NAVIQ

Navigation Intelligence

MTS160

Magnetic Track Sensor with Position and Angle Reporting

Installation and Operation Manual

Product Overview

Description

The MTS160 is a cutting-edge magnetic guide sensor designed specifically for mobile robots, offering precise tracking and position measurement capabilities. It is uniquely distinguished by its patented technology for detecting and measuring the angular incidence of a magnetic track, as well as its longitudinal position along the horizontal axis. This feature allows the robot to follow its designated paths with higher precision, and to navigate bends at increased speeds without compromising on accuracy or safety.

The MTS160 can serve as the sole guidance sensor in robots that follow fixed paths, offering the lowest cost solution without sacrificing precision or reliability. Alternatively, for robotic systems equipped with laser or vision navigation systems, the MTS160 can be integrated as an additional component to achieve last-millimeter positioning accuracy.

The sensor is optimized for detecting and following paths made with 25mm or 50mm adhesive magnetic tape, or other magnetic sources affixed to the floor. The MTS160 has a 160mm sensing width with a fine 1mm resolution and operates accurately at heights ranging from 10mm to 50mm.

This sensor supports selectable magnetic polarity of the track, allowing for the detection of both North or South polarities on top, and can manage 2-way forks and merges along the path. Additionally, it can detect magnetic “markers” of inverted polarity located on either side of the main track, allowing the robot to distinguish special locations along its path.

For connectivity, the MTS160 is equipped with an M8 4-pin watertight connector for power and signal transmission, and it supports a range of interfaces including CAN bus and RS232, making it compatible with all PLC brands and microcomputers. It features a built-in, software-enabled 120 ohm termination resistor, and boasts the industry's fastest update rate of 200Hz, ensuring timely and reliable data.

The sensor is also designed for ease of use, with RGB status LEDs for immediate feedback on tape and marker detection, and it comes with a PC utility for simple configuration, testing, and monitoring. Its software can be field-upgraded via the Internet to install the latest features, ensuring the sensor remains at the forefront of technology. An automatic self-test for internal magnetic sensor ICs guarantees consistent performance.

With its compact dimensions of 165 mm in width, 35 mm in depth, and 25 mm in height, and a durable IP54 rated enclosure, the MTS160 is built to operate in a wide range of environments, from -40o to +65o C, and is resistant to water splash. This makes it an ideal choice for a wide array of mobile robotics applications, offering both robustness and advanced technological features to navigate with precision and reliability.

Key Features

- Detects and measures position of up to two magnetic tracks along horizontal axis
- Reports angular position of each track
- Optimized for use with 25mm or 50mm wide adhesive magnetic tape
- 10mm to 50mm operating height

- 160mm sensing width with 1mm resolution
- 1-degree angular resolution
- Selectable, North or South on top, magnetic polarity of track
- Capable of detecting and managing 2-way forks and merges
- Detection of magnetic “markers” of inverted polarity at left or right of main track
- Precise detection along the X & Y axis of one or two magnetic point-sources
- M8 4-pin watertight connector for power and signals
- CANOpen interface up to 1Mbit/s
- Built-in, Software-enabled 120-ohm termination resistor
- RS232 Interface
- Compatible with all PLC brands and microcomputers
- Industry fastest 200Hz update rate
- RGB Status LEDs for tape and marker detection
- USB port for easy configuration, testing and monitoring using web app on PC or smartphone
- Field upgradeable software for installing latest features via the Internet
- Automatic self-test of internal magnetic sensor ICs
- Wide range 5V to 28V DC operation
- Low, < 1W power consumption
- 165 mm wide x 35 mm deep x 25 mm tall
- -40°C to +65°C operating environment
- IP54 rated enclosure. Resistant to water splash

Applications

- Automated Guided Vehicles
- Material Handling Systems
- Automated Manufacturing Lines
- Inventory Management Robots
- Personal Mobility Shuttles
- VNA (Very Narrow Aisle) truck Guidance
- Last-millimeter Positioning for Laser/Vision Guided Robots
- Theatrical Props
- Robotic Camera Dolly
- Smart Agriculture Systems
- Automated Parking Systems
- Interactive Exhibits

Important Safety Information

Intended Use

The MTS160 sensor is a non-contact sensor designed to provide navigation guidance to AGVs and Mobile Robot by determining the position of a magnetic line tape along a motion path.

Improper Use

The sensor is not classified as a safety device under the EC Machinery Directive (2006/42/EC) and must not be used in environments with explosion hazards. Any usage outside the specified intended use, or with unauthorized accessories, is considered improper and is at the user’s own risk. Improper use can lead to dangerous situations; users must strictly follow the usage guidelines and all operating instructions.

Limitation of Liability

While the Naviq MTS Magnetic Guide Sensor for AGVs and Mobile Robots utilizes state-of-the-art components and protection circuits, it is the responsibility of the user to ensure that their robot operates safely for both people and property at all times, regardless of the sensor's operating state. NAVIQ is not liable for any damages or injuries resulting from the use or misuse of this product. Naviq also accepts no liability for damages caused by failure to observe the operating instructions, improper use, untrained personnel, unauthorized modifications, or the use of unauthorized spare parts, consumables, or accessories.

Hazard Warnings and Operational Safety

Always adhere to the safety notes and warnings provided in these operating instructions to minimize risks and avoid hazardous situations.

Repairs

Repairs to the sensor should only be performed by NAVIQ's authorized and qualified personnel. Unauthorized repairs or modifications will void the warranty and may compromise safety.

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	200Hz
Number of Simultaneously 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, 512 or 1000kbits/
Bus Termination Resistor	120 ohm internal. Software enabled
Communication	
LEDs	Two RGB LEDs
Power-on Selftest	Physical verification on internal Sense ICs
Selftest	Full Hardware Diagnostics
Electrical	
Power Consumption	800mW
Supply Voltage	7 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	-20 oC to 65 oC
Certification	Compliant EN IEC 60947-5-2-2020
Dimensions	165mm x 35mm x25mm
Housing Material	SLA Resin or ABS
Weight	80g

Connector and LED Identification

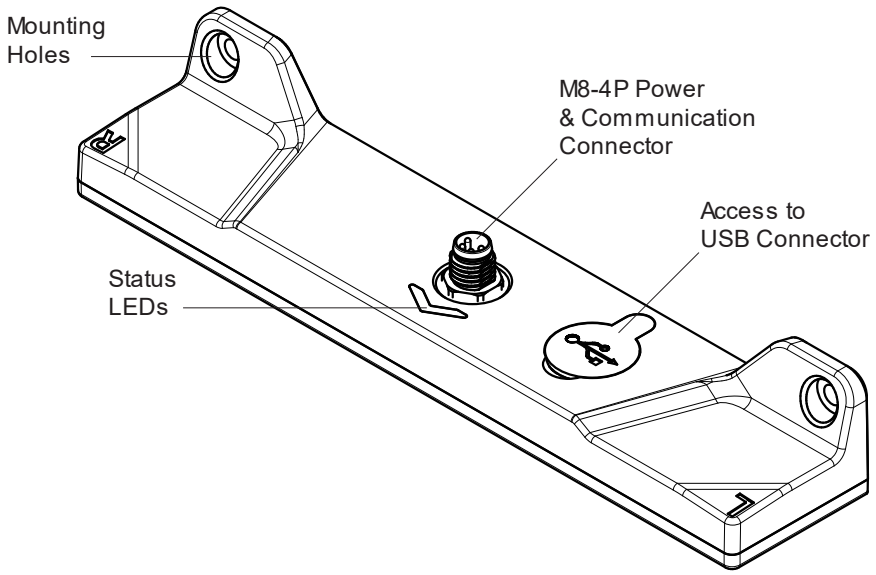


Figure 1 MTS160 features identification and location

Suitable magnetic materials

The sensor is designed to be compatible with magnetic tape that features a single pole pair (either north or south) with unipolar magnetization on one side, and it can accommodate various magnetic tape widths as well as various distances from the magnetic tape.

The sensor will not work with magnetic tape employing different forms of magnetization, such as alternating magnetization.

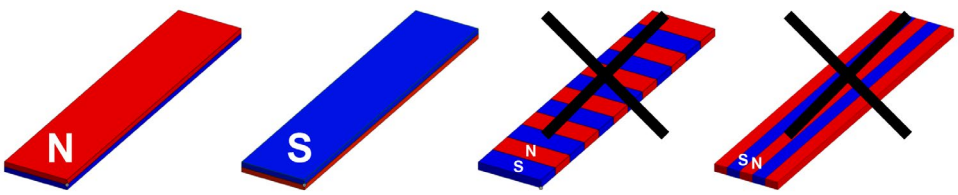


Figure 2: Suitable magnetization

The figure below showcases various types of magnetic materials that are compatible with the sensor. The field strength and polarity graph above the materials visually indicates the varying magnetic field strength and direction across different points.

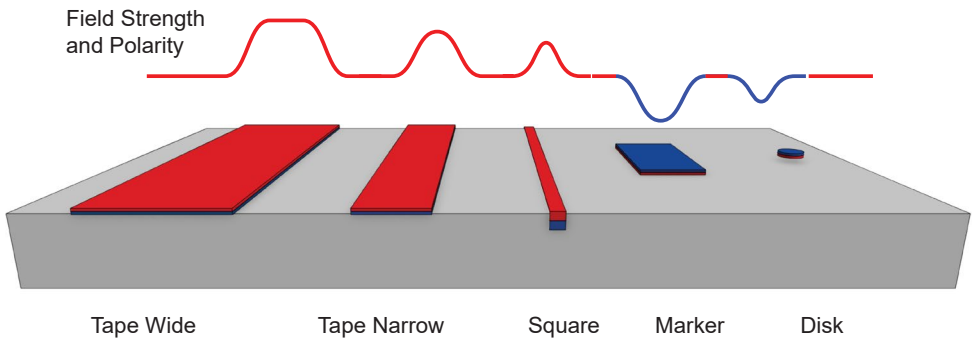


Figure 3: Useable Magnetic Components

Tracking Tape

Use magnetized tape to lay the track for the robot to follow. Tape is available in wide (50mm typical) and narrow (25mm typical) versions. The wider tapes generate a stronger field and have higher adhesion to the floor. The narrow tapes are more cost-effective.

For areas with high traffic of heavy equipment, flexible magnetic square profile can be inserted into the floor for best durability.

Position Markers

Markers are identical to tracking tape but have inverse polarity. They are used to provide reference points for robots along the track.

Point Source Disks

For more precise end-point positioning, the 20mm disks create a localized magnetic source which the sensor can use to align the robot in the X and Y direction. Point Source Markers may be ordered from Naviq.

Sensor Mounting

Left/Right Identification

As a convention, Left and Right sides are relative to the sensor's travel direction that is pointed by the arrow-shaped LED indicator, and are identified with the L and R letters engraved on the case.

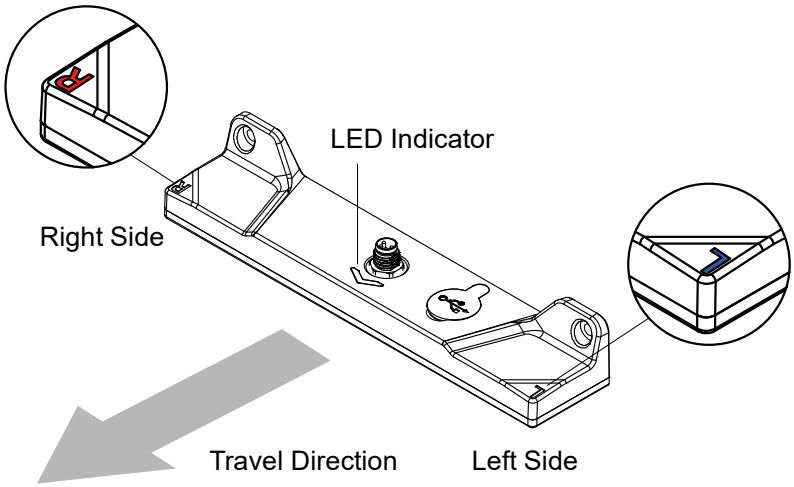


Figure 4: Left/Right sides identification

Mounting Orientation and Height

The mounting location on the robot must be as free from magnetic disturbance fields as possible.

The sensor must be fitted on the robot so that it is as perfectly parallel to the floor as possible along the length and width direction.

Ideal sensor height is 20mm from the floor.

The sensor must be fitted with the M8 connector facing upward.

For best performance, the sensor must remain at a constant height from the floor as the robot moves along the track.

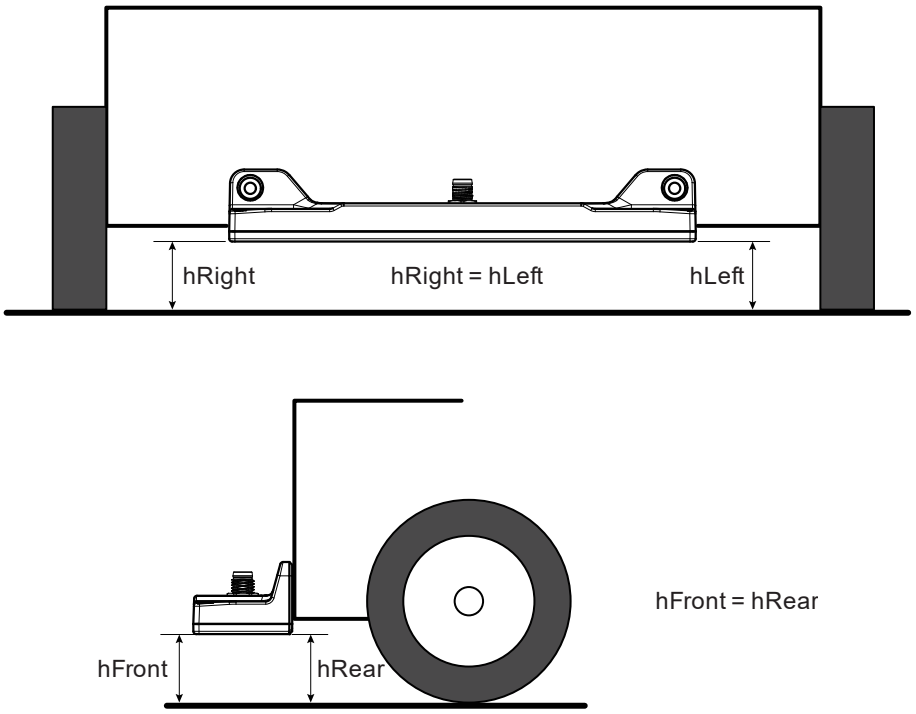


Figure 5: Sensor Mounting location and orientation

The center point of the sensor should be positioned at the Robot's center point, at a right angle to the direction of travel if possible.

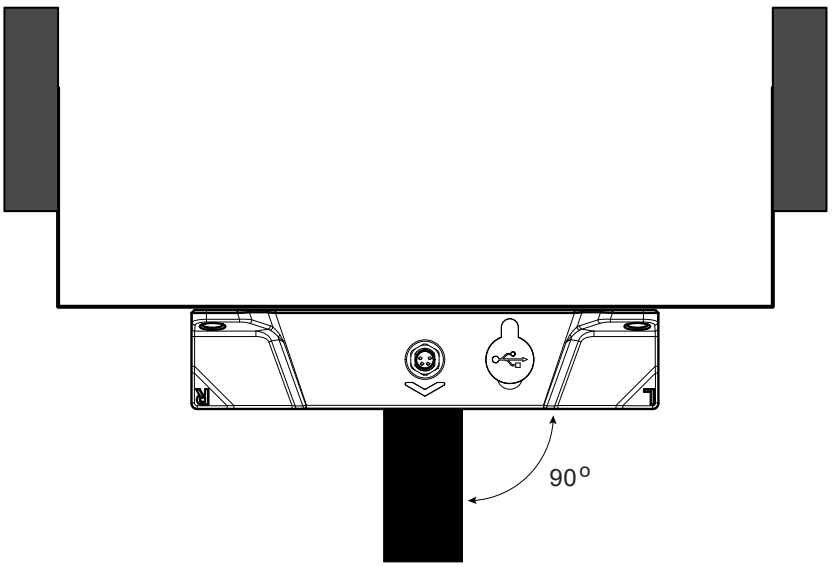


Figure 6: Sensor Mounting location and orientation

Optimal Position for Steering

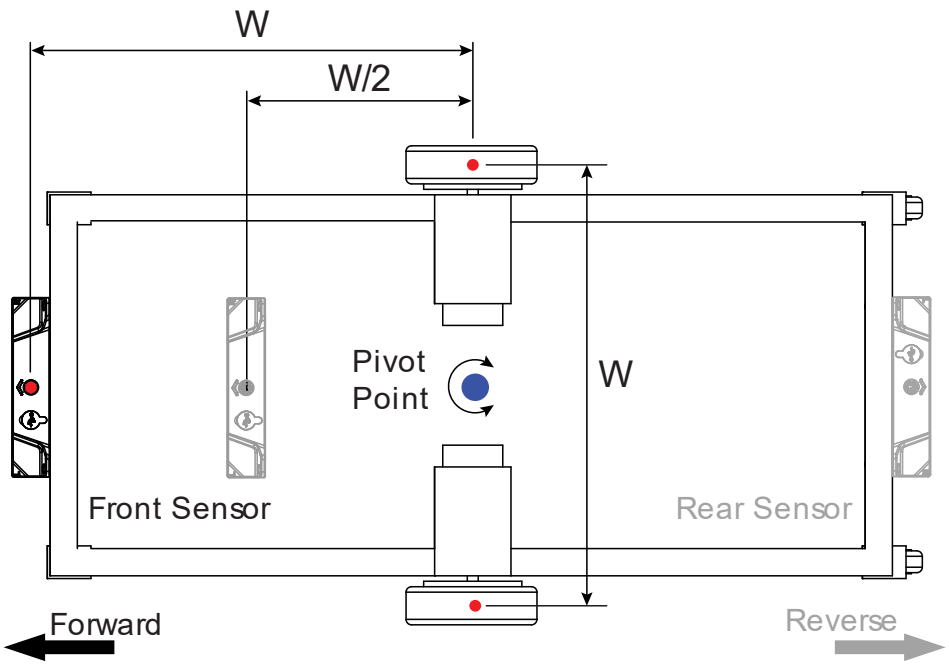


Figure 7: Optimal Sensor Placement

For robots using left/right motor-wheel arrangement the sensor must be placed at a distance relative to the wheel spacing W. 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).

Placing the sensor too close or too far from the pivot points will make it more difficult to achieve stable and precise control.

The sensor must be placed ahead relative to the robot's travel direction. For bidirectional control, sensors must be placed at both the front and rear ends of the robot.

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. The holes for the sensor are spaced 145 millimeters apart.

Position the holes 18.5mm higher than the desired height of the sensor above the floor. Drill two holes at these points that are sized appropriately for M4 screws and are drilled perpendicular to the mounting surface for a level attachment.

Align the sensor over the area, matching its mounting holes with those on the robot. Insert M4 stainless steel screws through the sensor's holes into the robot's holes. Stainless steel is preferred as it avoids the risk of magnetization, which could interfere with the sensor's functionality. Tighten the screws to secure the sensor in place, making sure it's firm but not overly tight to prevent any damage.

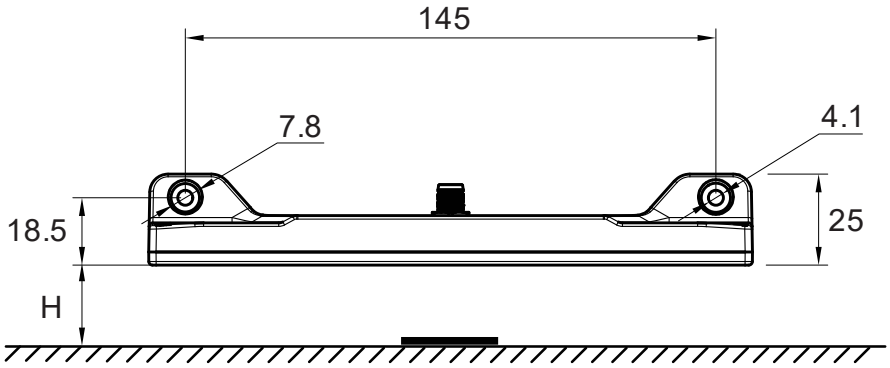


Figure 8: Dimensions for Mounting

M8 Connector Pin assignment

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

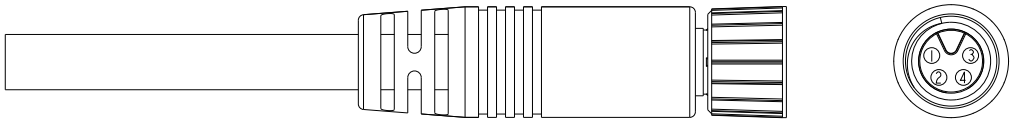


Figure 10: Preassembled M8 Cable

Pin Number	Signal	Description	Wire Color
1	VIN+	+5 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 30 V DC and capable of sourcing at least 2 W power.

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

Do not connect the M8 connector while the power is on. Always apply power after the connector is inserted.

Note that when the sensor is connected to a PC or smartphone via the USB port, it will be powered on from these devices if there is no power on the M8 cable.

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 choice of the protocol and interfaces are software selectable.

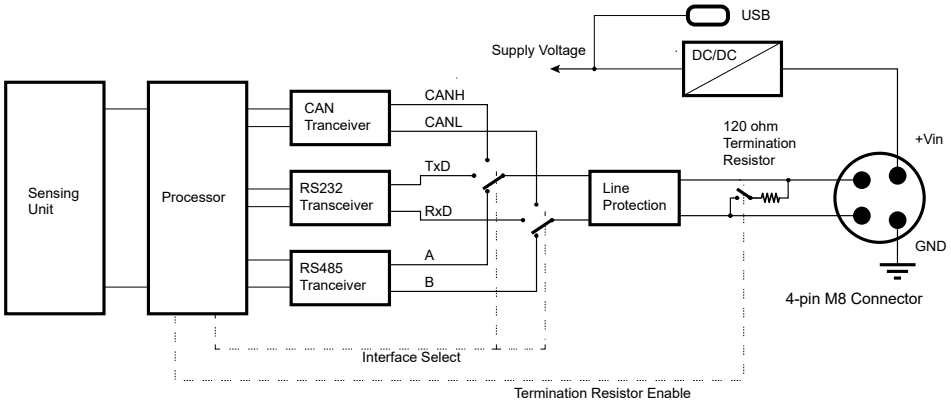


Figure 11: Internal Interface Switching Circuit

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.

It includes a built-in 120 Ohm termination resistor that can be activated via the Naviq PC Utility. The resistor is disabled by default.

When the built-in termination resistor is disabled, it is recommended to attach an external 120 Ohm terminator at both ends of the CAN bus network for optimal signal integrity.

RS232 Connection

When RS232 communication is selected, the RS232 Tx (transmit) and Rx (receive) data signals are mapped to the designated pins on the connector.

To establish communication with another RS232 device within the system, connect these two data lines along with the Ground.

USB Connection

The sensor can be directly connected to a PC or Smartphone via its USB C port that is located next to the M8 connector. After plugging in, the sensor will appear to the computer as a Serial Communication port.

The USB port is primarily used together with the Naviq utility for configuring, testing, and tuning the sensor.

While it will operate identically to the RS232 port, it is not recommended to use USB as the main communication interface with the navigation computer.

Preparing the Sensor for Use

The MTS160 is ready for operation with only minimal configuration.

Zero-Level Calibration

The sensor is calibrated at the factory. It may happen that the ambient magnetic level is different at the deployment location. It is therefore recommended to calibrate the sensor's zero level at the final installation. To do so, position the robot away from the track or other magnetic source and issue the zeroing command using the available communication methods or via the PC utility.

Tape Polarity Selection

In its factory default configuration, the sensor is set to detect and follow tracks made of tape with North polarity on the top side, and markers with South polarity on the top side. However, it can be adjusted to work with tape and markers that have the opposite magnetic polarity.

To check the tape's magnetic orientation, tie a strand of thin string around 50-100cm in length to a piece of tape. The tape's north-facing side will naturally align with the Earth's North Pole. As an alternative method, hold a compass against the top (non-sticky) side of the tape. You'll observe that the compass's north-facing needle is drawn towards the tape's south side, while its south-facing needle is drawn towards the north side.

Setting the tape polarity can be done via serial or CAN communication, or via the PC Utility.

Track and Markers Threshold

The MTS160's algorithm detects tracks and markers by analyzing changes in magnetic strength. It identifies tracks in zones where there is an increase in magnetic strength and markers in zones where there is a decrease in magnetic strength. For the main track, the detection threshold is defined as a percentage ratio of the track's peak magnetic value. For markers, the threshold is given as an absolute value in milliTeslas (mT). Both thresholds are factory-set to values that are effective under normal conditions and generally should not be changed.

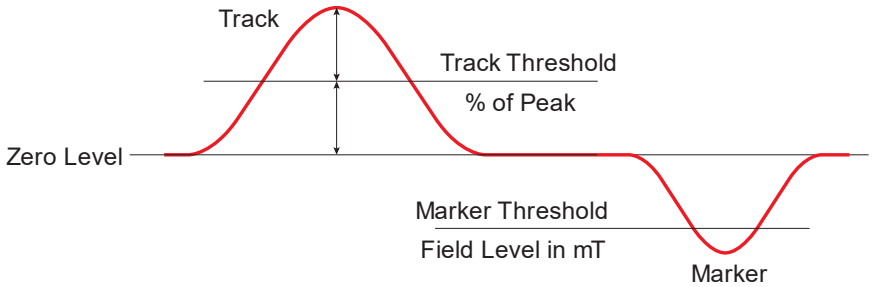


Figure 12: Track and Marker detection thresholds

However, certain situations—such as the presence of magnetized steel within the floor's concrete—may cause disturbances that affect the sensor's ability to accurately detect tracks or markers. In these cases, it may be useful to adjust the threshold levels to compensate for these disturbances. Before making any adjustments, these disturbances should be examined using the track and marker monitoring graphs available on the PC Utility's dashboard to understand their nature and determine if altering the threshold values could resolve the issue. If necessary, the two thresholds can be adjusted using the PC utility or via CANbus.

Communication Mode Selection

The MTS1600D can be configured to operate in the following modes:

- RS232 – Factory Default
- CANOpen

RS232 Configuration

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

Selectable bit rates are:

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

For compatibility with devices that require TTL-level serial inputs, the RS232 signal levels can be inverted through configuration settings. Default is non-inverted.

To set the RS232 bit rate and the level inversion, use the USB port in conjunction with the Naviq PC utility software.

CAN bus Configuration

Use the USB port in conjunction with the Naviq PC utility software to change the CAN settings.

CAN bus can be configured to operate at any the bit rates below:

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

The sensor’s CAN Node ID is user-selectable across the 7-bit range from address 1 to 127.

The factory default CAN Node ID for the sensor is set to address 1.

When operating in CAN mode, the sensor will send its measurements inside Process Data Objects (PDOs) at a periodic rate. PDO send rate is user-selectable, from 5 to 1000ms. The factory default is 10ms (100Hz)

It is highly recommended to configure these settings before incorporating the sensor into an active network to prevent potential conflicts or disturbances with other networked devices.

Sensor Data Reporting

The MTS160 measures and reports in real-time several parameters relative to the tracks and position markers. New data is evaluated at 200Hz, or every 5ms.

Continuous Dual Track Detection

The MTS160 always reports data of two tracks simultaneously: One data set for Left and one for the Right track. This happens even if only one track is present. In that case, the data for the Left and Right tracks are identical. This scheme greatly simplifies and improves the handling of merges and forks and is discussed further below.

Track Detection and Strength

The sensor will detect and report the presence of a track and its strength using two 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, regardless of the magnetic strength. It is however strongly recommended to always have a Medium or Strong level at all locations around the path.

If the magnetic strength is minimal, consider lowering the sensor closer to the track, or/and use magnetic tape with higher magnetization.

Lateral Tracks Positions

The sensor reports the lateral position of the tracks relative to the center of the sensor. Values are in millimeters. Positions left of the center are negative values. Positions right of the center are positive values.

Tape 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

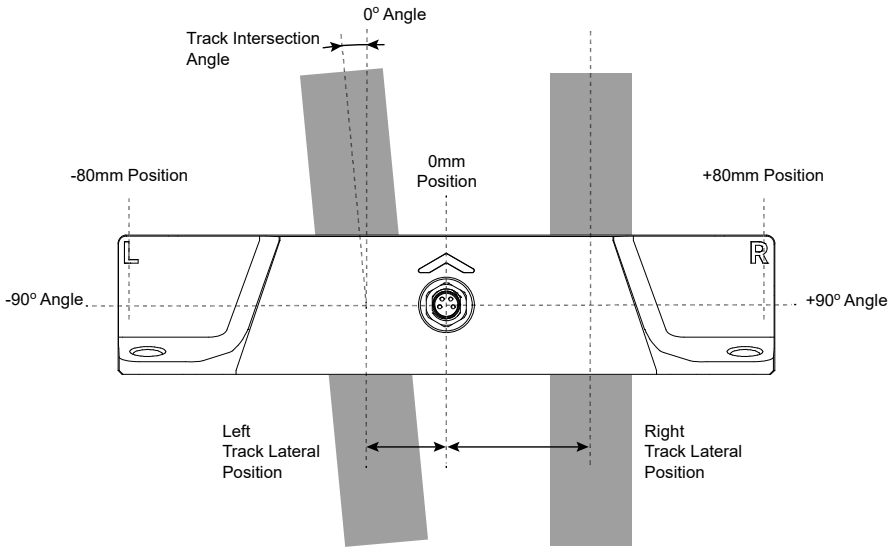


Figure 13: Angle and Lateral Position measurement

The benefits of using the angle and how to use it to optimize track following is discussed in detail further below in the document.

Forks and Merges

The MTS160 supports a very effective forks and merges management technique that ensures precise and smooth, jolt-free, transitions.

It is based on the fact that the sensor always sees two tracks simultaneously, even if only one track is actually present.

When approaching a fork, and the sensor is over a single track, it will report two positions and two angle values. Assuming the robot is perfectly centered and aligned with the track, these will be 0mm and 0 degrees.

When entering the fork, the second track begins to register, and its position and angle is measured and reported. Depending on which branch the robot needs to follow, the navigation computer will use the left or the right track information for steering.

Assuming the left track is followed, the right track information will be ignored as the branches separate.

After the fork is cleared, the sensor only sees a single track again and the left and right values are identical again.

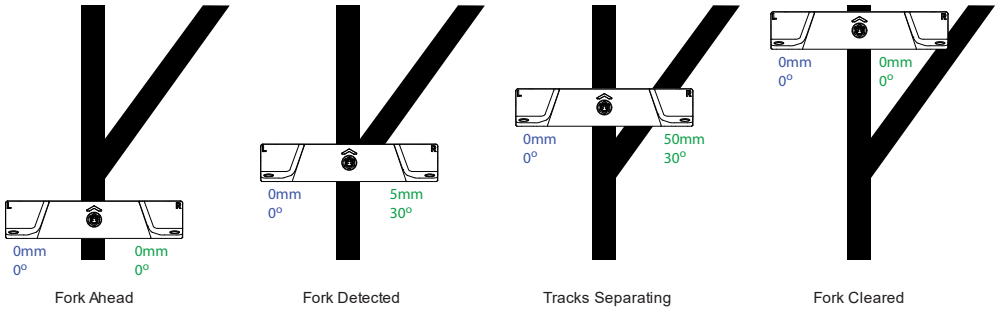


Figure 14: Sensor measurements at forks

Merges also use the fact that two position values are reported. Prior to entering a merge, the navigation computer must be set to follow the track that is opposite to this of the incoming branch. In the example below, the robot must be following the left track. As the robot progresses it will suddenly detect the track that is branching from the right, which it will simply ignore until the merge is complete.

Beware that if the robot is set to follow the right track, it will abruptly steer to follow the right track as soon as it is detected.

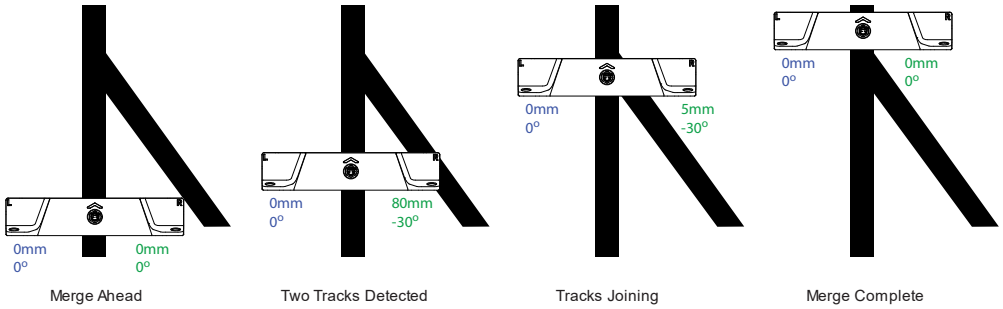


Figure 15: Sensor measurements at merges

Left and Right Position Markers

Markers are special bits of magnetic strip that have the opposite polarity to the main track. They are typically used to identify special locations along the robot's path. For instance, markers can indicate a fork ahead in the path, or a merge. They can tell the robot when it's approaching a charging station, or if it needs to adjust its speed, to either pick up the pace or slow down for safety.

The sensor can detect and report the presence of a Left Marker on the left side of the track, or a Right Marker one on the right side. Markers can be combined into patterns to uniquely identify more locations along the track.

Figure 16: Markers 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.

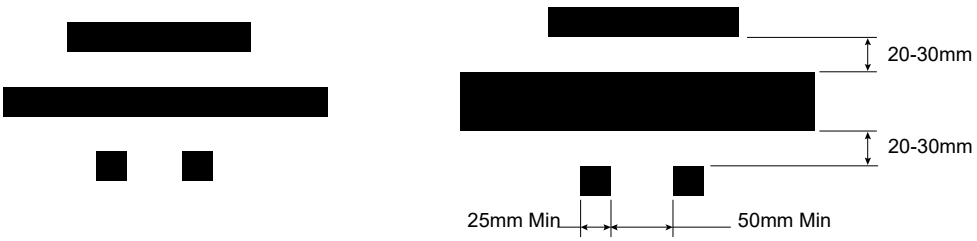


Figure 17: Recommended Marker Spacing

Last-Millimeter Magnetic Point-Source

Another unique capability of the MTS160 is the detection along the X and Y axis of point-source disk magnets with millimeter accuracy. By installing one such magnet at a precise known location on each side of the track, it is possible to evaluate the robot's exact position and orientation with very high precision.

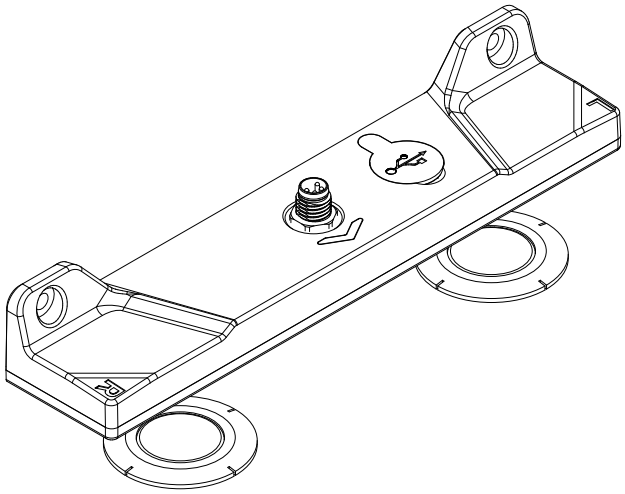


Figure 18: MTS160 Hovering over two point-source magnets

This feature makes the sensor a valuable accessory for last-millimeter positioning on robots using laser or vision navigation.

Magnetic disks must be of opposite magnetic polarity than this of the main track. The sensor therefore detects them the same way as regular markers. In addition, the sensor will report their X and Y position.

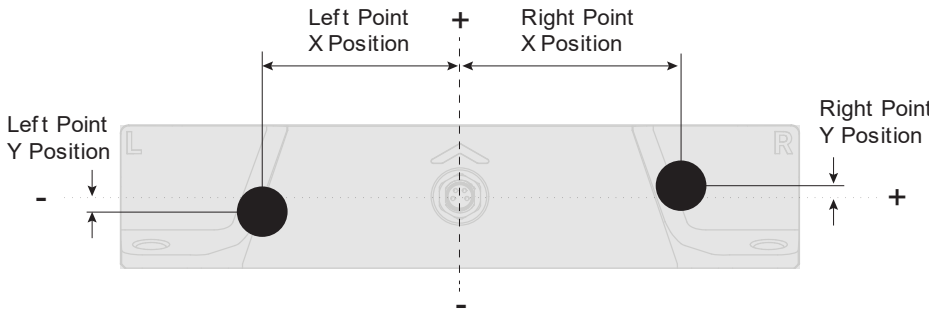


Figure 19: Detection of magnetic point-source

Adhesive point-source magnets can be ordered from Naviq

Navicode Coded Markers

The MTS160 sensor is designed to detect and decode specific combinations of left and right markers, utilizing a simple and efficient coding scheme. This scheme encodes data using basic patterns for binary values 1 and 0, which can be concatenated to form multi-bit numbers.

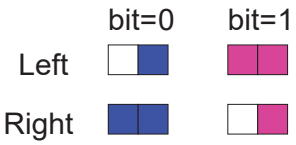


Figure 20: Base patterns for logic levels 1 and 0

Decoding begins when the sensor detects a marker on either the left or right side. The process continues as long as a marker is present on one side or the other. The decoding is completed, and the captured value is stored when no marker is detected on either side.

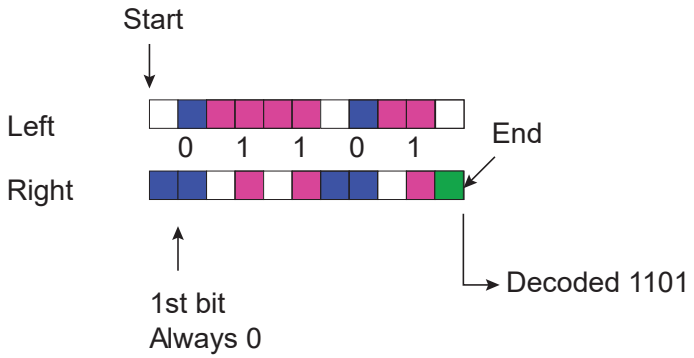


Figure 21: Example of 4-bit Navicode

Navicode always start with the bit value 0 and are terminated by an end marker as shows in the figure above. These ensure that a code can be detected and read correctly regardless of the orientation and travel direction of the robot.

Navicodes can range from 1-bit to 16-bits in length. Once a code is successfully detected and recognized, its value is stored in a register, accessible via serial communication or CANbus. Additionally, an 8-bit counter increments with each recognized code, which can also be read through the same communication channels.

The navigation computer or PLC can monitor this counter to identify when a new marker is detected and subsequently send a command to retrieve the code's value.

The table below shows the Navicode patterns for value 0 to 7. For each value, the code and its rotated copy are read the same way by the sensor.

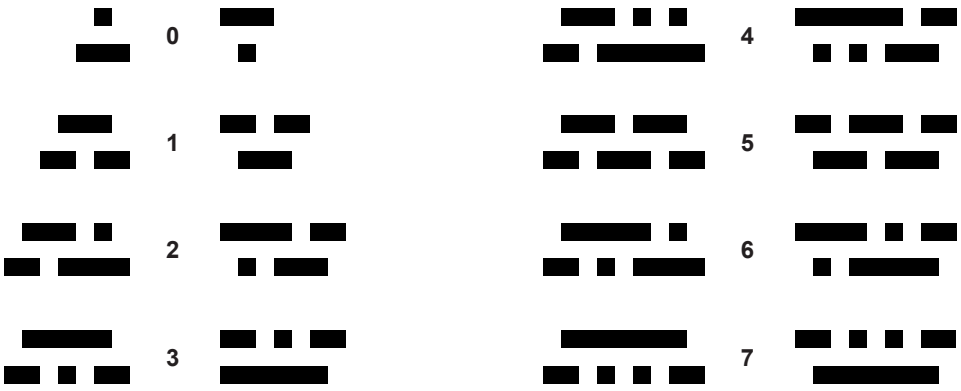


Figure 22: 3-bit Navicodes Table

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.

The MTS160 magnetic guide sensor features a Naviq-patented innovation that uses integrated electromagnets to periodically perform a self-test on each of the 32 internal sensor ICs.

This self-test is automatically conducted each time the sensor is powered on or when a command is issued via USB, Serial, or CAN interface.

During the test, the coils are energized to generate a magnetic field directly beneath each sensing element. The MCU then verifies that the output of each internal sensor changes by a value within the expected range. If any sensor fails to detect a change, or if the detected change falls outside the valid range, the test fails.

The results of the self-test are stored in three registers, which can be accessed at any time through the same communication channels. The registers contain the following information:

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 specify which of the 32 internal sensor ICs failed.

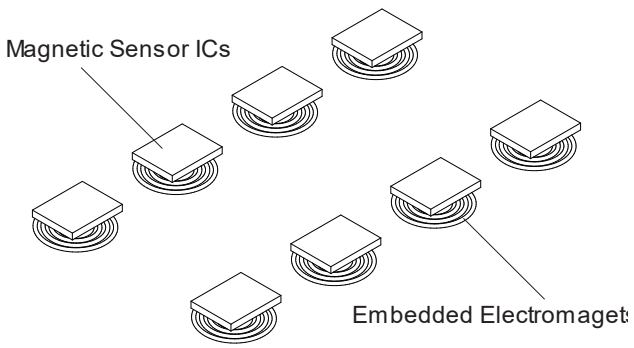


Figure 23: Embedded Self-Test electromagnets

In the event of a failure, the two RGB LEDs will flash red to provide a visual indication of the fault.

The complete test sequence takes approximately 30 milliseconds, during which the ambient magnetic fields should remain unchanged. It is recommended therefore to perform the test when the robot is stationary.

Status LED Flashing Patterns

The MTS has two RGB LEDs behind the arrow-shaped window. It is used to provide visual clues about the state of the sensor and the magnetic elements found within its detection range.

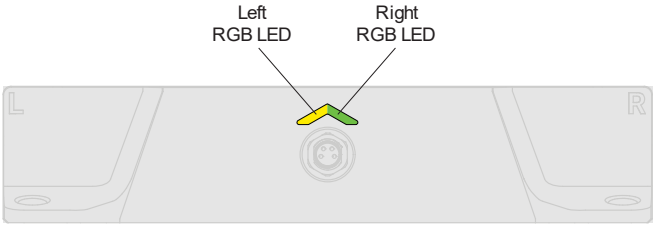
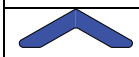
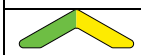
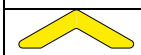
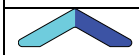
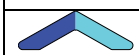
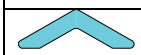
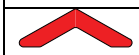


Figure 24: Status LED Indicator

LED Status		Track Detect	Left Marker	Right Marker	Description
	Steady Blue	No	No	No	The sensor is in a ready state but not engaged with a track; no markers or point-sources are within range.
	Steady Green	Yes	No	No	The sensor is detecting a magnetic track, but no markers are identified alongside the track.
	Steady Yellow Green	Yes	Yes	No	The sensor is detecting a magnetic track and one marker on one side. The yellow LED lights up on the side of the detected marker.
	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				The sensor is detecting only one marker and no track. The cyan LED lights up on the side of the detected marker.
	Steady Blue Cyan				
	Steady Cyan				The sensor is detecting two markers and no track.
	Steady Red	No	No	No	The sensor is inactive or has encountered a critical error.
	Flashing Red	Pattern Dependent			Alternating red and any or 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 MTS supports a set of ASCII text commands that can be exchanged on the RS232 and on the USB port. Commands are not case sensitive.

All commands and replies are terminated by the “Carriage Return” character, Hex 0x0D, \r

! Set

Commands starting with the ! character are used to execute actions or set configuration parameters.

Configuration changes are stored in flash upon receiving and remain in effect when power is cycled.

If the command is successfully received without syntax errors, the sensor will reply by repeating the command followed by “OK”

Example:

Set Zero Level:	!ZERO Reply: !ZERO,OK

? Get

Commands starting with the ? character are used to request sensor live data, sensor fixed information, or to read configuration parameters. The sensor will reply by repeating the Command name, followed by a coma and the returned data.

Examples:

Get Firmware Revision:	?FWVR Reply: ?FWVR,106,20240325,2882400018
Get Communication Configuration:	?SNCF Reply: ?SNCF,50,50

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 coma, 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.

Example:

Get Sensor Values every 10ms:	#SALL,10 Repeating reply: ?SALL,0,0,0,0,0,0,0,0,0,0,0,250

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	Sensor Zero

Data Requests (? Get Only)

Command	Description
FWVR	Firmware Version
HWVR	Hardware Version
NVCD	Navicode
RSEN	Raw Sensor Values
SALL	Read All Sensor Values
SNID	Sensor Serial Number
STRS	Self-Test Results

Configuration Commands (! Set and ? Get)

Command	Description
CMCF	Communication Mode
CNCF	CAN Configuration
RSCF	RS232 Configuration
SNCF	Sensor Configuration

Action Commands

RSET – Reset to Factory Defaults Category: Action Commands

Description:
Resets all configuration parameters to their factory default values.

Syntax: !RSET

Arguments: None

STST – Perform Self-Test Category: Action Commands

Description:

Trigger the self-test of the MTS160's 32 internal magnetic sensing ICs by briefly energizing electromagnets embedded in the unit. Use the ?STRS request to read the test's 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. Subtracts these values from subsequent reading.

Syntax: !ZERO

Arguments: None

Data Requests

FWVR – Read Firmware Version Category: Data Requests

Description:
Read the Firmware revision and date.

Syntax: ?FWVR

Reply: ?FWVR,Revision,Date,FirmwareHash

Revision
Type: Unsigned 32-bit Format: 010203 = 1.2.3

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: ?FWVR

Reply: ?FWVR,Version

Version
Type: Unsigned 8-bit

NVCD – Read Navicode Marker Category: Data Requests

Description:
Read the last captured Navicode Marker Value. Count is incremented every time a Navicode marker is detected.

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 Calibrated Category: Data Requests

Description:
Read the value of each of the 32 internal magnetic sensors. Returns value corrected with the zero offset.

Syntax: ?RSEN

Arguments: None

Reply: ?RSEN,Value1,Value2, …,Value32

Value(n)
Type: Signed 16-bit Units: milliTeslas Range: +/-16000

SALL – Read All Sensor Data Category: Data Requests

Description:
Read all the sensor's measurements into a single string. Values are coma delimited and determined by their order. An 8-bit counter is sent at the end of the string. The counter increments every time SALL is invoked, either by a new ?Get or #Repeat.

Syntax: ?SALL

Arguments: None

Reply: ?SALL,TDet,LTPos,LTAng,RTPos,RTAng,LM,RM,LMPos,RMPos,Count

1-TDet: Track Detect
Type: 4-bit Units: milliTeslas Range: 0-3

2-LTPos: Left Track Position
3-RTPos: Reft Track Position

Type: Signed 8-bit Units: Millimeters Range +/-80

4-LTAng: Left Track Angle
5-RTAng: Reft Track Angle
Type: Signed 8-bit Units: Degrees Range +/-90

6-LM: Left Marker Detect
7-RM: Right Marker Detect
Type: bool Units: - Range: 0-1

8-LMPos: Left Track Position
9-RMPos: Reft Track Position
Type: Signed 8-bit Units: Millimeters Range +/-80

10-Count: Frame Counter
Type: unsigned 8-bit Units: - Range 0-255

SNID – Read Sensor Serial Number Category: Data Requests

Description:
Read 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:
Read the results of the Self-Test, either performed at power up, or forced by the user. It returns a fail/pass value, followed by the lowest and highest values captured by any of the internal sensing ICs.

Syntax: ?STRS

Reply: ?STRS,Result,MinMagDelta,MaxMagDelta

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

MinMagDelta
Type: Unsigned 8-bit

MaxMagDelta
Type: Unsigned 8-bit

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

CNCF – CAN Configuration Category: Configuration Commands

Description:
Defines the parameters necessary for CANOperation.

Set Syntax:
!CNCF,NodeId,Bitrate,AutoRun,TermResistor,TPDO1Period,TPDO2Period,TPDO3Period

Get Syntax: ?CNCF
Reply:
?CNCF,NodeId,Bitrate,AutoRun,TermResistor,TPDO1Period,TPDO2Period,TPDO3Period

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

Bitrate
0: 125kbits/s
1: 250kbits/s (Factory Default)
2: 512kbits/s
3: 1000kbits/s

AutoRun
0: Disabled (Factory Default)
1: Enabled

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

TPDO1Period
TPDO2Period
TPDO3Period
Type: Unsigned 16-bit Units: milliseconds Range: 0-65536

Default: 0 (Disabled)

RSCF – RS232 Configuration Category: Configuration Commands

Description:
Defines the parameters necessary for RS232 operation.

Set Syntax: !RSCF,Baudrate,Inverted

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

Baudrate
- 0: 9600
- 1: 19200
- 2: 38400
- 3: 57600
- 4: 115200 (Factory Default)

Inverted – Rx and Tx signal inversion
- 0: Not inverted (Factory Default)
- 1: Inverted

SNCF – Sensor Configuration Category: Configuration Commands

Description:
Select whether tracking tape has magnetic North or South on top side. Markers setting will also change so that they are opposite polarity than track.

Set Syntax: !SNCF,Polarity,TrackTh,MarkerTh

Get Syntax: ? SNCF
Reply: ?TPOL,Polarity,TrackTh,MarkerTh

Polarity
- 0: North on Top (Factory Default)
- 1: South on Top

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

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

The MTS160 sensor is fully compatible with CANOpen, enabling easy integration with navigation computers, motor drives, and other accessories on a CANbus network

TPDO Communication

The MTS160 sensor transmits data via Transmit Process Data Objects (TPDOs), which are optimized for real time communication of key sensor information. The sensor supports up to three distinct TPDOs, each carrying a different class of sensor information.

Each of these TPDOs can be independently enabled or disabled, depending on the specific requirements of the application. Additionally, the send rate of each TPDO can be configured, providing flexibility in how frequently data is transmitted based on system needs.

"Sense" TPDO:

This TPDO provides critical information about the current track, including position, angle, and marker detection status. This data is the primary information needed for real-time navigation and control.

Header	Byte Count	Payload
0x180 + NodeID	6	5 Bytes Payload

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	Crossing Detect	Right Marker Detect	Left Marker Detect	Track Detect & Strength		Sensor Fault

The Track position and angle values are signed bytes.

"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	Payload
0x280 + NodeID	9	8 Bytes Payload

Frame Payload:

Byte 1	Byte 2	Byte 3	Byte 4

Left Marker X Position MSB	Left Marker X Position LSB	Left Marker Y Position MSB	Left Marker Y Position LSB

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

Position values are signed 16-bit number in millimeters x 10 (e.g. -235 is -23.5 mm)

"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**	**Payload**
0x280 + NodeID	4	3 Bytes Payload

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.

Automatic TPDO Transmission

The MTS160 sensor can be configured to start sending TPDOs automatically upon power-up, allowing the sensor to begin data transmission without waiting for commands from the CANOpen master.

By default, the sensor is set to wait for instructions from the CANOpen master before beginning data transmission. This setting can be modified using the PC Configuration Utility

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:

Zero Setting

Adjusting the sensor's zero point to calibrate the track position:

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

Perform Self-Test

The sensor automatically performs a self-test of its 32 internal magnetic sensing ICs by briefly energizing electromagnets embedded in the unit. If the robot remains powered for a long time, this SDO allows the computer to force a self-test sequence at any time.

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

Track and Marker Parameters

This SDO is used to modifying various parameters related to track and marker detection to suit specific application requirements.

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

Read Self-Test Results

The results of the Self-Test, either performed at power up, or forced by the uses are stored in registers which can be accessed with this SDO. The registers include a pass/fail value, as well as the lowest and highest values captured by any internal IC.

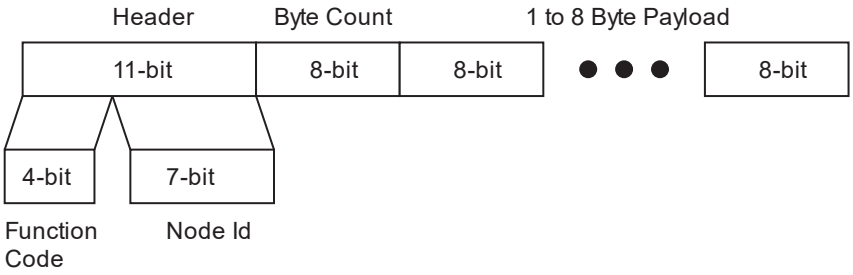
Index	Sub	Name	Type	Acess
0x2003	1	SELFTEST RESULT	Unsigned 8-bit	Read Only
0x2003	2	MIN MAGNETIC DELTA	Unsigned 8-bit	Read Only
0x2003	3	MIN MAGNETIC DELTA	Unsigned 8-bit	Read Only

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 PC Utility. With Auto-Run enabled, the sensor will start sending the TPDOs 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.
de
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 PC Utility

The MTS160 is supported by a user-friendly utility that simplifies several key tasks essential for maintaining optimal sensor performance. With this powerful tool, users can:

- Configure the sensor's operation mode
- Chart magnetic field strength in real-time
- Monitor track position, angle, and markers
- Capture and examine logs for analysis
- Update the sensor with the latest 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

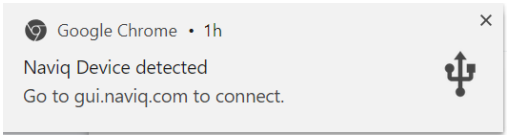
Platform and Hardware Independence: The MTS160 utility operates through a web browser, making it compatible with any operating system, such as Windows, macOS, Linux, and others. It is also hardware-independent, meaning it can run on various devices, including PCs, Macs, Linux machines, smartphones, and tablets, as long as they have an 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 server, so users always have access to the latest version without needing to manually update their software

Connecting the Sensors and Launching the Utility

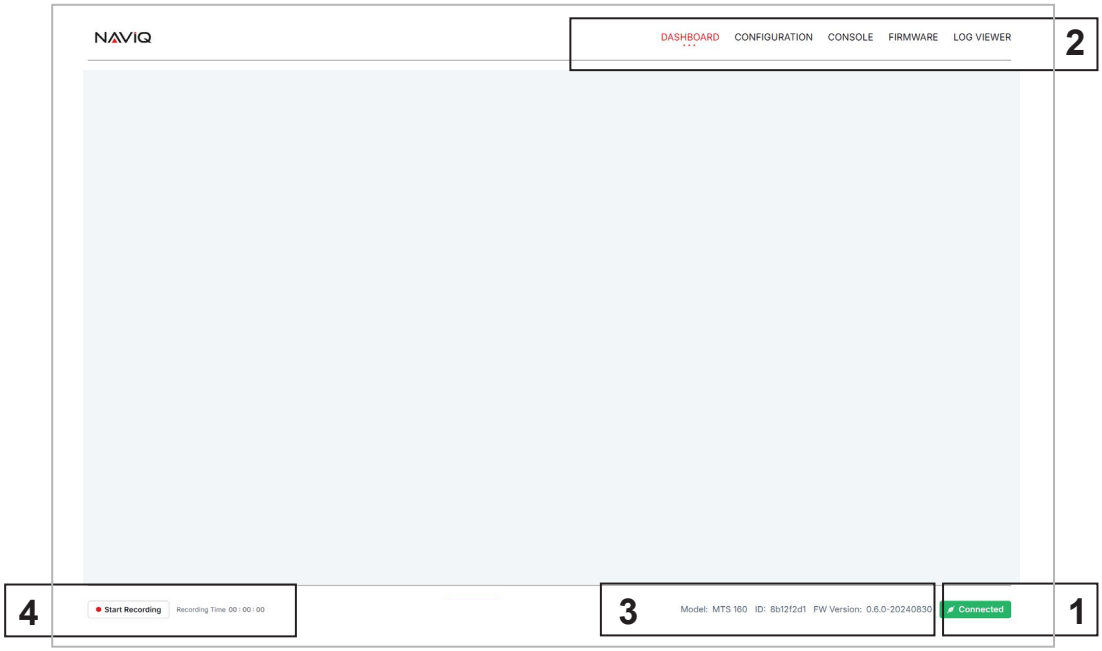
To launch the utility simply connect the sensor to the PC via the USB port, with or without power on the main M8 connector. If unconnected to a power supply, the sensor will take power from the PC and turn on.

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



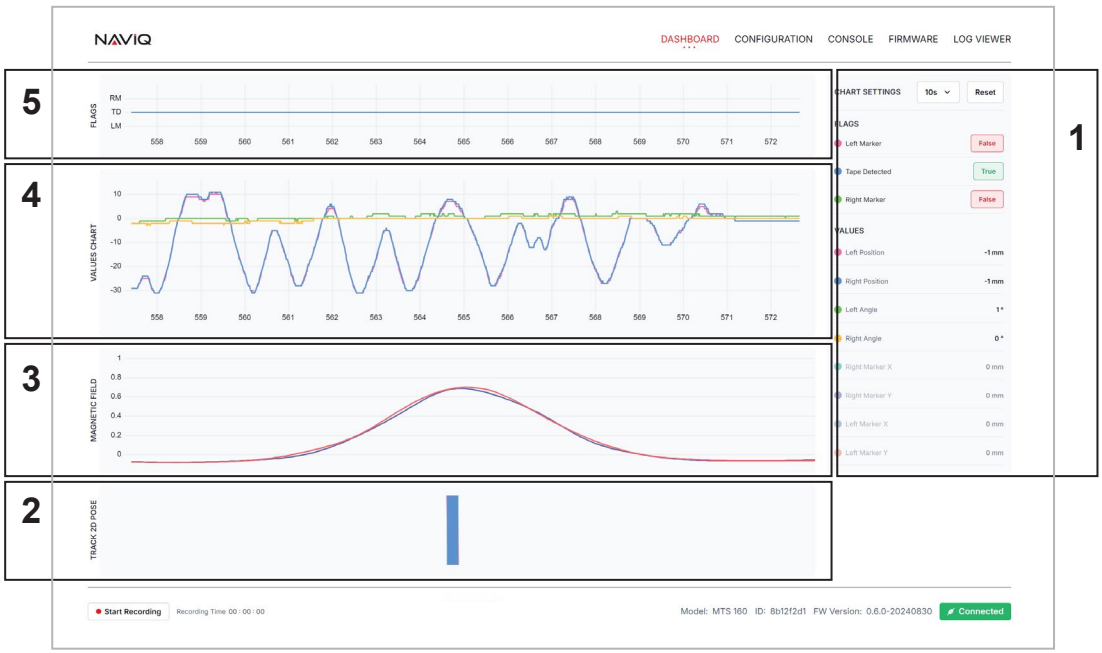
Clicking on that window will open a browser with the Naviq Utility.

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

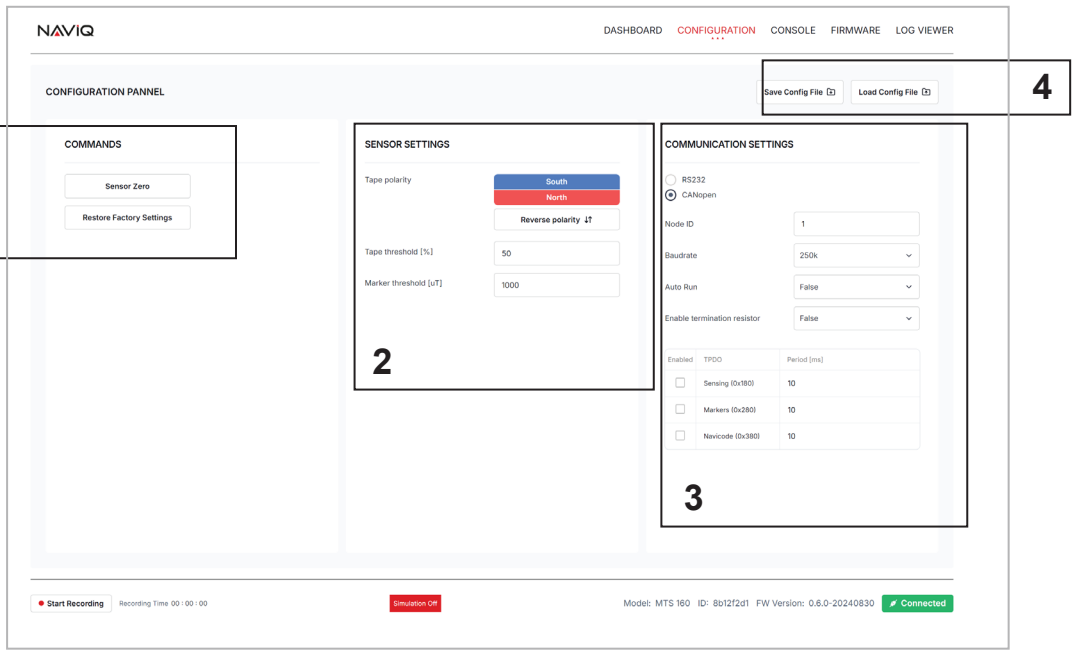


The dashboard is where the sensor information can be visualized. The screen is composed of 5 sections:

1- Numeric View and Chart Control, where each of the sensor's value are displayed. Clicking on any item will show or hide it from the plot windows.

2- Tracks visualization showing 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

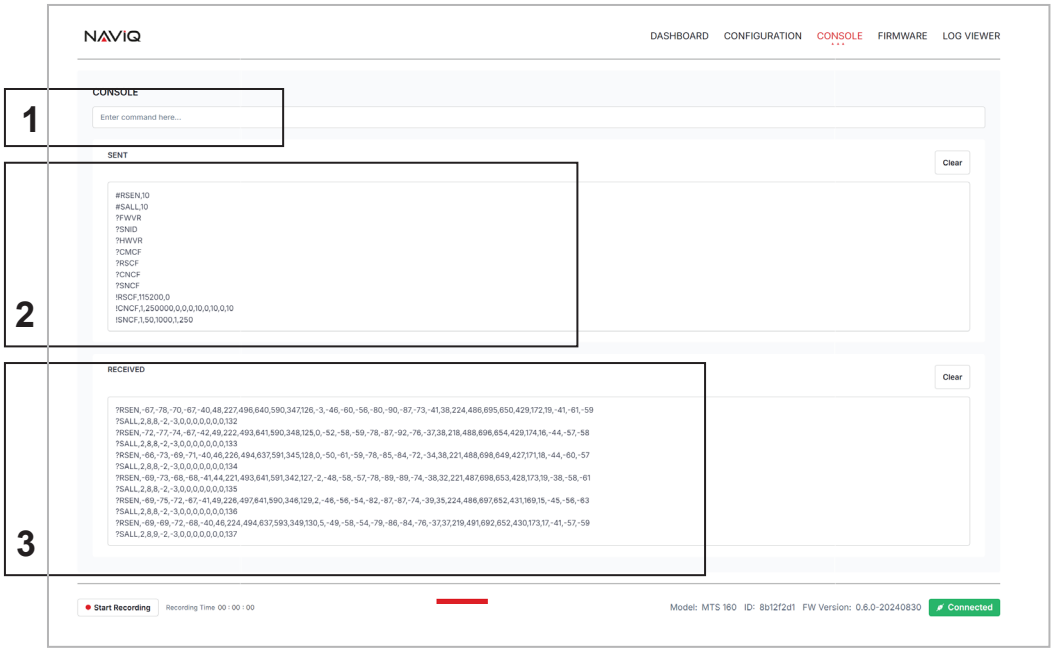
Configuration



The configuration screen is composed of four sections:

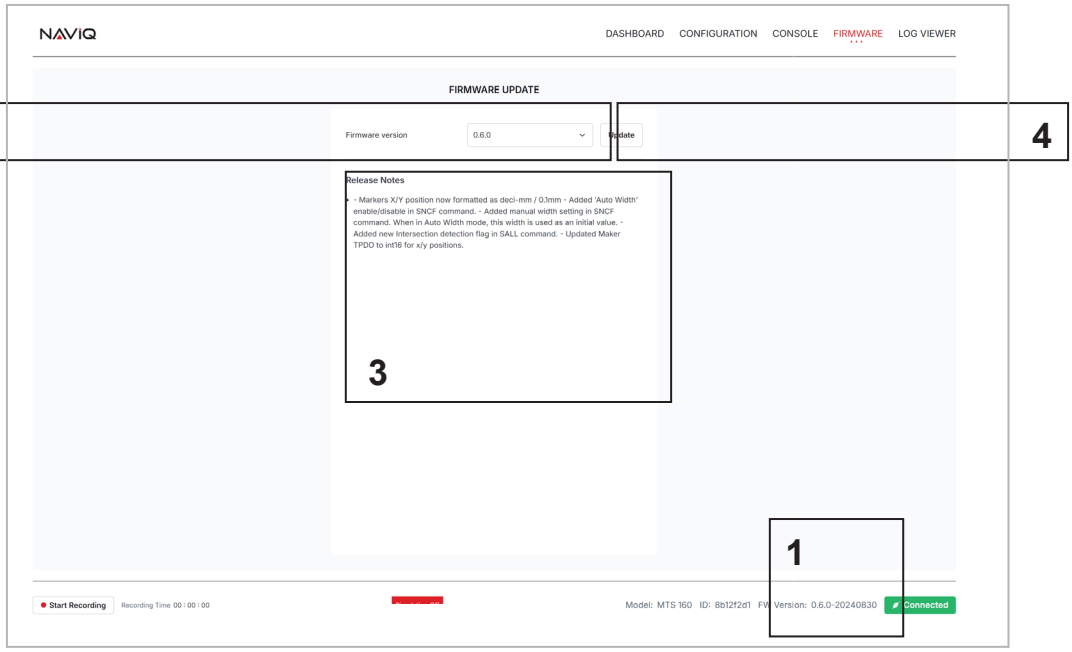
1- Commands buttons for calibrating the ambient zero-level reference and for resetting the sensor's factory default configuration.
2- Setting parameters relating to the track and marker detection
3- Selecting and setting the communication protocol
4- Saving and restoring configurations to/from disk.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

Console



The console is not required for normal use, as all the sensor data and configuration settings can be viewed and modified more effectively using the GUI. However, it is provided as a development aid for manually exercising the serial commands described earlier in this manual, particularly when integrating a navigation computer. This screen 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.



The Firmware window is used for updating the firmware. It is good practice to check for a new firmware version each time the sensor is connected to the Utility. The window contains the following elements:

1- The currently installed firmware revision is displayed in the footer, which appears on every page of the GUI
2- The Firmware selection menu automatically retrieves the latest firmware revision from the Naviq server, displaying the newest version at the top. Clicking on the arrow allows you to view and select earlier versions.
3- The Release Notes displays the history and list of changes and additions included in the selected version.
4- Clicking on the update button initiates the firmware update process. Once the update is complete, the new firmware version will be displayed at the bottom of the screen.

The Naviq GUI features a powerful and easy-to-use data logging function, which is highly beneficial for performance evaluation and troubleshooting. All sensor data can be captured and saved for later analysis and reporting. The Data Logging window consists of five components:

1- Logging can be started and stopped at any time from any GUI screen using the buttons on the left side of the footer. When logs are saved to a file, they are in CSV format for easy import into spreadsheet applications such as Excel or Google Sheets.
2- When the Log window is opened, the chart will automatically populate with the most recent log data, whether it was saved to disk or not. Other logs can be opened using the Log Recording File button.
3- The first graph area allows for plotting track data such as position and angle. Hovering the mouse over the curve displays the numerical value at that point. Each trace can be independently toggled on or off.
4- A second, similar graph area is provided to plot track detection and marker states.
5- A set of buttons is available to zoom and pan to areas of interest.

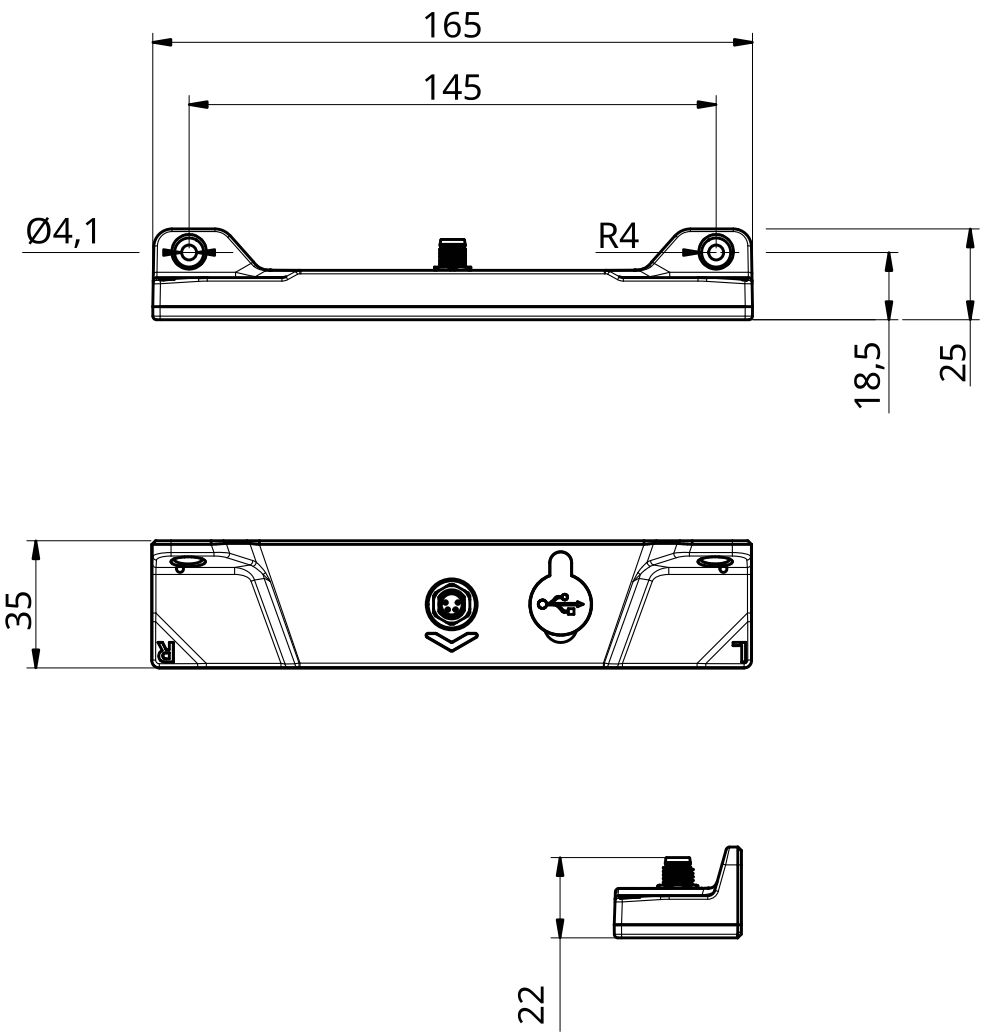


Figure 25: Mechanical dimensions

3D Step model is available at naviq.com