SureCross™ DX80 M-GAGE™ Node with Integrated Battery

Integrated battery Node for vehicle detection

2.4 GHz

900 MHz

Features

The SureCross™ DX80 is a radio frequency network system built around a Gateway and one or more Nodes.

- Internal three-axis magnetoresistive-based technology senses three-dimensional changes to the Earth's magnetic field caused by the presence of ferrous objects
- Designed to minimize the effects of temperature changes and destabilizing magnetic fields
- Sensor learns ambient background and stores settings in non-volatile memory
- *Flex*Power™ technology driven by one lithium primary battery integrated into the housing
- Frequency Hopping Spread Spectrum (FHSS) technology and Time Division Multiple Access (TDMA) control architecture combine to ensure reliable data delivery within the unlicensed Industrial, Scientific, and Medical (ISM) frequency bands
- Transceivers provide two-way communication between the Gateway and Node, including fully acknowledged data transmission
- Lost RF links are detected and relevant outputs set to user-defined conditions
- Sealed housing contains the battery, sensor, and antenna for a completely wireless solution

For additional information refer to Banner Engineering's website, www.bannerengineering.com/surecross.

Models

Model	*Flex*Power™	Frequency	I/O
DX80N9X1W0P0Z	3.6V dc Battery	900 MHz ISM Band	Internal M-GAGE™ (no additional I/O points)
DX80N2X1W0P0Z		2.4 GHz ISM Band	

⚠ WARNING . . . Not To Be Used for Personnel Protection

Never use these products for personnel protection. Doing so could lead to serious injury or death.

These products do NOT include the self-checking redundant circuitry necessary to allow their use in personnel safety applications. A failure or malfunction can cause either an energized or de-energized output condition. Consult your current Banner Safety Products catalog for safety products that meet OSHA, ANSI, and IEC standards for personnel protection.

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Overview

The M-GAGE™ sensor uses a passive sensing technology to detect large ferrous objects. The sensor measures the change in the Earth's natural magnetic field (ambient magnetic field) caused by the introduction of a ferromagnetic object.

The M-GAGE provides a direct replacement for inductive loop systems and needs no external frequency box. Its unique design allows quick installation within a core hole. For best performance, mount the sensor below-grade, in the center of the traffic lane. The M-GAGE also may be mounted above-ground.

Because the M-GAGE uses an internal battery, the device ships from the factory turned off. To turn on the M-GAGE, press and hold down button one for about three seconds. When the device powers up, the LEDs flash. Please refer to the DX80 Wireless I/O Network product manual, Banner document p/n 132607, for more information regarding the LEDs.

Theory of Operation

The sensor uses three mutually perpendicular magnetoresistive transducers, with each transducer detecting magnetic field changes along one axis. Incorporating three sensing elements produces maximum sensor sensitivity.

A ferrous object alters the local (ambient) magnetic field surrounding the object, as shown in Figure 1. The magnitude of this magnetic field change depends both on the object (size, shape, orientation, and composition) and on the ambient magnetic field strength and orientation.

During a simple programming procedure, the M-GAGE sensor measures the ambient magnetic field. When a large ferrous object alters that magnetic field, the sensor detects the magnetic field changes (anomalies). When the degree of magnetic field change reaches the sensor's threshold, the device reports a change of state.

Sensor Field of View and Range

The sensor range depends upon three variables:

- The local magnetic environment (including nearby ferrous material)
- The magnetic properties of the object to be sensed
- Sensor settings

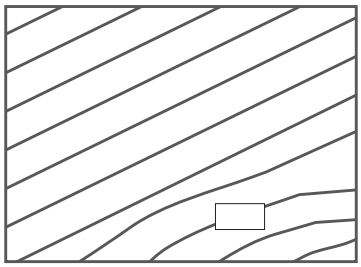
The sensor detects changes in the ambient magnetic field in all directions. As with other sensors, the range depends upon the target. The strong disturbance of a large ferrous object decreases as distance from the sensor increases; the magnitude and shape of the disturbance depends upon the object's shape and content.

The sensor can be programmed to react to magnetic field disturbances of greater or lesser intensity, using three adjustments: baseline, threshold, and hysteresis.

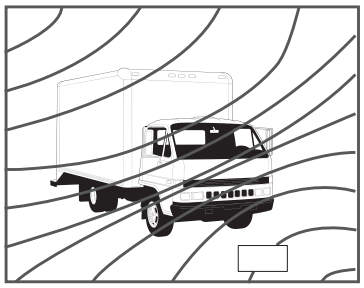
NOTE: The sensor continues to sense a vehicle in its sensing field even when the vehicle is stopped.

DX80 Gateway Devices

The M-GAGE Node works with the M-GAGE Gateway (model DX80G*M6*6P6Z, data sheet p/n 134303), the DIP switch M-GAGE Gateway (model DX80G*M6*6P6ZP, data sheet p/n 139075), and any standard Gateway, including the Gateway Pro.



Field A: Baseline magnetic field with slight disturbances caused by permanent ferrous-metal objects within or near the sensor.



Field B: After a large object is introduced, the magnetic field changes. The sensor detects the changes in the field's strength and orientation between the ambient field and Field B. If the differential is greater than the sensitivity threshold, the device reports a change of state.

Figure 1. Magnetic Detection Overview

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Modbus Register Block

I/O Point	Gateway Modbus Holding Register	Node Modbus Register	DX80 M-GAGE™ FLEX(Node)
1	1	1 + (Node# × 16)	M-GAGE
2	2	2 + (Node# × 16)	
3	3	3 + (Node# × 16)	
4	4	4 + (Node# × 16)	
5	5	5 + (Node# × 16)	
6	6	6 + (Node# × 16)	
7	7	7 + (Node# × 16)	Reserved
8	8	8 + (Node# × 16)	Device Message
9	9	9 + (Node# × 16)	
10	10	10 + (Node# × 16)	
11	11	11 + (Node# × 16)	
12	12	12 + (Node# × 16)	
13	13	13 + (Node# × 16)	Configuration Message
14	14	14 + (Node# × 16)	Baseline Command
15	15	15 + (Node# × 16)	Control Message
16	16	16 + (Node# × 16)	Reserved

There are sixteen Modbus holding registers for each device. Calculate the holding register number for each device using the equation:

Register number = I/O# + (Node# • 16).

Because the Gateway is always device 0, the Gateway's holding registers are registers 1 through 16 while registers for Node 1 are 17 through 32.

Using the equation, the register number for I/O point 15 for Node 7 is 127.

The M-GAGE value in I/O 1 is the deviation between the total measured magnetic field in the X, Y, and Z axes and the stored baseline.

To send configuration messages, use the Node's I/O point 13.

To create a baseline command, use a control message or use the Node's I/O point 14. For more instructions, refer to the *Baseline* section.

Baseline

The baseline function of the M-GAGE Node stores the ambient magnetic field values of the X, Y, and Z axes as a baseline reading. Once this baseline is established, any deviation in the magnetic field will be reflected in the M-GAGE register. The more disruption in the magnetic field, the larger the M-GAGE register value.

For a host-connected system using standard Gateways, set the baseline magnetic field by writing to a Modbus register. Sending the value of 4096 (0x1000) to the Node's I/O point 15 (Control Message) triggers the M-GAGE to read the existing magnetic field as the new baseline.

For non-host connected systems, use one of the two special M-GAGE Gateways to set the baseline:

- The inputs of the DIP switch M-GAGE Gateway (model DX80G*M6*6P6ZP) are mapped to the M-GAGE Node's I/O point 14. Activating the Gateway's input for at least five seconds triggers the M-GAGE to use the existing magnetic field as the new baseline.
- The special M-GAGE Gateway (model DX80G*M6*6P6Z) uses special mapping to baseline up to six M-GAGE Nodes.

Parameters

Baseline Filter (M-GAGE)

When the Baseline Filter, or drift filter, is on and the magnetic field readings are below a threshold setting, an algorithm is used to slowly match the device's baseline to the current ambient magnetic field. This filtering helps to account for natural fluctuations in the magnetic field.

Low Pass Filter

The filters T0 through T3 (default is filter T2) are parameter settings that define the degree of input signal filtering. T0 is the least amount of filtering. T3 is the highest filter setting and has the least amount of fluctuation between readings.

Sample and Report Rates

The sample rate defines how often the Node samples the sensor. The report rate defines how often the Node communicates the I/O status to the Gateway. For FlexPower™ applications, setting the sample and/or report rates to slower rates extends the battery life.

Change of state reporting sets the system to report only when the value crosses the threshold setting.

Sample High and Sample Low

The sample high counter parameter defines the number of consecutive samples that the input signal must be above the threshold before the signal is considered active. Sample low defines the number of consecutive samples the input signal must be below the threshold before the signal is considered inactive.

The sample high and sample low parameters are used to determine how the debounce filter examines signal transitions.

Threshold and Hysteresis (M-GAGE)

Threshold and hysteresis work together to establish the ON and OFF points for analog inputs. Setting a threshold establishes an ON point. Hysteresis defines how far below the threshold the analog input is required to be before the input is considered OFF. A typical hysteresis value is 10% to 20% of the unit's range.

The M-GAGE Node's threshold and hysteresis ranges are 0 to 65,535.

The factory default threshold setting is 100 and default hysteresis is 30 (the sensor detects an OFF condition at threshold minus hysteresis, or 100 - 30 = 70). With the default settings, once the magnetic field reading is above 100, an ON or "1" is stored in the lowest significant bit (LSB) in the Modbus register. When the M-GAGE reading drops below the OFF point (threshold minus hysteresis), the LSB of the Modbus register is set to "0."

To determine your threshold, take M-GAGE readings of the test objects at the distance they are likely to be from the sensor. For example, if a car reads 100, a bicycle 15, and a truck reads 200, setting the threshold to 150 will detect only trucks of a specific size. Magnetic field fluctuations vary based on the amount of ferrous metal present and the distance from the sensor.

Configuration

There are four ways to configure an M-GAGE™ Node:

1. M-GAGE Node DIP switches
2. M-GAGE Gateway DIP switches (see Banner document p/n 139075 for more information)
3. M-GAGE configuration using the M-GAGE Node register 13
4. Modbus registers 7, 15, and 16 to send Modbus configuration commands (see Banner document p/n 132114 for more information)

M-GAGE Node DIP Switches

The DIP switches on the M-GAGE board change the configuration of the device. After making any changes to the DIP switches, cycle power to the device to activate the changes.

In Rotary Switch address mode, the left rotary dial establishes the network ID and the right rotary dial sets the device ID. The wireless network is restricted to a maximum of 16 devices. Extended addressing mode allows for specific Node to Gateway binding and allows network expansion for more than 16 devices in a wireless network. For most users, this switch is OFF. For more information on extended address mode, refer to the SureCross™ Wireless I/O Network product manual, p/n 132607. Because the M-GAGE has no LCD, triple-click button 2 to activate binding mode instead of using the menu structure listed in document 132607.

Setting the Node's Use Switch Settings DIP switch (DIP switch 2) to the ON position allows the Node DIP switches 3 through 8 to be used for configuration. Configuration settings from the M-GAGE Gateway's DIP switches are active regardless of the Node's Use Switch Settings DIP switch position.

Set the Node's Use Switch Settings DIP switch to the OFF position to use either the Web Configuration tool to set the parameters or to send commands to I/O 13 directly from the host system.

	Switches							
Device Settings	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rotary Switch Address Mode	OFF*							
Extended Address Mode	ON							
Use Configuration		OFF*						
Use Switch Settings		ON						
Low Pass Filter T2			OFF*	OFF*				
Low Pass Filter T3			OFF	ON				
Low Pass Filter T0			ON	OFF				
Low Pass Filter T1			ON	ON				
Sample High Count 4					OFF*	OFF*		
Sample High Count 8					OFF	ON		
Sample High Count 1					ON	OFF		
Sample High Count 2					ON	ON		
Sample 250 milliseconds							OFF*	OFF*
Sample 500 milliseconds							OFF	ON
Sample 1 second							ON	OFF
Sample 125 milliseconds							ON	ON

* Default configuration

M-GAGE Gateway DIP Switches

The special M-GAGE Gateway, models DX80G*M6*6P6ZP, can configure up to two M-GAGE Nodes. To use the special M-GAGE Gateway's DIP switches to configure the M-GAGE Node, refer to the M-GAGE Gateway data sheet, Banner p/n 139075.

Configuration Using Register 13

A host system can configure the M-GAGE Node by setting I/O 13 on the M-GAGE Node. Writing a defined value to the Modbus register sets the M-GAGE operation immediately. The following parameters can be configured by writing to the M-GAGE Node Modbus register 13. The host system must resend the configuration settings if power is cycled to the wireless system.

	Modbus Register 13															
	Low Pass Filter			Sample High Counter			Report Rate		Sample Rate			Baseline Filter		Threshold and Hysteresis		
Device Settings	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
No Change	0	0	0													
No Low Pass Filter	0	0	1													
Low Pass Filter T0	0	1	0													
Low Pass Filter T1	0	1	1													
Low Pass Filter T2	1	0	0													
Low Pass Filter T3	1	0	1													
Low Pass Filter T4	1	1	0													
Low Pass Filter T6	1	1	1													
No Change				0	0	0										
1				0	0	1										
2				0	1	0										
3				0	1	1										
4				1	0	0										
8				1	0	1										
16				1	1	0										
32				1	1	1										
No Change							0	0								
Change of State							0	1								
16 sec							1	0								
Sample Rate							1	1								
No Change									0	0	0					
62.5 ms									0	0	1					
125 ms									0	1	0					
250 ms									0	1	1					
500 ms									1	0	0					
1 sec									1	0	1					
31 ms									1	1	0					
20 ms									1	1	1					
No Change												0	0			

Device Settings	Modbus Register 13															
	Low Pass Filter			Sample High Counter			Report Rate		Sample Rate			Baseline Filter		Threshold and Hysteresis		
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Filter Off												0	1			
Filter Threshold 30, 2 Hour												1	0			
Filter Threshold 30, 8 Hour												1	1			
Threshold / Hysteresis																
No Change														0	0	0
50 / 15														0	0	1
100 / 30														0	1	0
150 / 30														0	1	1
200 / 30														1	0	0
300 / 40														1	0	1
500 / 50														1	1	0
800 / 60														1	1	1

Sending the Configuration Message to Register 13

Modbus command 06 (write single holding register) is used in this example to set the parameter values for the M-GAGE Node. A sample configuration message for Node 1:

Modbus Register 13

	Low Pass Filter			Sample High Counter			Report Rate		Sample Rate			Baseline Filter		Threshold and Hysteresis		
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Values	0	0	0	0	1	0	1	1	0	1	0	0	1	1	0	1
Hex Values	0			B			4					D				

Sending this configuration message to register 13 sets the low pass filter to “no change;” the sample high counter to 2; the report rate and sample rate to 125 milliseconds; the baseline filter to 0, 15; the threshold to 300; and the hysteresis to 40.

The complete Modbus command, in hexidecimal, is:

Slave ID#	Modbus Command	Register Number		Configuration Value			
01	06	00	1C	0B	4D	CRC	CRC

Configuration Using Registers 7, 15, and 16

To send Modbus configuration commands to registers 7, 15, and 16, please refer to the Modbus Host Configuration Reference Guide, Banner document number 132114 for instructions and example commands.

Installation

The charts within figures 2 and 3 indicate the excess gain for a typical car. Excess gain is the measure of “extra” signal detected by the sensor in excess of the level needed to detect change in the magnetic fields.

Figure 3 illustrates a typical vehicle passing over a sensor mounted underground. Note that the excess gain is greatest when the front bumper is positioned such that the rear axle is directly over the M-GAGE™.

The graphs represent the default sensitivity threshold levels (solid line) and half the default sensitivity (dotted line). As shown in the table, the excess gain of the default sensitivity is twice that of the other sensitivity.

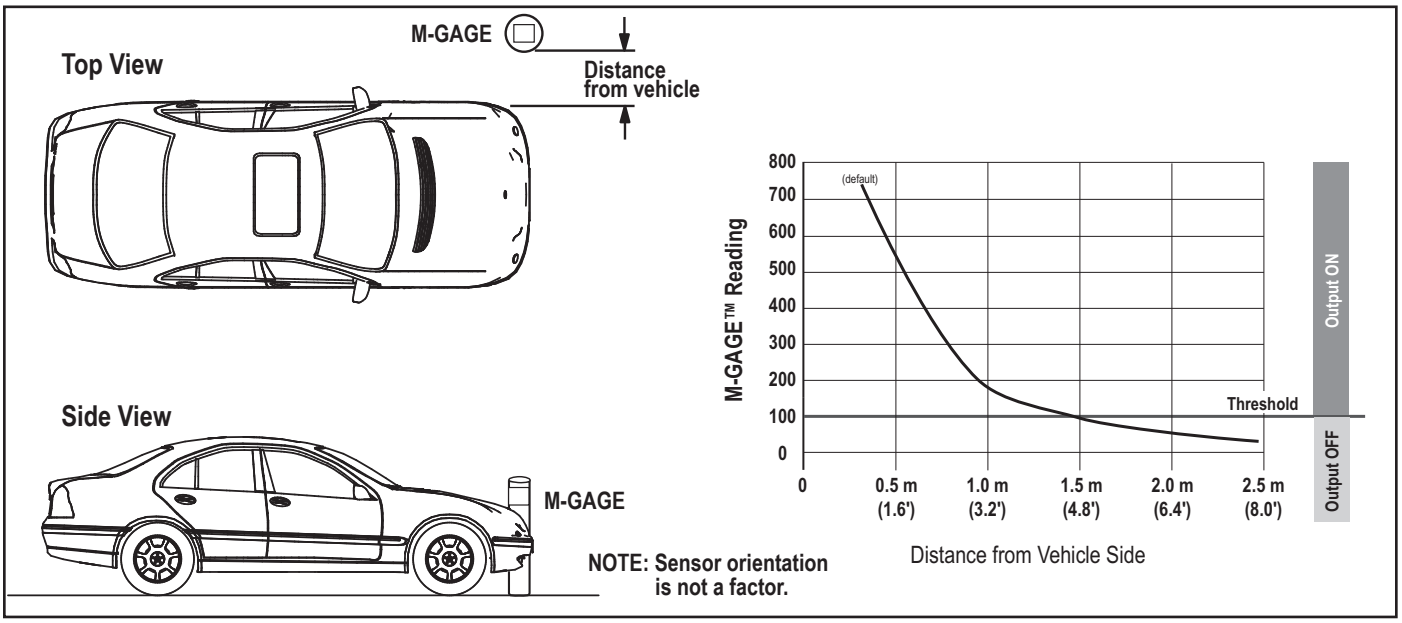

Figure 2. Sensor mounted one meter (3.2 ft) above the ground.

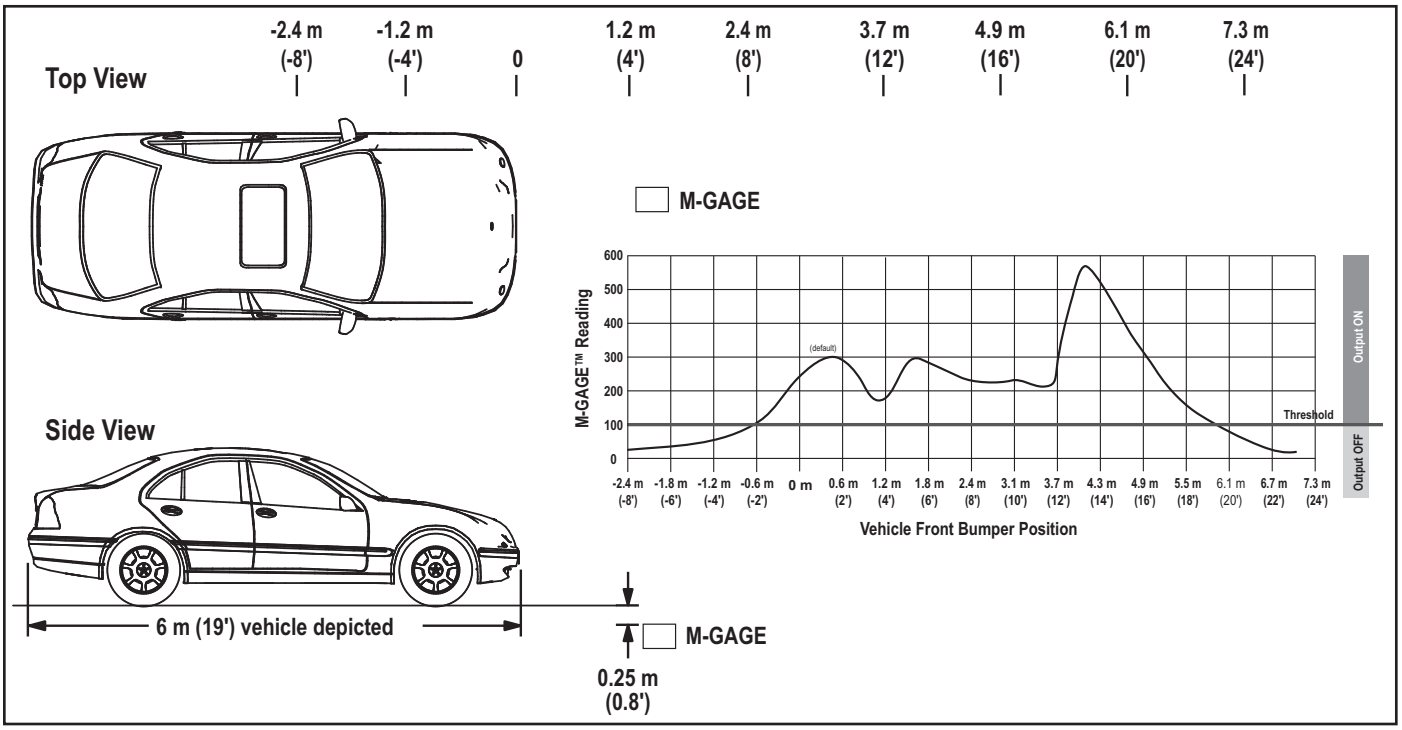

Figure 3. Sensor mounted 0.25 meters (0.8 ft) below the ground.

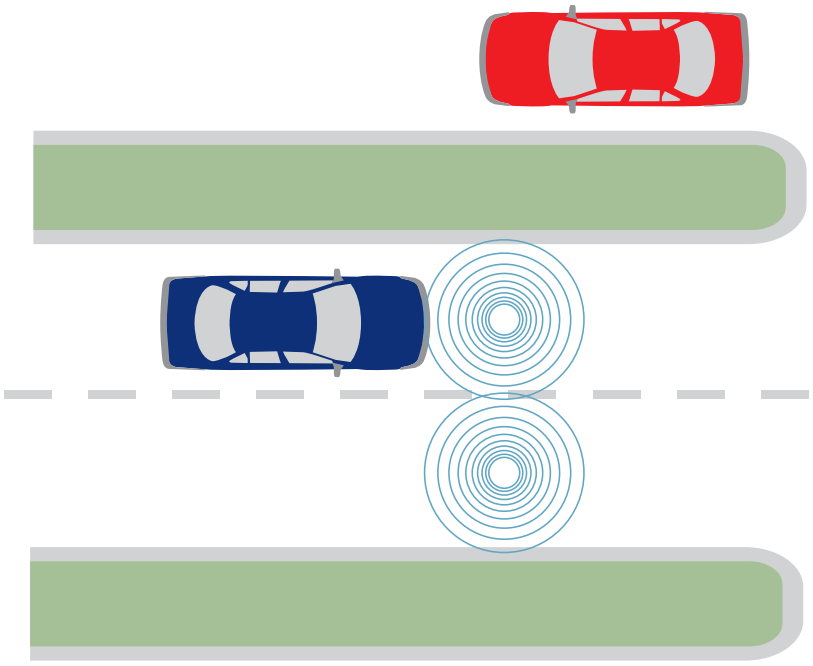

Figure 10. Optimal positioning of the M-GAGE device.

Good Placement

Figure 10 shows the optimum placement of M-GAGE™ sensors for vehicle detection. When the sensor is positioned in the middle of the traffic lane, it can be configured to a threshold level to detect vehicles only in the lane of interest. This is known as lane separation, or not detecting a vehicle in an adjacent lane.

A threshold level also aids the sensor in vehicle separation – detecting a break between the back bumper of a leading vehicle and the front bumper of the next vehicle. With proper placement and configuration, the M-GAGE can achieve vehicle separation with distances of 24 inches or less between vehicles.

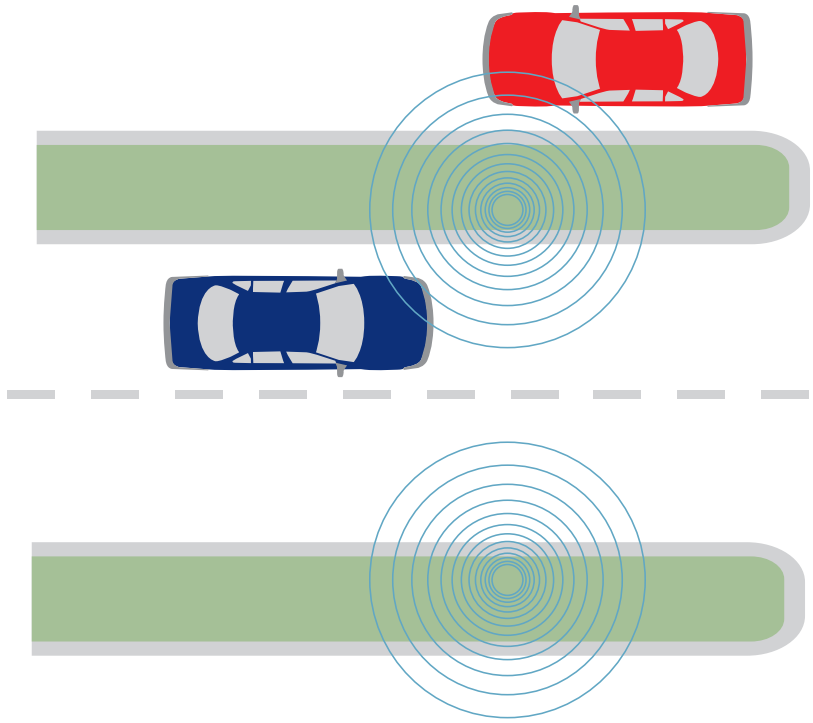

Figure 11. Poor positioning of the M-GAGE device.

Poor Placement

The drawing at left depicts a potential problem installation. While mounting the sensor at the side of a lane may be successful, this mounting location increases the potential for problems. To reliably detect a vehicle from the side, the sensor threshold must be increased to see objects further away in the lane of interest. Unfortunately, this enables the sensor to also detect lawn mowers in the median or vehicles in adjacent lanes, causing false counts.

Place the M-GAGE sensor at the edge of a traffic lane only if there is no possibility of the sensor detecting other objects. To avoid detecting other objects, ensure no vehicles will be within 10 feet of the sensor on the non-traffic side.

Buried Installation

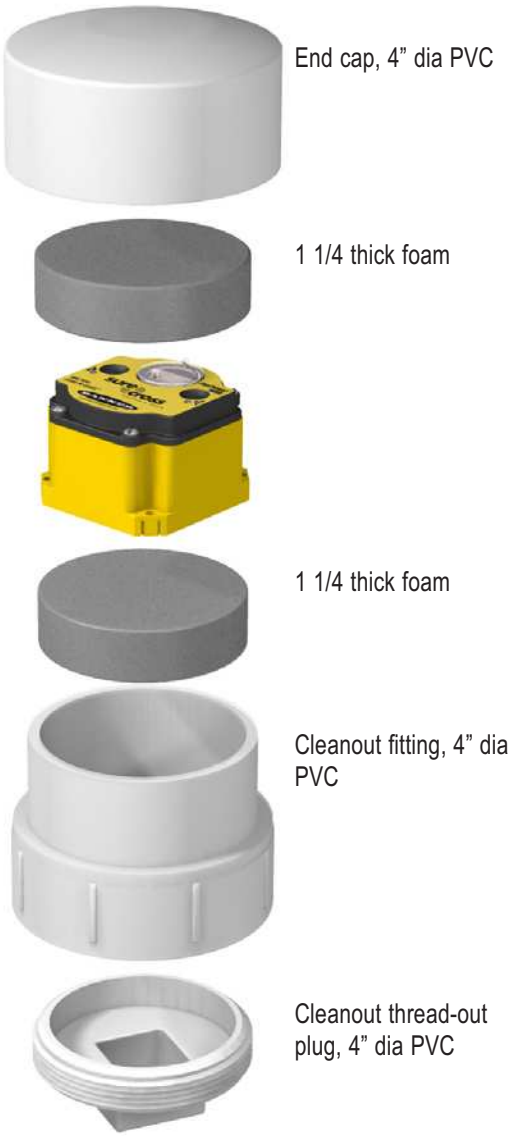

Figure 4. Additional items needed but not shown: 1/2” wide PTFE seal tape, PVC primer, PVC cement

To protect the M-GAGE in a buried application, Banner Engineering recommends installing the device within a protective 4” dia PVC enclosure. Form the enclosure using a cleanout fitting with a thread-out plug and end cap.

To create a waterproof environment for the M-GAGE Node, follow these steps:

1. Cut part of the mounting ears off, as shown in figure 5, to allow the M-GAGE Node to fit through the cleanout fitting.

Figure 5

2. Coat the joint area between the end cap and cleanout fitting with PVC primer and PVC cement.
3. Insert the cleanout fitting into the end cap until the fitting comes into full contact with the end cap.
4. Allow the adhesive to dry for 24 hours.
5. Wrap several layers of PTFE seal tape around the entire threaded edge of the cleanout plug.
6. Insert a 1” to 1 1/2” thick piece of foam into the end cap.
7. Enable the M-GAGE Node by pressing button 1 for four seconds. LED 1 should flash green to indicate the device is powered up and operating.
8. Insert the M-GAGE Node into the capsule on top of the first foam piece as shown in figure 4.
9. Place another foam piece behind the M-GAGE to prevent the device from moving in the capsule.
10. Place the cleanout plug into position and tighten until the top of the plug is flush with the surface of the fitting, as shown in figure 6.
11. Bury the capsule in the ground with the plug on the bottom and the end cap on the top.

Figure 6. When sealed, the cleanout plug should be flush with the surface of the fitting.

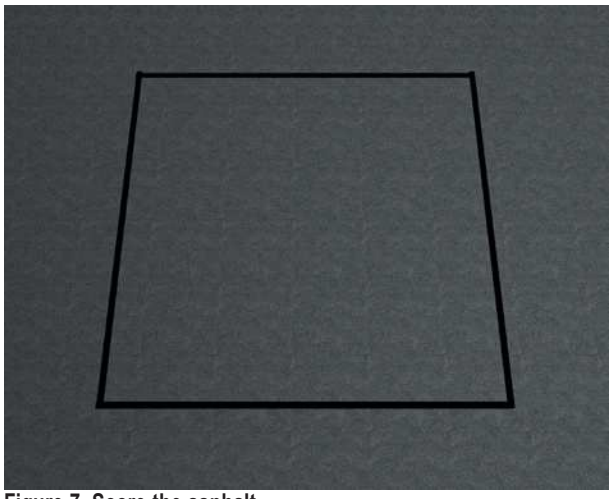

Figure 7. Score the asphalt.

Determine the geometric center of the space the vehicle would normally occupy and mark this location as the center of the hole. Score the asphalt in a square around the center point or use an auger drill to create a hole for the PVC enclosure.

Figure 8. Remote asphalt and aggregate to create a hole.

Using a masonry or diamond blade in a circular saw, cut the marked square, leaving clean, sharp edges for patching later.

Using a jackhammer or hammer and chisel, break away the asphalt to expose the aggregate underneath. Uncut asphalt in the corners of the square section do not have to be removed.

Remove enough asphalt to allow the PVC enclosure to pass through easily.

Clear the aggregate to make a hole approximately nine inches deep. Ensure the hole's bottom surface is level, flat, and tightly packed before continuing.

Figure 9. Place the PVC enclosure into the hole.

Place the PVC enclosure into the hole so that the top of the enclosure rests approximately three inches below the pavement's original surface. Backfill tightly around the perimeter of the enclosure with aggregate before patching the pavement.

Specifications

Many of the parameters are configurable. The values in the tables represent factory defaults unless otherwise noted.

Radio	
Range*	300 meters (1000 ft)
Frequency	**900 MHz:** 902 to 928 MHz ISM band **2.4 GHz:** 2.4 to 2.4835 GHz ISM Band
Transmit Power	**900 MHz:** 21 dBm Conducted **2.4 GHz:** 18 dBm Conducted, ≤ 20 dBm EIRP
Spread Spectrum Technology	FHSS (Frequency Hopping Spread Spectrum)
Link Timeout	Defined by Gateway

* The range depends on the environment and line of sight and is lower when buried.

General	
Power	3.6V dc low power option
Mounting	#10 or M5 (M5 hardware included)
M5 Fasteners Max. Tightening Torque	0.56 N•m (5 in•lbf)
Case Material	Polycarbonate
Weight	0.23 kg (0.50 lb.)
Indicators	Two LED, bi-color
Switches	Two Push Buttons
M-GAGE™ Input	Internal Magnetometer
Sample Rate	250 milliseconds
Report Rate	On Change of State
Ambient Temperature Effect	Less than 0.5 milligauss/°C
Sensing Range	See figures 2 and 3

Environmental	
Environmental Rating	IEC IP67; NEMA 6
Operating Temperature*	−40 to +85° C (Electronics); −20 to +80° C (LCD)
Operating Humidity	95% max. relative (non-condensing)
Radiated Immunity	10 V/m, 80-2700 MHz (EN61000-6-2)
Shock and Vibration	IEC 68-2-6 and IEC 68-2-7 **Shock**: 30g, 11 millisecond half sine wave, 18 shocks **Vibration**: 0.5 mm p-p, 10 to 60 Hz

* Operating the devices at the maximum operating conditions for extended periods can shorten the life of the device.

Compliance	
900 MHz Models	FCC ID TGUDX80: This device complies with FCC Part 15, Subpart C, 15.247 IC: 7044A-DX8009 CE
2.4 GHz Models	FCC ID UE300DX80-2400: This device complies with FCC Part 15, Subpart C, 15.247 ETSI/EN: In accordance with EN 300 328: V1.7.1 (2006-05) IC: 7044A-DX8024 CE

Included with Device	Model	Qty	Item
Mounting Hardware Kit	**BWA-HW-001**	4	Screw, M5-0.8 x 25mm, SS
		4	Screw, M5-0.8 x 16mm, SS
		4	Hex nut, M5-0.8mm, SS
		4	Bolt, #8-32 x 3/4", SS
SureCross Literature CD	**79685**	1	SureCross Literature CD
Data sheet		1	
Installation Pack	BWA-HW-005		M-GAGE Installation Pack (Two 1 1/4 thick foam pieces, PTFE tape)

It is Banner Engineering's intent to fully comply with all national and regional regulations regarding radio frequency emissions. Customers who want to re-export this product to a country other than that to which it was sold must ensure that the device is approved in the destination country. A list of approved countries appears in the SureCross DX80 Wireless Product Manual, in the *Agency Certifications* section. The SureCross wireless products were certified for use in these countries using the standard antenna that ships with the product. When using other antennas, verify you are not exceeding the transmit power levels allowed by local governing agencies. Consult with Banner Engineering if the destination country is not on this list.

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The manufacturer does not take responsibility for the violation of any warning listed in this document.

CAUTION. Make no modifications to this product. Any modifications to this product not expressly approved by Banner Engineering could void the user's authority to operate the product. Contact the Factory for more information.

Lightning Arrestors/Surge Protection. Always use lightning arrestors/surge protection with all remote antenna systems to avoid invalidating the Banner Engineering Corp. warranty. No surge protector can absorb all lightning strikes. Do not touch the SureCross device or any equipment connected to the SureCross device during a thunderstorm.

WARRANTY. Banner Engineering Corp. warrants its products to be free from defects for one year. Banner Engineering Corp. will repair or replace, free of charge, any product of its manufacture found to be defective at the time it is returned to the factory during the warranty period. This warranty does not cover damage or liability for the improper application of Banner products. This warranty is in lieu of any other warranty either expressed or implied.

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