for fine alignment. Point source disks are available from Naviq.

Sensor Mounting

Left/Right Identification

The sensor’s left and right sides are defined relative to the travel direction indicated by the arrow-shaped LED marker on the housing. The sides are also identified by the letters L and R engraved on the case.

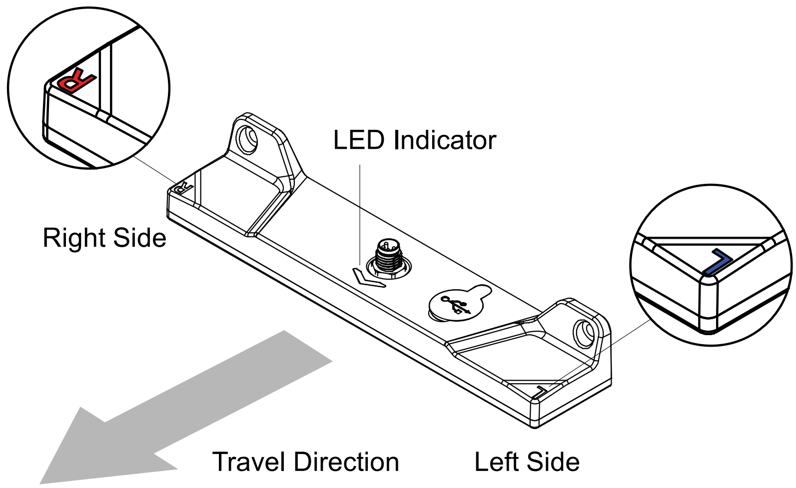

Figure 4: Left/Right sides identification

Mounting Orientation and Height

Install the sensor in a location with minimal magnetic interference from motors, wiring, steel structures, or other magnetic sources.

Mount the sensor so that it is parallel to the floor in both the longitudinal and transverse directions.

The recommended mounting height is 20 mm above the floor.

Install the sensor with the M8 connector facing upward.

For best performance, maintain a constant sensor height as the robot moves along the track.

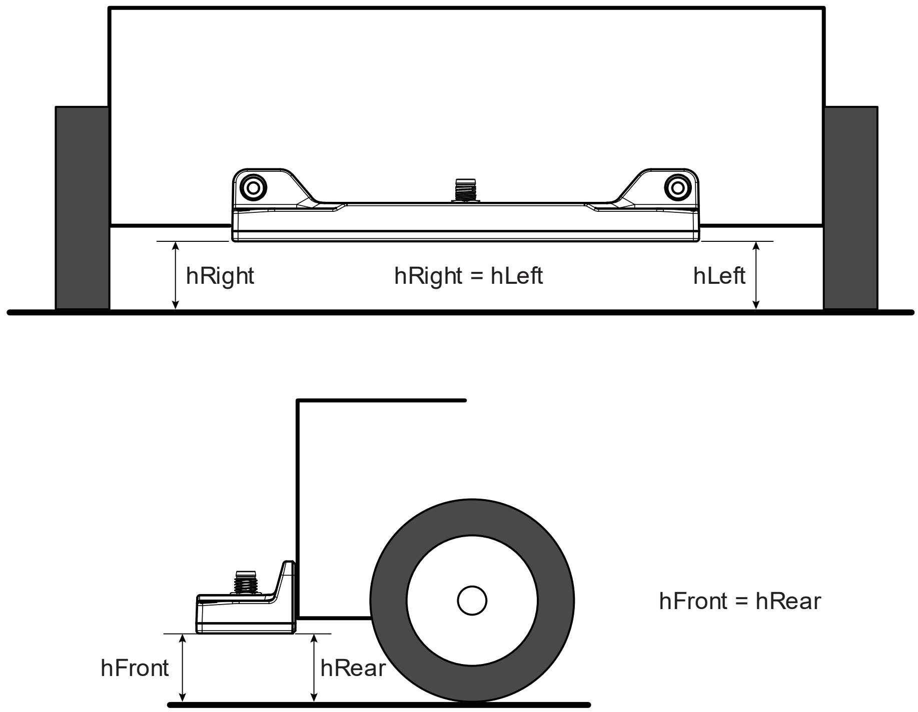

Figure 5: Sensor Mounting location and orientation

The center of the sensor should, where possible, be aligned with the centerline of the robot and mounted perpendicular to the direction of travel.

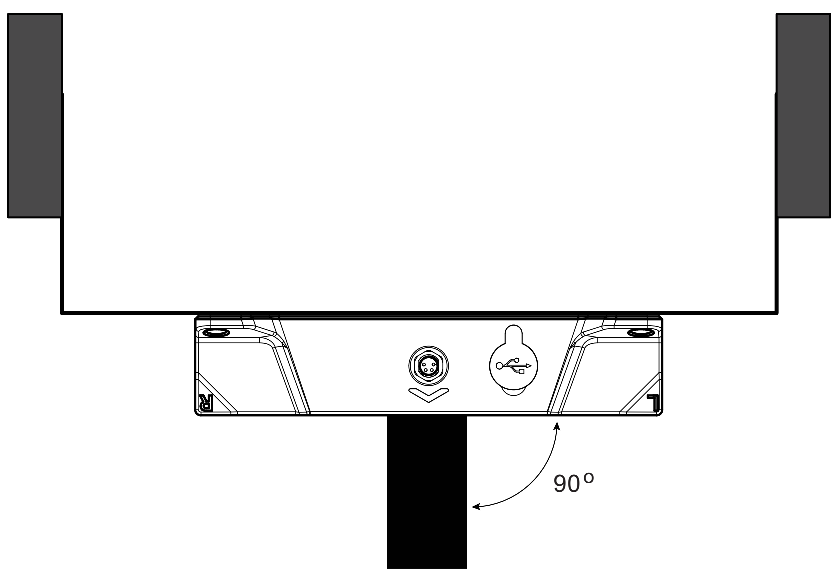

Figure 6: Sensor Mounting location and orientation

Optimal Position for Steering

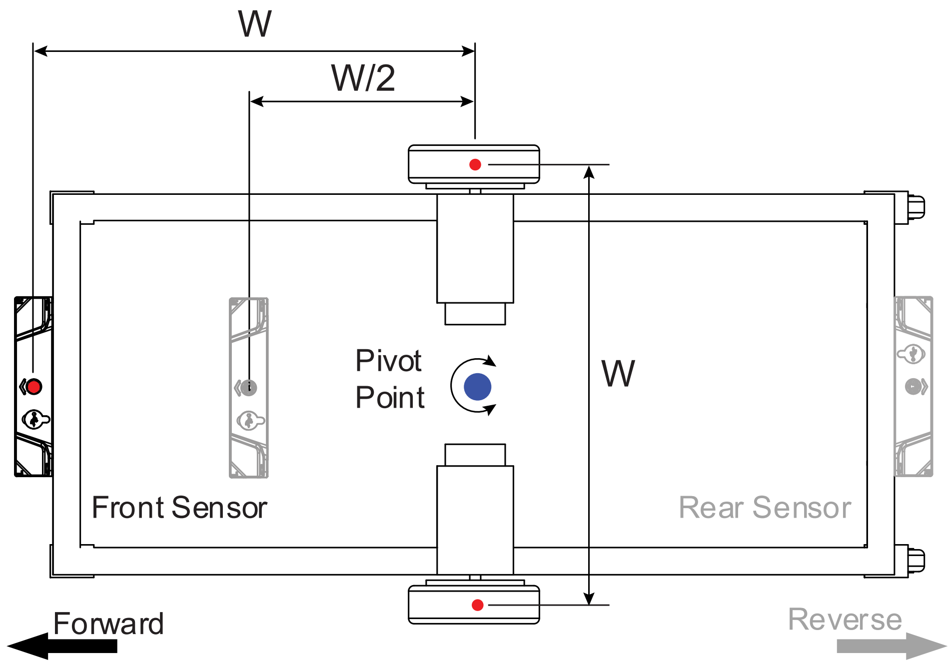

Figure 7: Optimal Sensor Placement

For robots with a differential-drive left/right wheel arrangement, the sensor should preferably be mounted ahead of the pivot point at a distance between W/2 and W, where W is the wheel spacing. To ensure that the robot can follow the magnetic path with precision and maintain control, the sensors should preferably be installed at a distance from the pivot point that falls between half the wheel spacing (W/2) and the full wheel spacing (W).

Mounting the sensor too close to or too far from the pivot point can make stable and accurate path-following more difficult.

For unidirectional travel, mount the sensor at the front of the vehicle. For bidirectional travel, use one sensor at the front and one at the rear.

Physical Attachment

To mount the sensor onto the robot, select an accessible area on the robot where the sensor will be attached. Refer to the dimensions indicated in the diagram and measure the spacing for the mounting holes accordingly. Mount the sensor using the two M4 mounting holes shown in Figure 8.

Position the mounting holes 18.5 mm above the desired sensing height H. Drill the holes perpendicular to the mounting surface to ensure proper alignment.

Align the sensor over the area, matching its mounting holes with those on the robot. Use M4 stainless steel screws to secure the sensor. Stainless steel is recommended to minimize the risk of magnetization that could affect sensor performance. Tighten the screws securely, but do not overtighten.

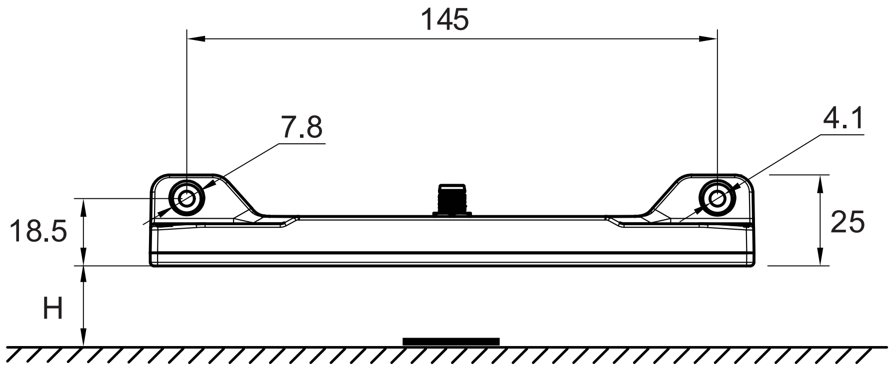

Figure 8: Dimensions for Mounting

Electrical Connections

M8 Connector Pin assignment

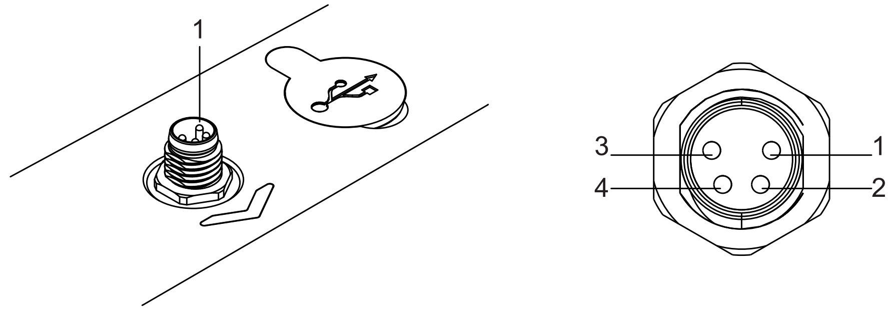

Figure 9: Pin assignment: M8-male, A-coded, 4-pin

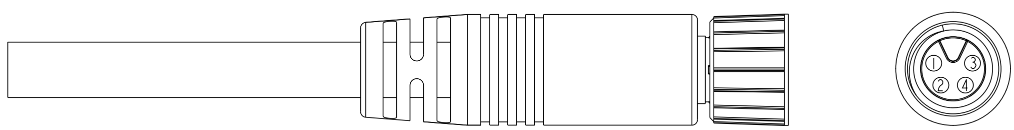

Figure 10: Preassembled M8 Cable

Pin Number	Signal	Description	Wire Color
1	VIN+	+7 to +28V Power Supply	Brown
2	CANH/RS232Tx	Data Signal 1	White
3	GND	Power Supply Ground	Blue
4	CANL/RS232Rx	Data Signal 2	Black

Connecting the supply voltage

The sensor must be connected to a stable voltage supply between 7V and 28 V DC and capable of sourcing at least 2 W power.

Always use the system's main power switch to turn the sensor on or off.

Do not connect or disconnect the M8 connector while power is applied. Connect the cable first, then apply power.

If no power is present on the M8 connector, the sensor can be powered through the USB port when connected to a PC or smartphone.

Data Connections

Data Pin assignment

The MTS160 features a unique multi-interface, multi-protocol communication port that uses only two shared pins or the 4-pin connector. The active interface and protocol are software-selectable.

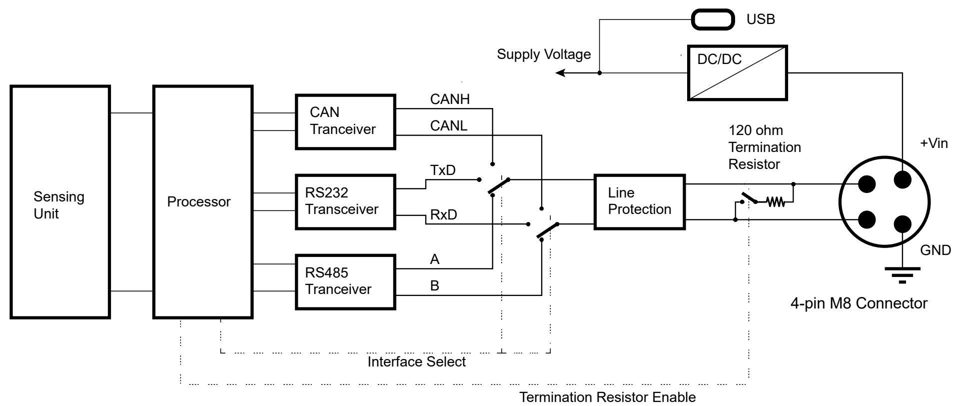

Figure 11: Internal Interface Switching Circuit

CAN connection

The sensor allows for seamless integration with a CAN network by routing the CAN-High and CAN-Low signals to the two signal pins on the M8 connector.

The sensor includes a built-in, software-selectable 120-ohm termination resistor. It is disabled by default.

If the internal termination resistor is disabled, external 120-ohm terminators should be installed at both ends of the CAN bus.

RS232 Connection

When RS232 communication is selected, the RS232 Tx and Rx signals are routed to the two signal pins of the connector.

To communicate with another RS232 device, connect Tx, Rx, and GND accordingly.

USB Connection

The sensor can be connected directly to a PC or smartphone through its USB-C port located next to the M8 connector. When connected, it appears to the host as a serial communication port.

The USB port is intended primarily for configuration, testing, tuning, and firmware updates using the Naviq utility.

Although USB provides the same command interface as RS232, it is not recommended as the primary communication interface to the navigation controller.

Preparing the Sensor for Use

The MTS160 is ready for operation with only minimal configuration.

Zero-Level Calibration

Zero-level calibration must be performed after installation and before normal operation. Ambient magnetic offset depends on the installation environment and can be affected by nearby steel structures, wiring, motors, or other magnetic sources. For accurate operation, position the robot away from the track and other magnetic sources, then issue the zeroing command through CAN, serial communication, or the Naviq utility.

If the unit has not been zero-calibrated, the arrow LED remains purple continuously. After successful calibration, the LED returns to its normal indication behavior.

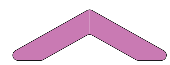

Figure 12: LED color on uncalibrated sensors

Important Notice: **Calibration is lost when Restoring Factory Defaults with the Naviq utility.**

Tape Polarity Selection

By default, the sensor is configured for tracking tape with North polarity on the top surface and markers with South polarity on the top surface. This setting can be reversed if the installed tape uses the opposite polarity.

To identify tape polarity, suspend a piece of tape from a 50–100 cm thread and allow it to align with the Earth's magnetic field. Alternatively, place a compass against the top, non-adhesive side of the tape. The north end of the compass needle will be attracted to the tape's south pole, and the south end will be attracted to the tape's north pole.

Tape polarity can be configured through serial communication, CAN communication, or the Naviq utility.

Track and Markers Threshold

The MTS160 detects tracks and markers by measuring changes in magnetic field strength. Tracks are detected where the field increases, while markers are detected where the field decreases.

The track detection threshold is defined as a percentage of the track's peak magnetic field.

The marker threshold is defined as an absolute magnetic field value in mT.

Both thresholds are factory-set for normal operating conditions and usually do not need adjustment.

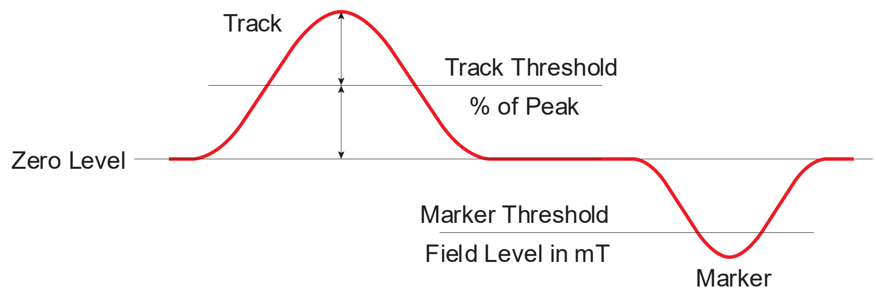

Figure 13: Track and Marker detection thresholds

In installations with magnetic disturbance, such as magnetized steel in the floor, threshold adjustment may improve detection reliability. Before changing these values, review the field and detection graphs in the Naviq utility to understand the disturbance and verify that threshold adjustment is appropriate. Thresholds can then be adjusted through the Naviq utility or via CAN bus.

Communication Mode Selection

The MTS160 can be configured to operate in the following modes:

- RS232 – Factory Default
- CANopen

RS232 Configuration

RS232 is the factory-default communication mode. It operates in full-duplex mode with 8 data bits, no parity, one stop bit, and no flow control. The sensor does not echo received commands.

Selectable bit rates are:

- 9600 bps
- 19200 bps
- 38400 bps
- 57600 bps
- 115200 bps – Factory default

For compatibility with systems that require inverted serial logic levels, the serial signal polarity can be changed in the configuration. The default setting is non-inverted.

Use the USB port together with the Naviq utility to change RS232 settings.

CAN bus Configuration

Use the USB port together with the Naviq utility to configure CANopen settings.

Selectable CAN bit rates are:

- 125 kbps
- 250 kbps (default)
- 500 kbps
- 1 Mbps

The CAN node ID is user-selectable from 1 to 127. The factory default node ID is 1.

PDO Send Interval: In CAN mode, the sensor can transmit measurement data in PDOs at a user-configurable interval. The PDO send interval accepts values from 0 to 65535 ms. PDO transmission is disabled in the factory default. Sensor measurements are generated every 5 ms, so PDO periods below 5 ms can repeat the same measurement sample.

Heartbeat Interval: The sensor also supports the standard CANopen heartbeat mechanism. The heartbeat interval accepts values from 0 to 65535 ms. The factory-default heartbeat interval is 1000 ms. A value of 0 disables heartbeat transmission. For any nonzero setting below 100 ms, the firmware uses a 100 ms heartbeat interval.

Termination Resistor:
The sensor includes a built-in, software-selectable 120-ohm CAN termination resistor. It is disabled by default. Enable it only when the sensor is installed at one end of the CAN bus and termination is required.

Auto Run. When Auto Run is enabled, the sensor enters CANopen operational state at power-up and begins transmitting enabled TPDOs. Heartbeat messages are transmitted whenever the heartbeat period is nonzero. When Auto Run is disabled, the sensor starts in CANopen pre-operational state and waits for network control before transmitting TPDOs. If the heartbeat period is nonzero, heartbeat messages are still transmitted in pre-operational state.

It is recommended to configure CAN settings before connecting the sensor to an active network in order to avoid bitrate or node-ID conflicts

Sensor Data Reporting

The MTS160 measures and reports several track and marker parameters in real time. New measurement data is generated at 200 Hz (5 ms intervals).

Continuous Dual Track Detection

The MTS160 always reports data for two tracks simultaneously: one data set for the left track and one for the right track. This is true even when only a single physical track is present. In that case, the left and right reported values are identical. This reporting method simplifies the handling of forks and merges.

Track Detection and Strength

The sensor reports track presence and magnetic strength using two status bits:

TS1	TS0	Track Detection	Magnetic Strength
0	0	No Track	-
0	1	Track Present	Minimal
1	0	Track Present	Medium
1	1	Track Present	Strong

The sensor operates correctly whenever a track is detected. However, for best performance, the magnetic field should be at least medium over the full path.

If the reported strength is minimal, reduce the sensor height or use magnetic tape with stronger magnetization.

Lateral Tracks Positions

The sensor reports the lateral position of each track relative to the center of the sensor in millimeters. Positions to the left of center are negative; positions to the right are positive.

Track Incidence Angles

One of the MTS160's unique capabilities is the measure of the track's incidence with the sensor. This enables the robot to distinguish between going off track, and therefore the need to apply only small trajectory corrections and entering a curve and therefore needing to apply sustained steering.

The sensor reports the incidence angle of each track with a 1-degree resolution

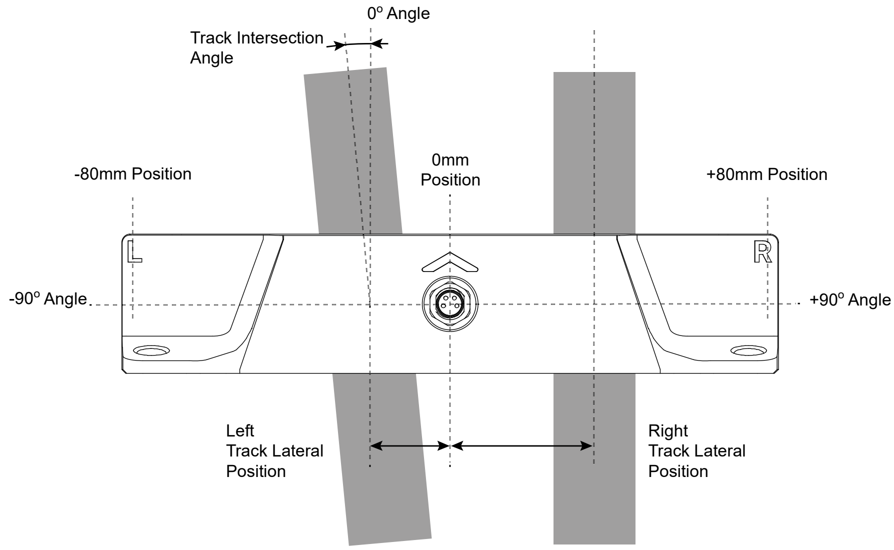

Figure 14: Angle and Lateral Position Measurements

The advantages of using the angle and methods to improve track following are explained later in this document.

Forks and Merges

The MTS160 uses a simple but very effective method for handling forks and merges smoothly.

The sensor always reports the position and angle of two tracks: a left track and a right track. This is true even when there is only one physical track under the sensor. In that case, the reported left-track and right-track values are identical.

When the robot is traveling on a single track, the sensor reports two identical track positions and two identical angle values. Assuming the robot is perfectly centered and aligned with the track, these will be 0mm and 0 degrees.

Forks

As the robot enters a fork, the second branch begins to appear within the sensing area. The sensor then reports two distinct tracks, one on the left and one on the right, each with its own position and angle.

The controller can choose which branch to follow simply by selecting either the reported left track or the reported right track.

Once the fork is passed and only one physical track remains, the left and right reported values become identical again.

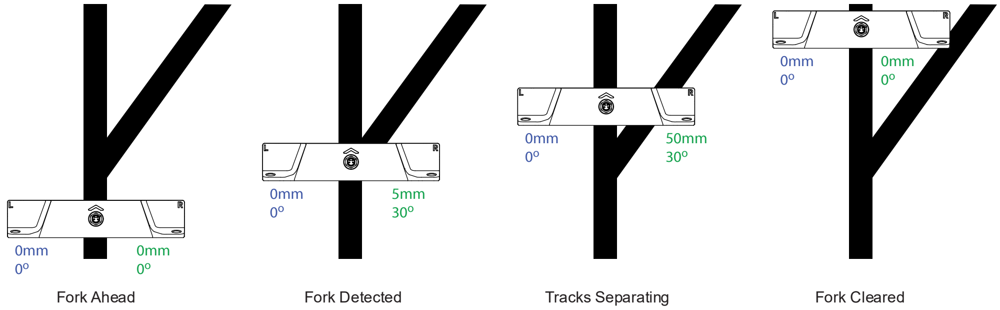

Figure 15: Sensor measurements at forks

Merges

The same principle applies to merges. Before reaching a merge, the controller must already be set to follow the track corresponding to the desired path.

As the merging branch enters the sensing area, the sensor reports both tracks with a sudden large separation value. If the controller is following the correct side, the robot will continue smoothly through the merge.

After the merge is completed and only one physical track remains, the left and right values again become identical.

Beware that If the robot is set to follow the wrong side, the robot will steer abruptly toward the incoming branch as soon as it is detected.

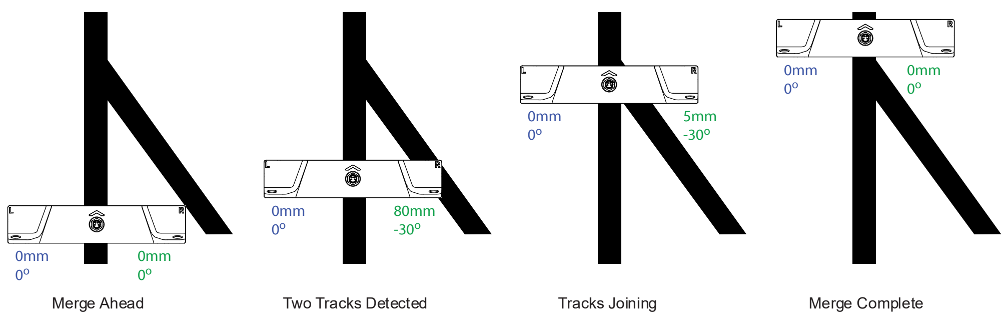

Figure 16: Sensor measurements at merges

Left and Right Position Markers

Markers are short pieces of magnetic material with polarity opposite to that of the main track. They are used to identify specific locations along the robot path, such as forks, merges, charging points, speed-change zones, or other reference locations.

The sensor can detect and report a left marker on the left side of the track and a right marker on the right side. Markers can also be combined into patterns to identify multiple locations uniquely

.

Figure 17: Marker Types

It is recommended to use 25mm or longer markers. Markers that are too short will not have enough surface to ensure strong adherence to the floor. Markers shorter than 25mm may also have insufficient magnetic strength.

While markers must have a minimal length to be physically detected by the sensor, their presence will be reported to the PLC or Navigation Computer as they appear and disappear. Left and Right markers need to be longer as the robot moves faster or/and if their position is read at a lower frequency. This restriction does not apply to Navicode coded markers as these are decoded within the sensor.

It is recommended to place the markers so that their edge is 20 to 30mm away from the edge of the main track. The sensor reports the lateral position of markers when detected.

When two markers are on the same side, spacing between them should be 50mm for their magnetic fields to be distinct from one another.

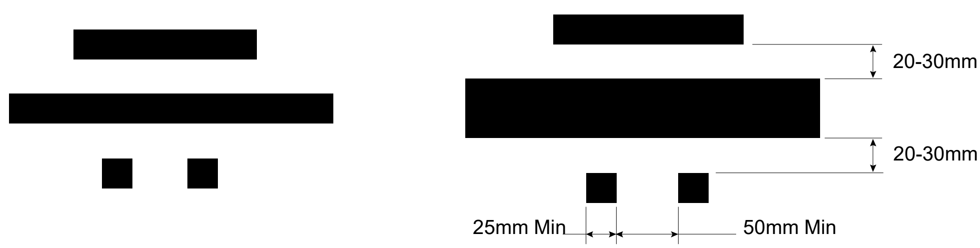

Figure 18: Recommended Marker Spacing

Last-Millimeter Magnetic Point-Source

Another unique capability of the MTS160 is the detection of magnetic point sources with millimeter-level X and Y position reporting. By installing one magnetic disk at a known location on each side of the track, the robot's position and orientation can be determined with very high precision.

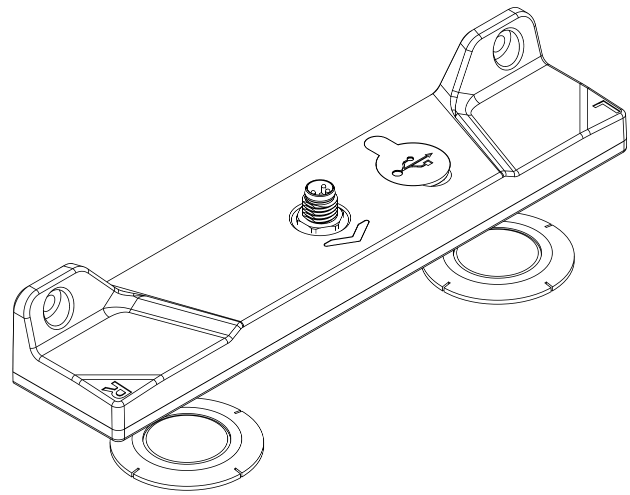

Figure 19: MTS160 Hovering over two point-source magnets

This feature makes the sensor a valuable accessory for last-millimeter positioning in robots that primarily use laser or vision navigation.

The magnetic disks must have polarity opposite to that of the main track. The sensor detects them in the same way as regular markers, while also reporting their X and Y coordinates.

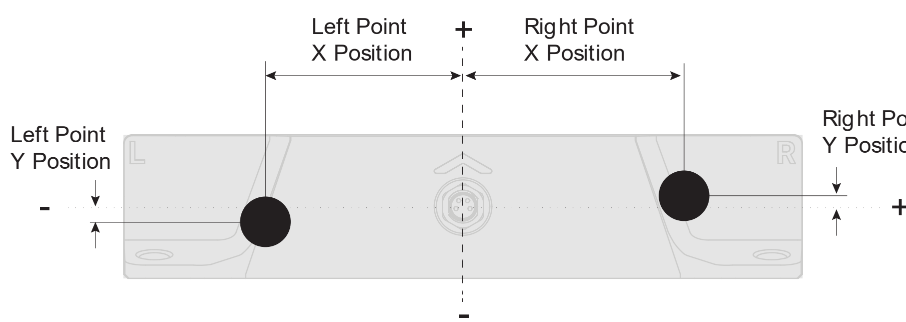

Figure 20: Detection of magnetic point-source

Adhesive point-source magnets are available from Naviq

Navicode Coded Markers

The MTS160 can detect and decode specific combinations of left and right markers using a simple coding scheme. The scheme represents binary **0** and **1** using basic marker patterns that can be concatenated to form multibit values.

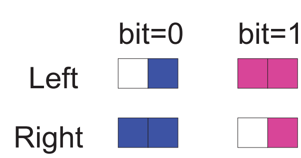

Figure 21: Base patterns for logic levels 1 and 0

Decoding begins when the sensor detects a marker on either side of the track. It continues as long as markers are present on the left or right side. Decoding is completed when no marker is detected on either side, at which point the captured value is stored.

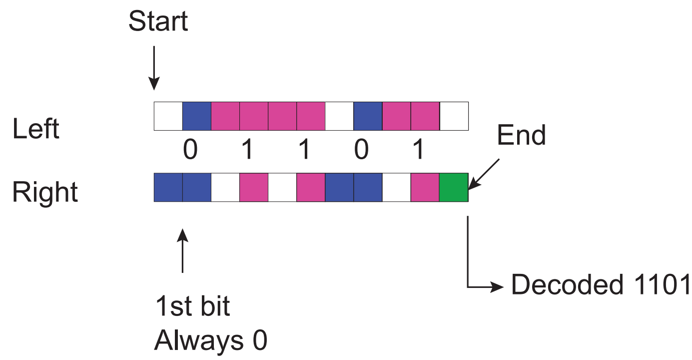

Figure 22: Example of 4-bit Navicode

A Navicode always starts with bit value **0** and ends with an end marker, as shown in the figure. These conventions allow the code to be detected correctly regardless of robot orientation or travel direction.

Navicodes can range from 1 bit to 16 bits in length. When a code is successfully recognized, its value is stored in a register that can be read through serial communication or CAN communication.

An 8-bit counter increments each time a valid code is recognized. The navigation controller or PLC can monitor this counter to detect the arrival of a new code and then read the stored code value.

The table below shows Navicode patterns for values **0 to 7**. Each code and its rotated version are decoded identically by the sensor.

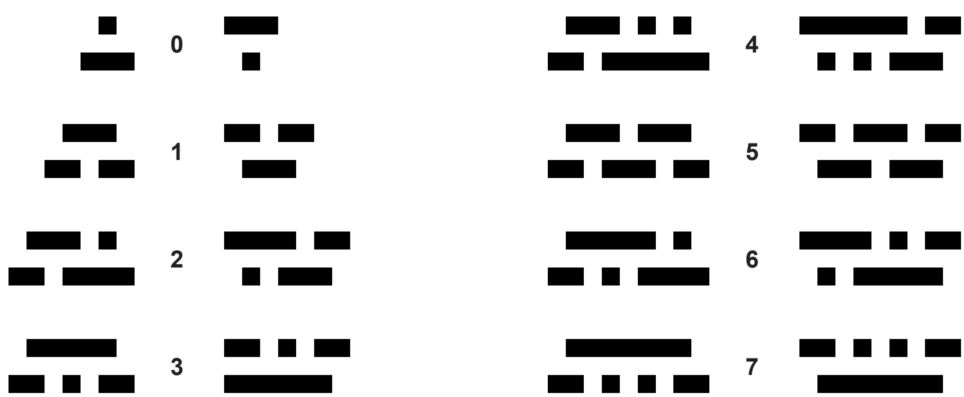

Figure 23: 3-bit Navicodes Table

A Navicode pattern generator is available on the Naviq website. This tool will create an image of the marker elements' arrangement based on a user-entered value.

Internal Sensors Self-Test

The MTS160 includes an internal self-test function that verifies the operation of its 32 internal magnetic sensor ICs. The test is performed automatically at power-up and can also be started manually through USB, RS232, or CANopen communication.

During the test, embedded electromagnets are briefly energized to generate a local magnetic field beneath each sensing element. The MCU checks that the response of each internal sensor changes by an amount within the expected range. If any sensor does not respond correctly, or if the measured change falls outside the valid range, the self-test fails.

The self-test results are stored in three registers and can be read at any time through the communication interface. The reported values are:

1- **Fail/Pass Status:** A value of 1 indicates the test failed, while 0 indicates a pass condition
2- **Minimum Field Difference**: The smallest change in the magnetic field detected by any of the sensors.
3- **Maximum Field Difference**: The largest change in the magnetic field detected by any of the sensors.

If the test fails, the specific type of fault can be determined, although the test does not indicate which of the 32 internal sensor ICs failed.

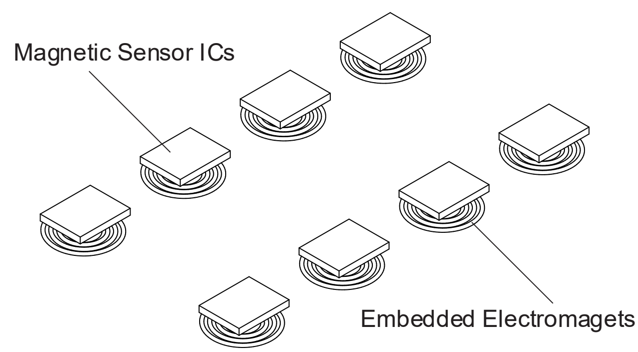

Figure 24: Embedded Self-Test electromagnets

In the event of a failure, the two RGB LEDs flash red to indicate a fault. Robot operation should be stopped until the cause has been investigated.

The complete self-test sequence takes approximately 30 ms. During this time, ambient magnetic conditions should remain stable, so manual self-tests should be performed while the robot is stationary.

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Status LED Flashing Patterns

The MTS160 has two RGB LEDs located behind the arrow-shaped window. These LEDs indicate the operating state of the sensor and the presence of tracks, markers, or point sources within the sensing range.

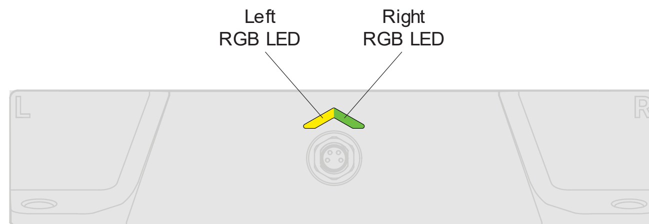
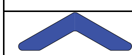
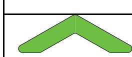
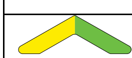
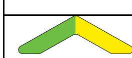
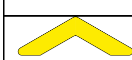
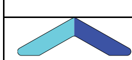
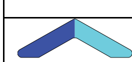
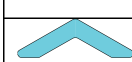
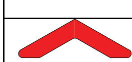
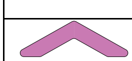
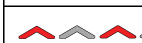


Figure 25: Status LED Indicator

LED Status		Track Detect	Left Marker	Right Marker	Description
	Steady Blue	No	No	No	The sensor is powered and ready, but no track, markers, or point sources are detected.
	Steady Green	Yes	No	No	The sensor is detecting a magnetic track, with no markers detected alongside it.
	Steady Yellow Green	Yes	Yes	No	The sensor is detecting a magnetic track and a marker on the left side. The yellow LED indicates the side on which the marker is detected.
	Steady Green Yellow	Yes	No	Yes	
	Steady Yellow	Yes	Yes	Yes	The sensor is detecting a magnetic track with markers on both sides.
	Steady Cyan Blue	No	Yes	No	The sensor is detecting a left-side marker only, with no track present. The cyan LED indicates the side on which the marker is detected.
	Steady Blue Cyan	No	No	Yes	
	Steady Cyan	No	Yes	Yes	The sensor is detecting markers on both sides, with no track present.
	Steady Red	No	No	No	The sensor is non-functional or has encountered a critical fault.
	Steady Purple				Sensor is not calibrated. Perform zero-calibration with the Naviq utility
	Flashing Red	Pattern Dependent			Alternating red and any of the color patterns listed in this table indicates that the sensor failed one or more internal self-tests. It may still output data, but robot operation should be stopped, and the sensor serviced.

Serial Commands

The MTS160 supports a set of ASCII text commands over RS232 and USB. Commands are not case-sensitive.

All commands and replies are terminated by a carriage return character (0x0D, \r)

! Set

Commands beginning with ! are used to execute actions or update configuration parameters.

When a command is accepted, the sensor replies with the command name followed by ,OK. If a command is recognized but cannot be completed, the sensor replies with ,ERROR. Unknown or malformed commands may return no reply.

Most configuration commands update the active runtime configuration immediately, but do not write the new values to nonvolatile memory by themselves. Send !SAVE after configuration changes to keep them after power cycling. !ZERO and !RSET save their changes automatically.

Example:

Set Sensor Configuration: !SNCF,0,50,600,1,250
Reply: !SNCF,OK

Save Configuration: !SAVE
Reply: !SAVE,OK

? Get

Commands beginning with ? are used to request live sensor data, fixed sensor information, or current configuration values.

The sensor replies with the command name followed by a comma and the requested data.

Examples:

Get Firmware Revision: ?FWVR
Reply: ?FWVR,106,20240325,2882400018

Get Sensor Configuration: ?SNCF
Reply: ?SNCF,0,50,600,1,250

Repeat / @ Stop Repeat

Commands starting with the # character are Get commands identical to these above, except that the sensor will send a reply with new data repeatedly. The repeat rate is determined by a value in milliseconds, separated by a comma, at the end of the command.

Multiple repeat commands can be running at the same time all with their own repeat rate.

Sending the @ character stops all the running repeat commands.
Use repeat mode only with Get commands. The repeat scheduler runs with a 5 ms internal resolution, so periods that are multiples of 5 ms are recommended.

Example:

Get Sensor Values every 10ms: #SALL,10
Repeating reply: ?SALL,2,-12,15,3,-4,1,0,0,1,0,-240,55,0,0,250

Stop Repeating: @

Commands Summary

The tables below summarize all the commands supported by the sensor. Details for each command are in the sections that follow.

Actions Commands (! Set Only)

Command	Description
RSET	Reset to Factory Defaults
STST	Perform Self-Test
ZERO	Calibrate Zero Level
SAVE	Save Active Configuration to Flash

Data Requests (? Get Only)

Command	Description
CNER	CAN Error Counters
FWVR	Firmware Version
HWVR	Hardware Version
NVCD	Navicode
RSEN	Internal Sensor Values
SALL	Read All Sensor Data
SNID	Sensor Serial Number
STRS	Self-Test Results
TWID	Tape Magnetic Width

Configuration Commands (! Set and ? Get)

Command	Description
CMCF	Communication Mode
CNCF	CAN Configuration
RSCF	RS232 Configuration
SNCF	Sensor Configuration
TDTH	Tape Detection Strength Thresholds

Action Commands

RSET — Reset to Factory Defaults

Category: Action Commands

Description:
Resets calibration, sensor configuration, and communication configuration to factory-default values, saves the defaults to nonvolatile memory, and reloads the active communication settings.

This command clears the zero calibration. The sensor must be zero-calibrated again before use.

Syntax: !RSET

Arguments: None

STST — Perform Self-Test

Category: Action Commands

Description:
Initiates the internal self-test of the MTS160 sensing system. Use ?STRS to read the test results.

Syntax: !STST

Arguments: None

ZERO — Calibrate Zero Level

Category: Action Commands

Description:
Captures and stores the ambient magnetic field strength at each internal sensor when no track or markers are present. These values are subtracted from subsequent readings.

Syntax: !ZERO

Arguments: None
The zero calibration is saved to nonvolatile memory automatically.

SAVE — Save Active Configuration

Category: Action Commands

Description:
Writes the current active configuration to nonvolatile memory.

Use this command after changing communication settings or sensor configuration with !CMCF, !RSCF, !CNCF, !SNCF, or !TDTH if the changes should remain in effect after power cycling.

Syntax: !SAVE
Arguments: None

Data Requests

CNER — Read CAN Error Counters

Category: Data Requests

Description:
Reads the current CAN controller transmit and receive error counters.

Syntax: ?CNER

Reply: ?CNER,TxError,RxError

TxError
Type: Unsigned 8-bit Range: 0-255
RxError
Type: Unsigned 8-bit Range: 0-255

FWVR — Read Firmware Version

Category: Data Requests

Description:
Reads the firmware revision, build date, and firmware hash.

Syntax: ?FWVR

Reply: ?FWVR,Revision,Date,FirmwareHash

Revision
Type: Unsigned 32-bit Format: 10203 = v1.2.3

Date
Type: Unsigned 32-bit Format: YYYYMMDD

FirmwareHash
Type: Unsigned 32-bit

HWVR — Read Hardware Version

Category: Data Requests

Description:
Read the Hardware Version code.

Syntax: ?HWVR

Reply: ?HWVR,Version

Version
Type: Unsigned 8-bit

NVCD — Read Navicode Marker

Category: Data Requests

Description:
Reads the last decoded Navicode value and the associated detection counter. The counter increments each time a valid Navicode is detected. Navicode decoding requires markers alongside a detected guide tape; standalone point-source markers without tape do not update this value.

Syntax: ?NVCD

Reply: ?NVCD,NaviCode,Count

NaviCode
Type: Unsigned 16-bit Range: 0-65535

Count
Type: Unsigned 8-bit Range: 0-255

RSEN — Read Internal Sensor Values

Category: Data Requests

Description:
Reads the values of all 32 internal magnetic sensors after zero-offset correction. The first 16 values are the front row and the next 16 values are the back row.

Syntax: ?RSEN

Arguments: None

Reply: ?RSEN,Front1,...,Front16,Back1,...,Back16

Front(n), Back(n)
Type: Signed 16-bit Units: µT

SALL — Read All Sensor Data

Category: Data Requests

Description:
Reads the main sensor measurement set in a single comma-delimited reply. The values are defined by their fixed order in the message. An 8-bit frame counter is appended at the end of the reply and increments each time SALL is requested, either by a ? command or by a # repeat command.

Syntax: ?SALL

Arguments: None

Reply:

?SALL,TDet,LTPos,RTPos,LTAng,RTAng,LM,RM,Fork,Merge,Intersection,LMX,LMY,RMX,RMY,Count

TDet: Tape detect and strength
Type: Unsigned 8-bit Units: - Range: 0 = none, 1 = weak, 2 = medium, 3 = strong

LTPos: Left track position
RTPos: Right track position
Type: Signed 8-bit Units: mm Range: -128 to 127

LTAng: Left track angle
RTAng: Right track angle
Type: Signed 8-bit Units: degrees Range: -128 to 127

LM: Left marker detected
RM: Right marker detected
Type: Unsigned 8-bit Units: - Range: 0 or 1

Fork: Fork feature flag
Merge: Merge feature flag
Intersection: Intersection feature flag
Type: Unsigned 8-bit Units: - Range: 0 or 1

LMX: Left marker X position
LMY: Left marker Y position
RMX: Right marker X position
RMY: Right marker Y position
Type: Signed 16-bit Units: 0.1 mm

Count: Frame counter
Type: Unsigned 8-bit Units: - Range: 0-255

Fork, Merge, and Intersection are implemented feature flags in current firmware. They are advisory detection hints derived from the magnetic geometry and should be validated on the actual tape layout before being used for route decisions.

Marker X/Y fields are reported in tenths of a millimeter. For example, -235 means -23.5 mm. When a marker is not detected, its position fields report 0. When no guide tape is present, a standalone point-source magnet is commonly reported as both left and right marker detections at the same lateral position.

SNID — Read Sensor Serial Number

Category: Data Requests

Description:
Reads the sensor's unique hardware identification number.

Syntax: ?SNID

Reply: ?SNID,SerialNum

SerialNum
Type: Unsigned 32-bit

STRS — Read Self-Test Results

Category: Data Requests

Description:
Reads the results of the most recent self-test, whether performed automatically at power-up or started by the user. Returns the pass/fail status followed by the minimum and maximum magnetic delta measured across the internal sensing ICs.

Syntax: ?STRS

Reply: ?STRS,Result,MinMagDelta,MaxMagDelta

Result
Type: Unsigned 8-bit - Range: 1 = Pass
0 = Fail

MinMagDelta
Type: Unsigned 16-bit Units: µT Range: 0-65535

MaxMagDelta
Type: Unsigned 16-bit Units: µT Range: 0-65535

TWID — Read Tape Magnetic Width

Category: Data Requests

Description:
Reads the current tape magnetic width used by the tracking algorithm.

Syntax: ?TWID
Reply: ?TWID,Valid,MagneticWidth

Valid
Type: Unsigned 8-bit Range: 0 or 1

MagneticWidth
Type: Unsigned 16-bit Units: 0.1 mm Range: 0-65535

Valid indicates whether automatic width detection has converged. MagneticWidth is reported in tenths of a millimeter.

Configuration Commands

CMCF — Communication Mode

Category: Configuration Commands

Description:
Select the sensors communication mode and protocol

Set Syntax: !CMCF,Mode

Get Syntax: ?CMCF
Reply: ?CMCF,Mode

Mode
- 0: RS232 (Factory Default)
- 1: CANopen

Use !SAVE after changing this value if the new mode should remain active after power cycling.

CNCF — CAN Configuration

Category: Configuration Commands

Description:
Defines the parameters necessary for CAN Operation.

Set Syntax:
!CNCF,NodeId,Bitrate,AutoRun,TermResistor,Heartbeat,TPDO1on,Period1,TPDO2on,Period2,TPDO3on,Period3

Get Syntax: ?CNCF
Reply:
?CNCF,NodeId,Bitrate,AutoRun,TermResistor,Heartbeat,TPDO1on,Period1,TPDO2on,Period2,TPDO3on,Period3

NodeId
Type: Unsigned 8-bit - Range: 1-127
Default: 1

Bitrate
- 125000: 125kbits/s
- 250000: 250kbits/s (Factory Default)
- 500000: 500kbits/s
- 1000000: 1000kbits/s

AutoRun
- 0: Disabled (Factory Default)
- 1: Enabled

TermResistor - 120-ohm Termination Resistor
- 0: Disabled (Factory Default)
- 1: Enabled

Heartbeat

Type: Unsigned 16-bit Units: milliseconds Range: 0-65535 Default: 1000

TPDO1on
TPDO2on
TPDO3on
 0: Disabled (Factory Default)
 1: Enabled

Period1
Period2
Period3
Type: Unsigned 16-bit Units: milliseconds Range: 0-65535 Default: 10
A TPDO is transmitted only when its enable field is 1 and its period is nonzero. Use !SAVE after changing CAN settings if they should remain after power cycling.

RSCF — RS232 Configuration

Category: Configuration Commands

Description:
Defines the operating parameters for the RS232 interface.

Set Syntax: !RSCF,Baudrate,Inverted

Get Syntax: ?RSCF
Reply: ?RSCF,Baudrate,Inverted

Baudrate
 9600 bit/s
 19200 bit/s
 38400 bit/s
 57600 bit/s
 115200 bit/s (Factory Default)

Inverted
 0: Standard RS232 signaling (Factory Default)
 1: Reserved
Baud-rate changes are applied after the !RSCF,OK reply is sent. The Inverted field is retained for compatibility; use 0 for current firmware. Use !SAVE after changing these values if the new settings should remain after power cycling.

SNCF — Sensor Configuration

Category: Configuration Commands

Description:
Configures tape polarity, marker polarity, tape edge detection, marker threshold, and tape magnetic width handling.

Set Syntax:
!SNCF,Polarity,TapePulseThreshold,MarkerThreshold,AutoWidth,TapeMagneticWidth

Get Syntax: ?SNCF
Reply:
?SNCF,Polarity,TapePulseThreshold,MarkerThreshold,AutoWidth,TapeMagneticWidth

Polarity
0: Tape north on top, marker south on top (Factory Default)
1: Tape south on top, marker north on top

TapePulseThreshold
Type: Unsigned 8-bit Units: % Range: 0-100
Default: 50

MarkerThreshold
Type: Unsigned 16-bit Units: uTesla Range: 0-65535
Default: 600

AutoWidth
Type: Unsigned 8-bit Range: 0: Disabled, 1: Enabled Default: 1

TapeMagneticWidth
Type: Unsigned 16-bit Units: 0.1 mm Range: 0-65535 Default: 250

When AutoWidth is enabled, the sensor estimates the magnetic width from the detected tape. When AutoWidth is disabled, TapeMagneticWidth is used as the fixed magnetic width. The default value 250 means 25.0 mm. Use !SAVE after changing these values if the new settings should remain after power cycling.

TDTH — Tape Detection Strength Thresholds

Category: Configuration Commands

Description:
Configures the absolute magnetic field thresholds used to classify tape strength in the TDet field of ?SALL and the CAN TPDO status byte.

Set Syntax: !TDTH,Weak,Medium,Strong
Get Syntax: ?TDTH

Reply: ?TDTH,Weak,Medium,Strong

Weak
Type: Unsigned 16-bit Units: µT Default: 400

Medium
Type: Unsigned 16-bit Units: µT Default: 800

Strong
Type: Unsigned 16-bit Units: µT Default: 1200

Use !SAVE after changing these values if the new thresholds should remain after power cycling.

CAN Communication

The MTS160 supports CANopen, allowing integration with navigation controllers, motor drives, PLCs, and other devices on a CAN bus.

TPDO Communication

The MTS160 transmits sensor data using up to three Transmit Process Data Objects (TPDOs). Each TPDO carries a different class of information and can be enabled or disabled independently.

A TPDO is transmitted when it is enabled and its configured transmission period is nonzero. Through the CANopen event-timer SDO (0x1800:5, 0x1801:5, or 0x1802:5), writing a nonzero period enables the corresponding TPDO and writing 0 disables it. Through the serial CNCF command, both the TPDO enable field and the period field must be set.

Valid period values are 0 to 65535 ms. Sensor measurements are generated every 5 ms, so TPDO periods below 5 ms can repeat the same measurement sample.
Multi-byte values in TPDO payloads are transmitted little-endian, with the least significant byte first.

"Sense" TPDO:

This TPDO reports the main track-following data, including left and right track position, left and right track angle, and sensor status flags. It is the primary TPDO used for real-time navigation control.

Header	Byte Count
0x180 + NodeID	5

Frame Payload:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Left Position	Right Position	Left Angle	Right Angle	Status Flags

Status Flags Byte Detail:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Merge Detect	Fork Detect	Intersection Detect	Right Marker Detect	Left Marker Detect	Track Detect & Strength		Unused (0)

Track position and angle values are signed 8-bit integers.
The two Track Detect & Strength bits use the same encoding as the serial SALL TDet field: 0 = no tape, 1 = weak, 2 = medium, 3 = strong. Bit 0 is unused in current firmware and is transmitted as 0.
The fork, merge, and intersection bits are implemented in current firmware. Treat them as advisory feature flags derived from magnetic geometry and validate them on the actual tape layout before using them for route decisions.

"Marker" TPDO:

The "Marker" TPDO delivers precise lateral and longitudinal position data related to point-source markers. This information is critical for last-millimeter positioning.

Header	Byte Count
0x280 + NodeID	8

Frame Payload:

Byte 1	Byte 2	Byte 3	Byte 4
Left Marker X Position LSB	Left Marker X Position MSB	Left Marker Y Position LSB	Left Marker Y Position MSB

Byte 5	Byte 6	Byte 7	Byte 8
Right Marker X Position LSB	Right Marker X Position MSB	Right Marker Y Position LSB	Right Marker Y Position MSB

Position values are signed 16-bit values in tenths of a millimeter (e.g. -235 is -23.5 mm)
When no guide tape is present, a standalone point-source magnet is commonly reported as both left and right marker detections at the same lateral position.

"Navicode" TPDO:

This TPDO reports the presence and value of Navicode Markers, allowing for the detection and decoding of these localization markers along a navigation path.

Header	Byte Count
0x380 + NodeID	3

Frame Payload:

Byte 1	Byte 2	Byte 3
Navicode LSB	Navicode MSB	Counter

Counter is incremented every time a new Navicode is detected and captured.
Navicode decoding requires markers alongside a detected guide tape; standalone point-source markers without tape do not update this TPDO.

Auto-Run Automatic TPDO Transmission

When Auto Run is enabled, the sensor enters CANopen operational state at power-up and begins transmitting enabled TPDOs. Heartbeat messages are transmitted whenever the heartbeat period is nonzero.

When Auto Run is disabled, the sensor starts in CANopen pre-operational state and waits for network control before transmitting TPDOs. If the heartbeat period is nonzero, heartbeat messages are still transmitted in pre-operational state.

SDO Objects

The MTS160 sensor supports a set of Service Data Objects (SDOs) that allow for parameter setting and sensor configuration. The functions accessible via SDOs are: SDO writes update the active configuration in RAM. To make changes survive a power cycle, save the configuration through the Naviq utility or by sending the serial !SAVE command over USB or RS232.

Zero Setting

Starts zero-level calibration of the internal magnetic sensors. This should be performed after installation and before normal operation:

Index	Sub	Name	Type	Access
0x2000		ZERO	Unsigned 8-bit	Write Only

Perform Self-Test

Starts the internal self-test of the 32 magnetic sensing ICs. This command can be used to force a self-test at any time while the sensor is powered.

Index	Sub	Name	Type	Access
0x2001		SELFTEST	Unsigned 8-bit	Write Only

Track and Marker Parameters

This SDO is used to modify the first three sensor-configuration parameters exposed by the serial SNCF command.

Index	Sub	Name	Type	Access
0x2002	1	TAPE POLARITY	Unsigned 8-bit	Read/Write
0x2002	2	TAPE PULSE THRESHOLD	Unsigned 8-bit	Read/Write
0x2002	3	MARKER THRESHOLD	Unsigned 16-bit	Read/Write

Tape polarity values are 0 for tape north on top and marker south on top, or 1 for tape south on top and marker north on top. Tape pulse threshold is a percentage of the detected tape peak. Marker threshold is in microtesla.

Read Self-Test Results

This SDO provides the results of the most recent self-test, whether performed automatically at power-up or started by the user. It returns the test result together with the minimum and maximum magnetic delta measured across the internal sensing ICs.

Index	Sub	Name	Type	Access
0x2003	1	SELFTEST RESULT	Unsigned 8-bit	Read Only
0x2003	2	MIN MAGNETIC DELTA	Unsigned 16-bit	Read Only
0x2003	3	MAX MAGNETIC DELTA	Unsigned 16-bit	Read Only

Self-test result is 1 for pass and 0 for fail. Minimum and maximum magnetic delta values are in microtesla.

Heartbeat

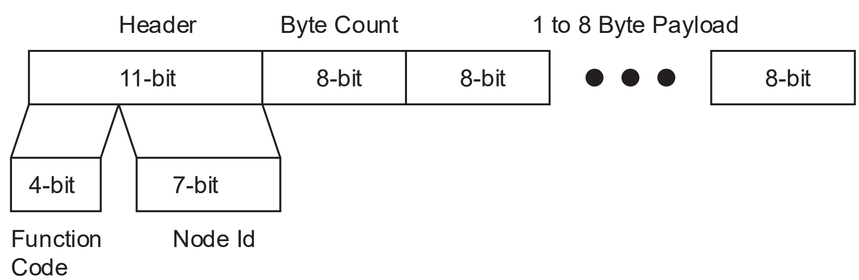
The sensor supports the standard CANopen heartbeat mechanism. The heartbeat interval can be set from 0 to 65535 ms. The factory-default heartbeat interval is 1000 ms. A value of 0 disables heartbeat transmission. For any nonzero setting below 100 ms, the firmware uses a 100 ms heartbeat interval.

Using the Sensor without CANopen

The sensor can be easily operated by Navigation Computers with a CAN interface, even if they do not have a full CANopen Protocol Stack.

To achieve this, enable and set the send rate for the desired TPDO(s) and activate the Auto-Run feature using the Naviq Utility. With Auto-Run enabled, the sensor will start sending the TPDOs and heartbeat at the specified rate, regardless of any other activity on the CAN network.

The data can then be captured and parsed using C or Python code on the navigation computer. Most CAN drivers will store the complete incoming frame, which is structured as follows:



The parsing program first analyzes the header. Performing a bitwise AND operation with 0x7F will isolate the Node ID, which must then be compared with the sensor's Node ID to verify if the frame originated from the MTS160 sensor.

If this is the case, the upper part of the header should be isolated by performing a bitwise AND operation with 0xFF80. It should then be compared with 0x180, 0x280, and 0x380 to determine whether the frame contains TPDO1, TPDO2, or TPDO3.

The payload is then parsed according to the corresponding TPDO mapping described earlier in this manual.

Sample code can be obtained from the Naviq website.

CANopen EDS File for MTS160 Magnetic Guide Sensor

The Electronic Data Sheet (EDS) file for the MTS160 Magnetic Guide Sensor is provided to facilitate integration into a CANopen network. Containing information such as communication parameters and device-specific settings, the EDS file is necessary for proper configuration and operation within the network. It can be downloaded from the Resources section on the Naviq website at naviq.com

Connecting and Using the Naviq Utility

The MTS160 is supported by the Naviq Utility, which provides tools for configuration, monitoring, logging, and firmware updates. It can be used to:

- configure the sensor operating mode
- view magnetic field strength in real time
- monitor track position, angle, and marker detection
- capture and review data logs
- update the sensor firmware

Web-Based Utility

The **MTS160 utility** is a web-based program that users access through a web browser, offering several key benefits:

No Installation Required: Users do not need to download or install any software, simplifying the process and reducing potential software conflicts

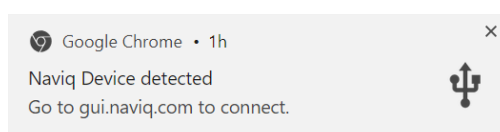
Platform and Hardware Independence: The MTS160 utility operates through a web browser, making it compatible with any operating system, such as Windows, macOS, Linux, and others. It is also hardware-independent, meaning it can run on various devices, including PCs, Macs, Linux machines, smartphones, and tablets, as long as they have a USB port for connecting to the sensor. This broad compatibility eliminates the need for multiple versions of the software and ensures all users have a consistent experience.

Automatic Updates: Updates are applied directly on the Naviq server, so users always have access to the latest version without needing to manually update their software

Connecting the Sensors and Launching the Utility

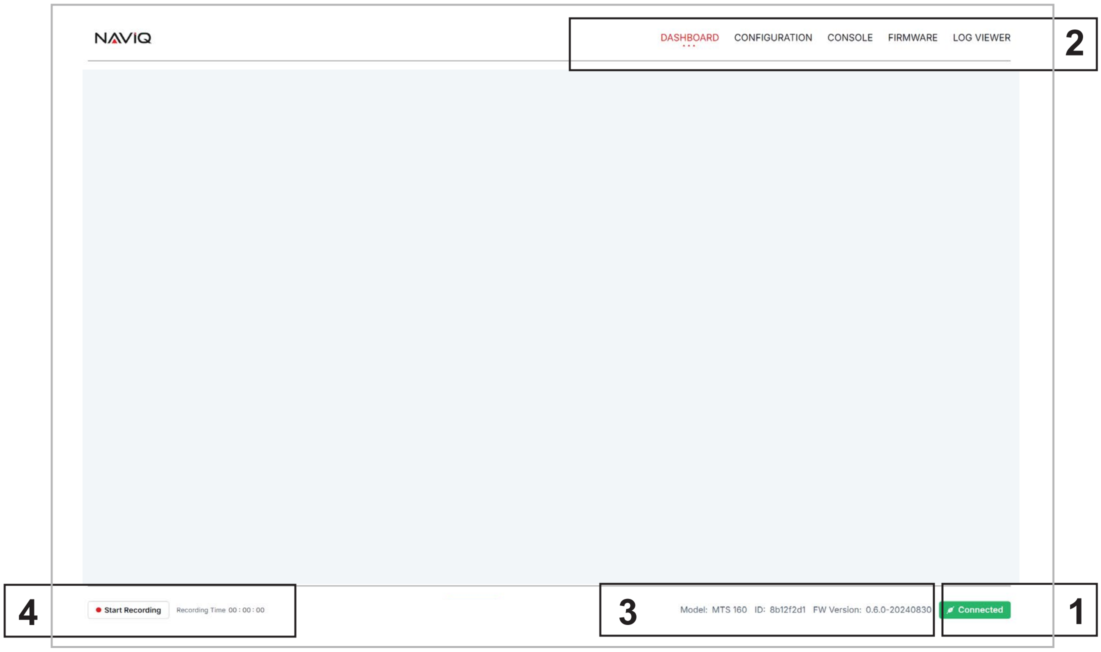
To launch the utility simply connect the sensor to the PC via the USB port, with or without power on the main M8 connector. If unconnected to a power supply, the sensor will take power from the PC and turn on.

The PC will establish the USB communication and a small pop up window will appear at the bottom right of the screen.



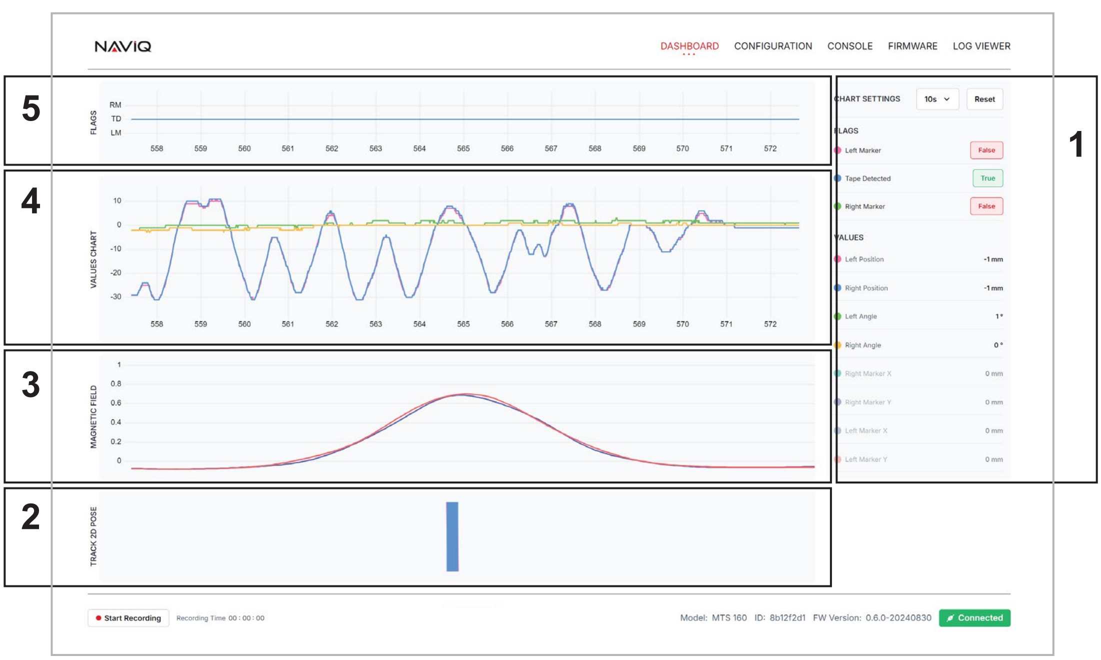
Clicking on that window will open a browser with the Naviq Utility.

The GUI is composed of a header menu and a footer that remain displayed at all times. The key components are:



1- Connection status. If the sensor is attached to USB and the flag shows disconnected, click on it to select the sensor and pair it
2- Main Menu
3- The sensor hardware and firmware identification
4- Data Logging Control

Dashboard

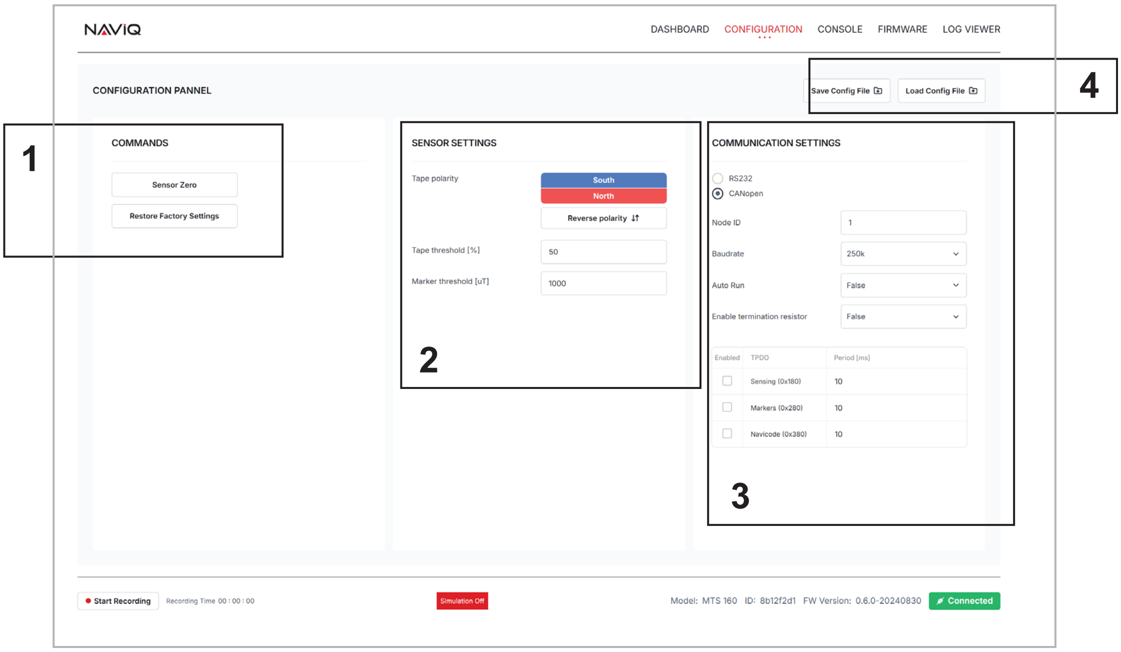


The dashboard is where the sensor information can be visualized. The screen is composed of 5 sections:

1- Numeric Views and Chart Controls. Clicking on any item will show or hide it from the plot windows.

2- Visualization of the relative position and angle of each of the two tracks.
3- Magnetic field visualization,
4- Scroll chart for plotting any of the sensor’s captured values.
5- Track and Markers Presence Scroll chart

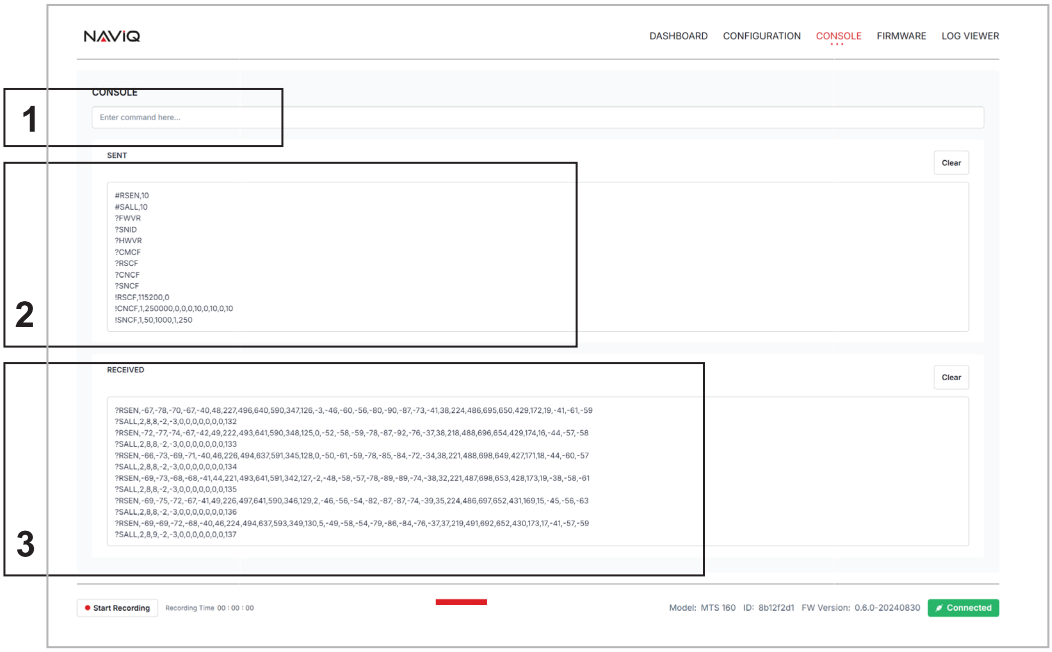
Configuration



The configuration screen is composed of four sections:

1- Commands buttons for calibrating the ambient zero-level reference and for resetting the sensor’s factory default configuration.
2- Setting parameters relating to the track and marker detection
3- Selecting and setting the communication protocol
4- Saving and restoring configurations to/from disk. This functionality is useful when multiple sensors need to be prepared with the same configuration during production.

Console

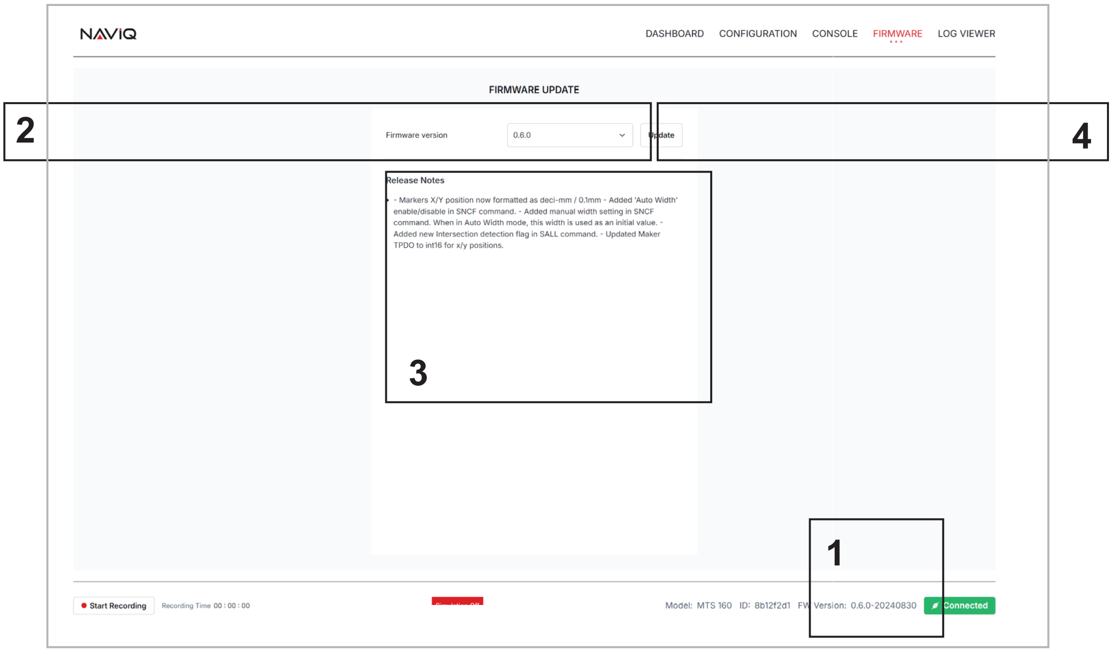


The console is intended primarily as a development and integration aid. Normal operation does not require it, since sensor data and configuration settings can be viewed and changed more efficiently through the GUI.

It is provided as a development aid for manually exercising the serial commands described in this manual, particularly when integrating a navigation computer. The console simplifies the process of sending raw commands and displaying the sensor's response. It consists of three elements:

1- User entry field.
2- History of commands sent to the sensor, including these sent by the GUI as a result of user selections.
3- Responses from the sensor.

Firmware Update



The firmware page is used to update the sensor firmware. It is good practice to check for newer firmware whenever the sensor is connected to the utility. The window contains the following elements:

1- Currently installed firmware revision, shown in the footer on all GUI pages
2- Firmware selection menu, which retrieves available firmware versions from the Naviq server and lists the newest version first
3- Release Notes, which display the changes included in the selected version
4- Update button, which starts the firmware update process.

Data Logging

The Naviq Utility includes a data logging function for performance evaluation and troubleshooting. Sensor data can be captured and saved for later analysis. The data logging page includes five components:

1- Start/stop logging controls, available from any GUI page through the footer. Saved logs are stored in CSV format for import into spreadsheet tools such as Excel or Google Sheets.
2- Log file selection, allowing the most recent log or a previously saved log to be opened
3- Track-data graph, used to plot values such as track position and angle. Hovering over a trace shows the numeric value at that point. Each trace can be enabled or disabled independently.
4- Detection-state graph, used to plot track-detect and marker states
5- Zoom and pan controls for examining areas of interest.

Mechanical Dimensions

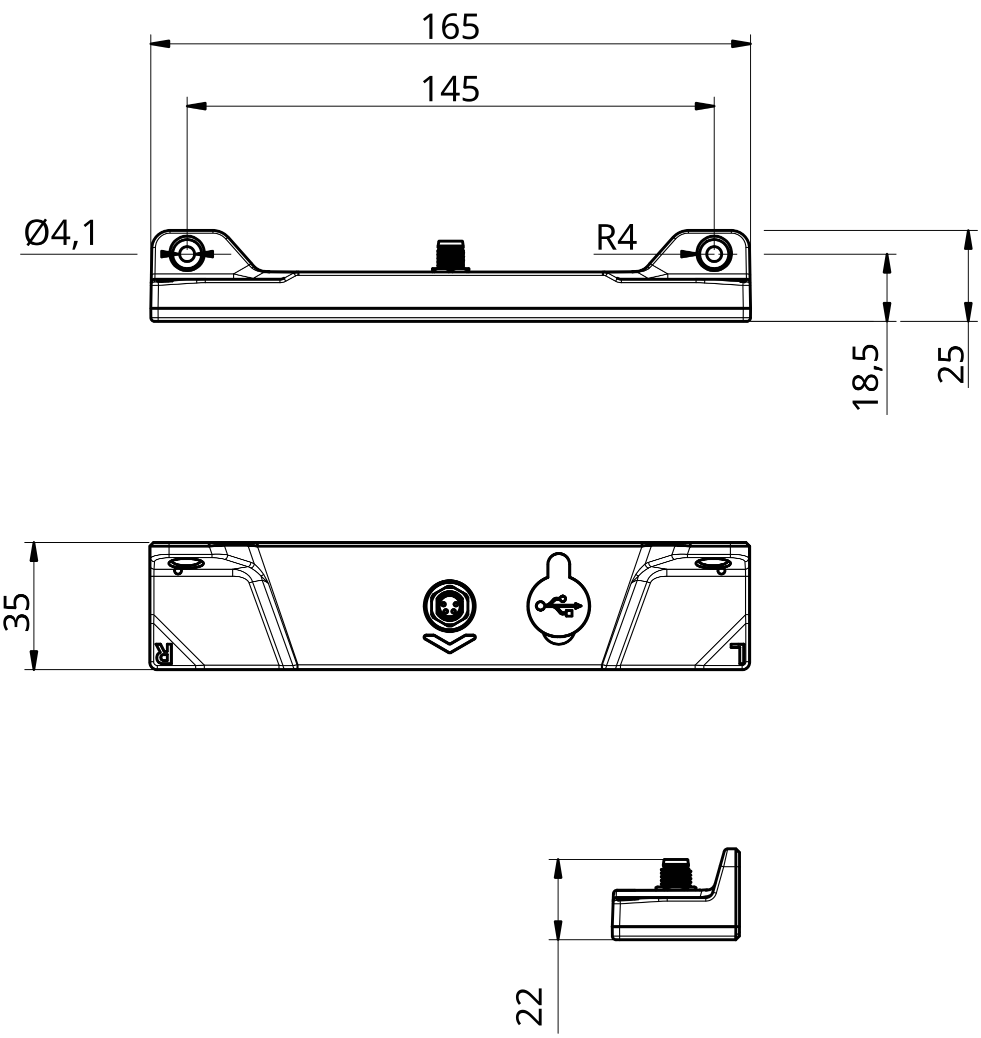


Figure 26: Mechanical dimensions

All dimensions are in milimeters

A 3D Step model of the MTS160 is available at naviq.com