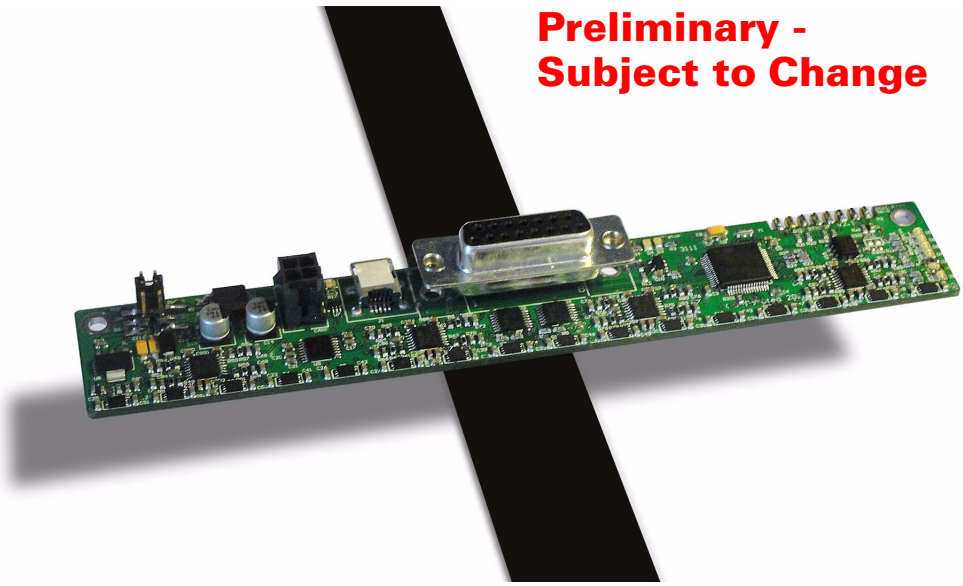
MGS1600

Preliminary - Subject to Change

Precision Magnetic Track Following Sensor



The MGS1600 is a sensor capable of detecting and reporting the position of a magnetic field along its horizontal axis. The sensor is intended for line following robotic applications, using a magnetic tape to form a track guide on the floor.

The sensor uses advanced signal processing to accurately measure its lateral distance from the center of the track, with millimeter resolution, resulting in nearly 160 points end to end. Tape position information can be output in numerical format on the sensor's RS232 or USB ports. The position is also reported as a 0 to 5V voltage output and as a variable PWM output.

The sensor will detect and manage up to 2-way forks and can be instructed to follow the left or right track using commands issued via the serial/USB ports, or using the state of two digital inputs. All of the sensor's operating parameters and commands are also accessible via its CAN bus interface.

In addition to detecting a track to follow, the sensor will detect and report the presence of magnetic markers that may be positioned on the left or right side of the track. The sensor is equipped with several LEDs for easy monitoring and diagnostics.

The sensor incorporates a high performance, Basic-like scripting language that allows users to add customized functionality to the sensor. A PC utility is provided for configuring the sensor, capture and plot the sensor data on a strip chart recorder, and visualize in real time the magnetic field as it is seen by the sensor.

The sensor firmware can be updated in the field to take advantage of new features as they become available.

Applications

- Automatic Guided Vehicles
- Automated warehouses
- Automated shelves restocking system
- Material conveying robots
- Flexible assembly lines

Key Features

- Detects and measures position of magnetic track along horizontal axis
- Optimized for use with 25mm or 50mm wide adhesive magnetic tape
- 10mm to 60mm operating height
- 160mm sensing width with 1mm resolution
- Selectable, North or South on top, magnetic polarity of track
- Up to 2-way fork and merge detection and management
- Detection of magnetic "markers" of inverted polarity at left or right of main track
- Simple interface to most PLC brands and to microcomputers
- Direct and seamless interface to Roboteq motor controllers
- 100Hz update rate
- Status LEDs for tape and marker detection
- Digital inputs for "follow left, or right" command at forks
- Digital outputs for "tape present" and left/right marker detect
- Numerical Tape position data output on RS232 or USB ports
- Tape position on PWM output with user selectable period and pulse width range

- Tape position on 0-5V analog output
- CAN interface up to 1Mbit/s
- Built-in programming language for optional local processing of tape and marker data
- Easy configuration, testing and monitoring using provided PC utility
- Field upgradable software for installing latest features via the internet
- Selectable 5V or 8-15V operation
- 160 mm wide x 25 mm deep x 15 mm tall
- -40o to +85o C operating environment
- Available as open board
- Fully enclosed version available in Q4, 2012

Orderable Product References

Reference	Description
MGS1600	160 mm wide magnetic tape sensor with serial, USB, analog, PWM and CAN output
MTAPE25NR	25 mm wide magnetic tape for MGS1600 with North top side. 50m (150ft) roll
MTAPE50NR	50 mm wide magnetic tape for MGS1600 with North top side. 50m (150ft) roll

Benefits of Magnetic Line Tracking

Because they are totally passive, magnetic tracks are easy to lay and modify. They are dirt immune and can be made totally invisible under carpet, tile or other flooring cover. The table below lists the differences between the three major line following technologies used in the industry today.

TABLE 1.

	Magnetic	**Optical**	**Induction**
Track type	Passive	Passive	Active (1)
Track shape	Flat tape	Flat trace	Wire
Track laying	Easy	Easy	Difficult (2)
Laying forks & merges	Easy	Easy	Difficult (2)
Dirt immune	Yes	No	Yes
Sensible to light conditions	No	Yes	No
Invisible track	Yes (3)	No	Yes
Markers	Yes (4)	No	No
Note 1: Requires high frequency current to flow in wire.			
Note 2: Forks & merges must not disrupt current flow.			
Note 3: Magnetic tape may be hidden under carpet or other non ferrous floor covering.			
Note 4: Markers use tape of inverted magnetic polarity and therefore very distinctive to the sensor.			

Magnetic Tape Selection & Installation

The sensor is factory calibrated for use with 25mm or 50mm wide tape from Roboteq, but may be used with tape from other suppliers as well. Only unipolar tape must be used, where one side is all of one magnetic polarity and the other of the other polarity. In the default configuration, the sensor expect South on the top side for the track and North on the top side for markers. The sensor can be configured to operate with tape of inverted polarity. The sensor will not work with tape of alternating polarity.

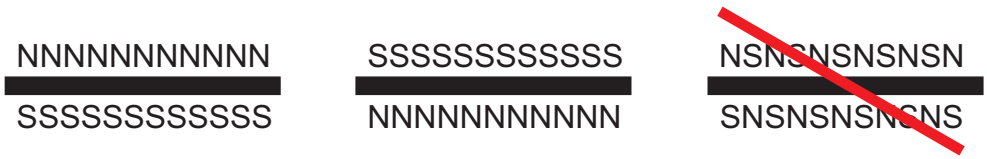


FIGURE 1. Magnetic tape

Operating height is up to 50mm when used with 25mm wide tape and 60mm when used with 50mm wide tape. At higher heights, the magnetic field of the tape is weaker and the sensor will be less immune to noise. For best results, operate at 20 to 30mm with 25mm tape and 20 to 40mm with 50mm tape.

Sensor Installation

The sensor must be mounted so that it is parallel with the floor and the magnetic track. Two mounting holes are provided at both ends of the PCB. The two nuts on the 15-pin connector can also be used to hold the sensor in place if no mechanical stress is expected. The sensor can be located inside a cover as long as the protection is made of non-ferrous material.

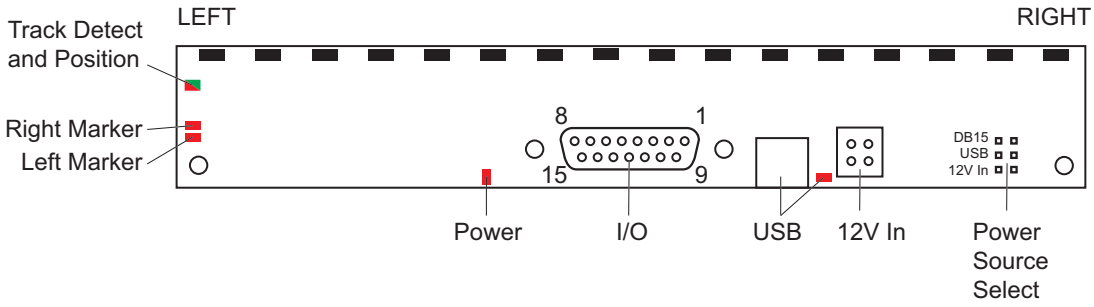


FIGURE 2. Sensor outline

Powering the Sensor

The sensor can be powered from one of three sources:

- Regulated 5V from the power input pins on the 15-pin I/O Connector
- The 5V from the PC via the USB connector
- Unregulated 8V to 15V DC power supply

The 8V to 15V must be supplied through the sensor's 4 pin connector. Use Molex Microfit reference 0430200401.

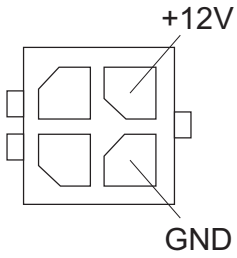


FIGURE 3. 12V input connector

The power source selection is done using a jumper on the 6-pin header (see Figure 2).

I/O Connector

All sensor commands and data signals are located on a standard DB15 female connector. The table below shows the connector's pin assignment.

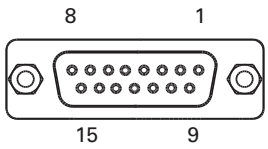


FIGURE 4. Connector pin locations

TABLE 2.

Connector Pin	Name	Type	Description
1	Fork Left	Input	Select left track
9	Left Marker	Output	Left marker detected

TABLE 2.

Connector Pin	Name	Type	Description
2	TxData	Output	RS232 transmit data
10	Reserved	Output	
3	RxData	Input	RS232 receive data
11	Right Marker	Output	Right marker detected
4	Ana Out	Output	Track position analog output
12	Reserved	Output	
5	Ground	Power	Ground
13	Track Present	Output	Track detected
6	CANL	I/O	CAN Low
14	5V IN	Power	5V power input
7	CANH	I/O	CAN High
15	PWM Out	Output	Track position PWM output
8	Fork Right	Input	Select right track

Serial Port Settings

The baud rate and communication settings on the sensor are set as follows:

- 115200 bits/s
- 8-bit data
- Even parity
- No flow control

Track information

The presence and position of a magnetic track is output on the I/O connector, and/or transmitted via the serial communication port or USB. When the sensor detects the presence of a magnetic track it will activate the Track Present output on the I/O connector. The track position information is also output as a 0-5V analog signal, and a PWM pulse of user definable period and duty cycle range. The track detect and position are reported on the RS232 or USB ports. The position is reported as a signed value, in millimeters, using the center of the sensor as the 0 reference.

Fork and Merge Management

The sensor has an algorithm for detecting and managing up to 2-way forks and merges along the track. Internally, the controller always assumes that 2 tracks are present: a left track and a right track. When following a single track, the sensor considers that the 2 tracks are superimposed. When entering forks, the track widens, so does the distance between the left and right tracks.

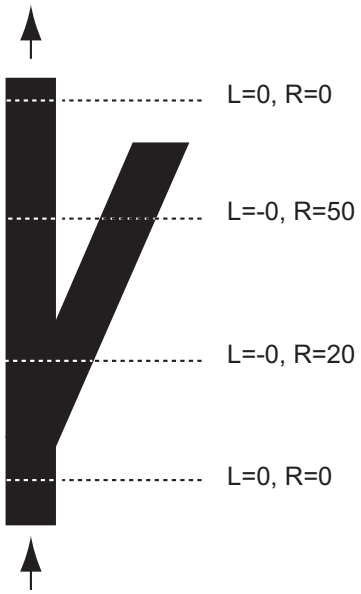


FIGURE 5. Fork management

When approaching merges, the sensor will report a sudden spread of the left and right tracks, but will otherwise operate the same way as at forks.

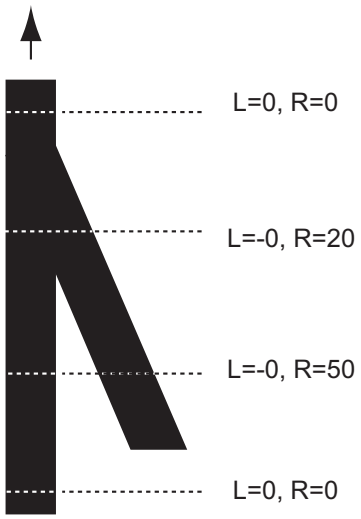


FIGURE 6. Merge management

Both tracks positions can be read via the serial port. Using the state of the Fork Left and Fork Right digital inputs, the sensor will select the left or right track information onto the analog and PWM outputs, according to the selection table below.

TABLE 3.

Fork Left	**Fork Right**	**Analog and PWM Output**
Low	Low	No change
High	Low	Left
Low	High	Right
High	High	RS232/USB command

When both inputs are high or unconnected, the selected track will be based on command received via the sensor's serial/USB port, or set using the sensor's scripting language.

Marker Detection

Markers are pieces of magnetic tape that are affixed on the left or/and right side of the main track. To differentiate them from the track, markers have opposite magnetic polarity. These markers can be used to inform the robot of special areas along the track, such as forks or merges ahead, high or low speed zones, charge stations, etc. Markers must be positioned 15 to 30mm away from the edge of the main track for proper operation.

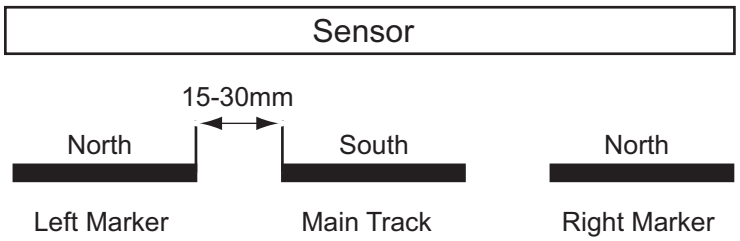


FIGURE 7. Direction markers

The figure below shows example of a simple marker (i.e. marker present or absent) and 2 dimensional markers where a pattern is used to encode more complex information. In this example, using the built in scripting language, the sensor can be made to count the number of right markers while a left marker is present.

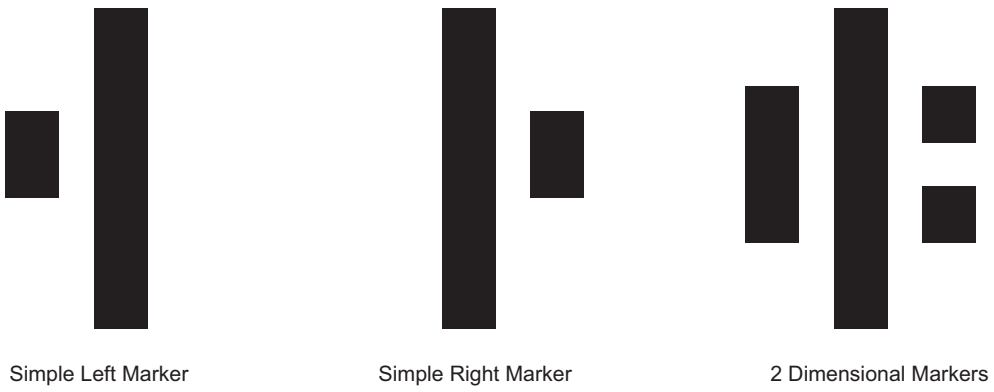


FIGURE 8. Markers usage examples

Diagnostic LEDs

Since magnetic fields are invisible, the sensor is equipped with a few LEDs to help setup and troubleshooting. The LED positions are shown in Figure 2. The Power LED will lit when the sensor is on. The Track Detect/Track Position LED is a dual usage LED that will lit when a track is present. The LED is bicolor and will gradually shift to red when the track is at the left of the sensor, and to green as the track moves to the right. Two additional LEDs will turn on when left or right markers are detected.

Interfacing the Sensor to PLCs

The sensor can be fully interfaced to a PLC with only 3 wires as shown in the figure below. Prefer the PWM method to analog as it is more accurate and noise immune.

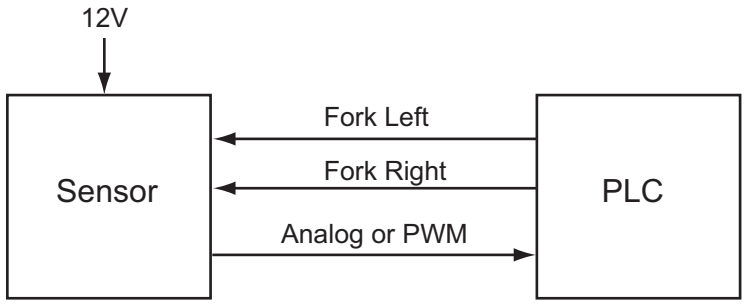


FIGURE 9. PLC interfacing

Interfacing the Sensor to Roboteq Motor Controllers

The MGS1600 will interface directly and seamlessly to all Roboteq models of controllers for brushed and brushless DC motors. The sensor can be powered from the controller's 5V output. The left, right, tape detect and marker information is sent from the sensor using the PWM Output configured as "Roboteq MultiPWM". The signal must be connected to any of the controller's Pulse Inputs configured with the PC utility as "Magsensor". The data is sent continuously with a 10ms update rate. Roboteq provides script examples that run in the motor controller for implementing basic line following AGV functionality.

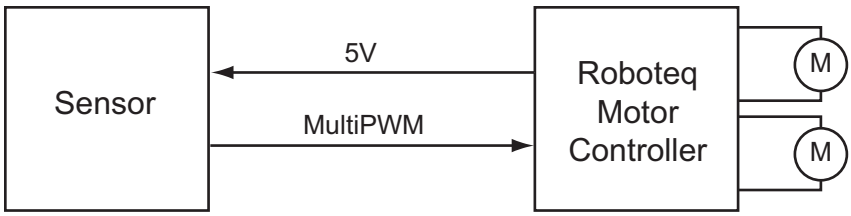


FIGURE 10. Roboteq motor controllers interfacing

Interfacing the Sensor to PCs or Microcomputers

Interfacing the sensor to a PC requires a simple USB connection. The sensor will be powered via the 5V present on the USB.

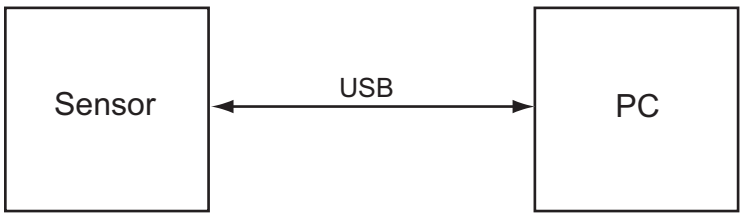


FIGURE 11. PC interfacing

If no USB is available, interfacing can be done using the PC or Microcomputer RS232 port and a separate 12V power supply.

Using the PC Utility

A powerful utility is available for download from Roboteq's web site for setting up, monitoring and performing maintenance functions. While the sensor is delivered ready to use right off the box, it contains many parameters that can easily be changed using user-friendly menus. For testing and troubleshooting, the utility includes a graph that plots in real time the shape and strength of the magnetic field as it is seen by the sensor. A strip chart recorder allows the user to plot the track and marker information, and save the data in an excel spreadsheet for analysis. The utility is also used for performing field updates of the sensor firmware and for editing and running scripts.

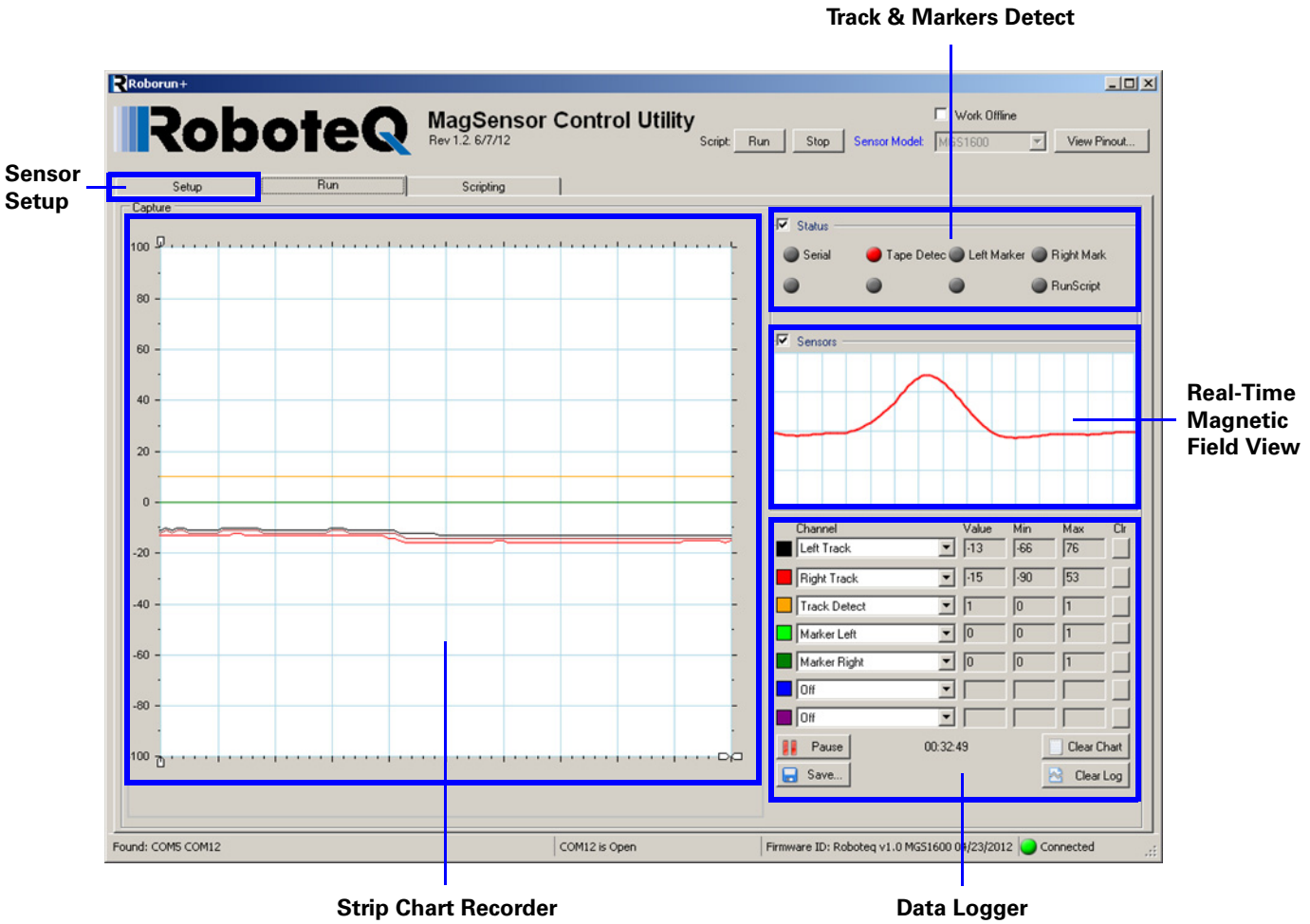


FIGURE 12. MagSensor Control Utility

MicroBasic Scripting

The MGS1600 features the ability for the user to write programs that are permanently saved into, and run from the sensor's Flash Memory. This capability is the equivalent of combining the functionality of a PLC or Single Board Computer directly into the sensor. The language is a very simple, yet powerful language that resembles Basic. Scripts can be simple or elaborate, and can be used for various purposes. For example sensor data manipulation and conversion, 2 dimension marker processing, or even the full motion and steering control for a simple line following robot.

Sensor Calibration

The sensor is factory calibrated for 25mm and 50mm wide magnetic tapes available from Roboteq. If tapes of different width or magnetic strength are used, the sensor can be recalibrated by the user. The sensor is also factory calibrated to compensate for the natural ambient magnetic field. For best results, the ambient "zero" must be reset in every new installation. This is done by issuing the following command using the PC utility: **%zero_%clsav**.

Command Reference Summary

The sensor accepts a number of commands via its RS232 and USB ports for reading operational data, sending commands, setting configuration, and performing maintenance.

Real Time Queries

These are commands for reading sensor data. They begin with the question mark character. Table 4 shows the list of supported queries.

Each time a query is executed, it is stored in a history buffer and may therefore be automatically repeated at a periodic rate using the **#** character with the following syntax:

repeat last query in queue
 # nn repeat last queries ever nn ms. Example: **# 100** to execute one query from the history queue every 100ms
 # C clear queue

TABLE 4.

Command	Arguments	Description	Examples
TS	[TrackNumber]	Read both the left and right tracks, or one of the 2	?TS, ?TS 2
T	None	Read selected track	?T
D	None	Read Track Detect	?D
M	[MarkerNumber]	Read all markers, or one of the 2	?M, ?M 2
MZ	[SensorNumber]	Read all raw sensor values, or one of the 16	?MZ, ?MZ 16

Real Time Commands

These are commands used to instruct the sensor to do something. They begin with the exclamation mark character. Table 5 shows the list of supported commands.

TABLE 5.

Command	Arguments	Description	Example
X	none	Follow Left track	!X
V	none	Follow Right track	!V
R	option	Run/Stop/Resume MicroBasic scripts	!R = Run/Resume, !R 0 = Stop, !R 2 = Restart

Configuration Commands

These commands are used to read or modify sensor configuration parameters. They begin with the **~** character for reading and the **^** character for writing.Table 6 shows the list of supported configuration commands. It is easier and preferable to use the PC utility menus for inspecting and changing configurations.

TABLE 6.

Command	Arguments	Range	Default	Description
TPOL	Value	0 = North top, 1= South top	0	Select magnetic tape width
TWDT	Value	0 = 25mm, 1= 50mm	0	Select magnetic tape polarity
TXOF	Value	-100 to +100	0	Offset added/subtract to track position values
TINV	Value	0 = Left - to Right +, 1= Left + to Right -	0	Change sign of position values
SCRO	ScriptOutput	0 = last port used, 1 = RS232, 2 = USB	0	Output port for MicroBasic print commands
TELS	String	up to 48 characters	empty	Chain of sensor commands and queries that will be executed by sensor at power up
BRUN	Value	0 = disable, 1 = enable	0	Auto start MicroBasic script at power up
PWM	Value	0 = Roboteq MultiPWM, 1= 250Hz, 2 = 500Hz	0	PWM Output mode
PWMI	Value	1 to 99%	5	Min duty cycle for modes 1 and 2
PWMX	Value	1 to 99%	95	Max duty cycle for modes 1 and 2

Maintenance Commands

These commands are used to perform maintenance functions on the sensor. They begin with the **%** character. Table 7 shows the list of supported configuration commands.

TABLE 7.

Command	Arguments	Description
ZERO	None	Set zero calibration level for sensors
EERST	None	Load factory default configuration
EESAV	None	Save configuration to EEPROM
EELD	None	Load configuration from EEPROM
CLSAV	None	Save calibration to EEPROM
CLRST	None	Load factory default calibration

Sensor Characteristics

TABLE 8.

Parameter	Min	Typ	Max	Units
Capture width		160		mm
Resolution	1	1	2	mm
Operating height with 25mm track	10	30	50 (1)	mm
Operating height with 50mm track	20	30	60 (1)	mm
Update rate		100		Hz
Note 1: Ambient magnetic fields may impair sensor data at highest height.				

Electrical Characteristics

Absolute Maximum Values

The values in the table below should never be exceeded. Permanent damage to the controller may result.

TABLE 9.

Parameter	Measure point	Min	Typ	Max	Units
5V Input voltage	5V input on DB15 or USB connectors	-1		5.5	Volts
12V Input voltage	12V input header	-1		18	Volts
Digital Input Voltage	Fork Left and Right inputs	-1		15	Volts
Digital Output Current	Digital and PWM outputs sink			20	mA
Analog Output Current	Analog Output			10	mA
CAN Input Voltage	Ground to CAN-H and CAN-L pins			40	Volts
RS232 I/O pins Voltage	External voltage applied to Rx/Tx pins			25	Volts

Power Stage Electrical Specifications (at 25oC ambient)

TABLE 10.

Parameter	Measure point	Min	Typ	Max	Units
Input Voltage on 5V inputs	Ground to 5V pin on DSub15	4	4.75	5.5	Volts
Input Voltage on 12V inputs	12V Power input header	8	12	15	Volts
Power consumption	5V or 12V inputs		50		mA

Command, I/O and Sensor Signals Specifications

TABLE 11.

Parameter	Measure point	Min	Typ	Max	Units
Main 5V Output Voltage	Ground to 5V pin on DSub15	4.6	4.75	4.9	Volts
5V Output Current	5V pin on DSub15			100	mA
Digital Output 1 Level	Ground to Output pins		4.5	5	Volts
Digital Output 0 Level	Ground to Output pins			0.5	Volts

TABLE 11.

Parameter	Measure point	Min	Typ	Max	Units
Digital Output Current	Output pins, sink current			20	mA
Digital Input 0 Level	Ground to Input pins	-1		1	Volts
Digital Input 1 Level	Ground to Input pins	3		15	Volts
Analog Output Range	Ground to Output pin	0		5 (1)	Volts
Analog Output Current	Ground to Output pin			20	mA
PWM Frequency	PWM Output	250 (2)		500 (2)	Hz
PWM Duty Cycle	PWM Output	1		99	%
Note 1: When sensor is powered with external 12V. Output may not reach 5V if sensor is powered via USB or 5V input. Note 2: 250 or 500Hz user selectable					

Scripting

TABLE 12.

Parameter	Measure Point	Min	Typ	Max	Units
Scripting Flash Memory	Internal		2048		Bytes
Max Basic Language programs	Internal		500	750	Lines
Integer Variables	Internal			1024	Words (1)
Boolean Variables	Internal			1024	Symbols
Execution Speed	Internal		50 000		Lines/s
Note 1: 32-bit words					

Environmental & Mechanical Specifications

TABLE 13.

Parameter	Measure Point	Min	Typ	Max	Units
Operating Temperature	Sensor	-20		85	oC
Weight	Sensor		50		g (lbs)