Sure Cross® MultiHop M-GAGE

Datasheet

M-GAGE™ MultiHop radios detect the presence or absence of ferrous objects and work as end-point radios within a MultiHop wireless network.

- 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
- Powered by a D-cell lithium battery integrated into the housing
- Functions as an endpoint (slave) radio within a MultiHop wireless network
- Message routing improves link performance
- Sure Cross® architecture creates self-forming and self-healing wireless networks
- Built-in site survey mode enables rapid assessment of a location's RF transmission properties
- Fully potted and sealed housing contains the power source, sensor, and antenna for a completely wireless solution

For additional information, updated documentation, and a list of accessories, refer to Banner Engineering's website, *www.bannerengineering.com/wireless*.

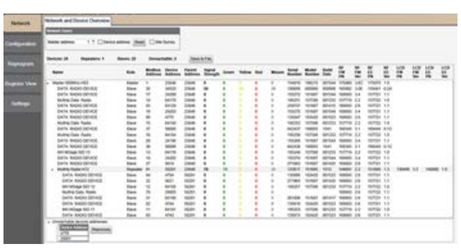
Models	Power	Frequency	I/O
DX80DR9M-HMD	D-cell Lithium battery integrated into the housing	900 MHz ISM Band, 100 mW	Internal M-GAGE™
DX80DR2M-HMD		2.4 GHz ISM Band, 65 mW	

WARNING: Not To Be Used for Personnel Protection

Never use this device as a sensing device for personnel protection. Doing so could lead to serious injury or death. This device does not include the self-checking redundant circuitry necessary to allow its use in personnel safety applications. A sensor failure or malfunction can cause either an energized or de-energized sensor output condition.

MultiHop Configuration Tool

Use Banner's MultiHop Configuration Tool software to view your MultiHop radio network and configure the radio and its I/O.



The MultiHop Configuration Tool connects to a MultiHop master radio using one of four methods.

- Serial; using a USB to RS-485 (for RS-485 radios) or a USB to RS-232 (for RS-232 radios) converter cable.
- Modbus TCP; using an Ethernet connection to an Ethernet radio master.
- Serial DXM; using a USB cable to a DXM controller to access a MultiHop master radio.
- TCP DXM: using an Ethernet connection to a DXM controller to access a MultiHop master radio.

For MultiHop DX80DR* models, Banner recommends using BWA-UCT-900, an RS-485 to USB adapter cable with a wall plug that can power your 1 Watt MultiHop radio while you are configuring it. The adapter cable is not required when connecting to a DXM controller.

Download the most recent revisions of the UCT software from Banner Engineering's website: *www.bannerengineering.com/wireless*.

M-GAGE 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.

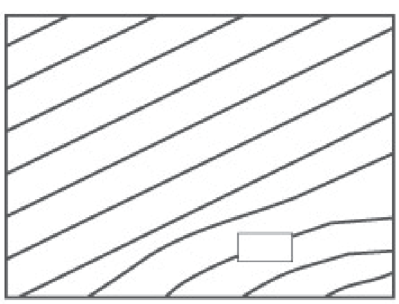
Because the M-GAGE uses an internal battery, the device ships from the factory in a "deep sleep" mode. While in "deep sleep" mode, the M-GAGE does not attempt to transmit to a parent radio and remains in deep sleep until an LED light at the receiving window wakes it up. To wake the device:

1. Point the optical commissioning device at the receiver.
2. Click and hold the button until the red/green LED in the center of the M-GAGE lights up, about five seconds.

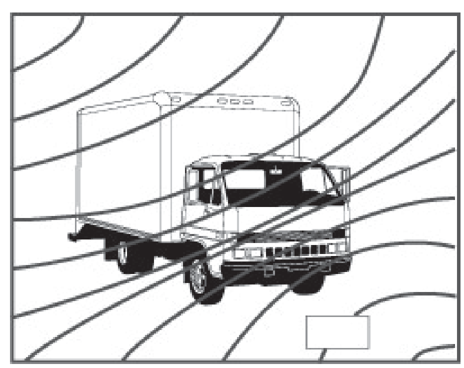
When the device wakes up, the LEDs flash according to the LED table. To return the M-GAGE back to its "deep sleep" mode, click and hold the button until the red LED in the center of the M-GAGE stops blinking, about five seconds.

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. 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.



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.

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.

Setting Up Your MultiHop M-GAGE Network

To set up and install your wireless MultiHop M-GAGE network, follow these steps:

1. Use the LED light to wake up the M-GAGE radios.
2. Form the wireless network by binding the M-GAGE radios to their master radio.
3. Observe the LED behavior to verify the devices are communicating with each other.
4. Conduct a site survey between the MultiHop Radios.
5. Install your M-GAGE radios.

Using the LED Light

The LED flashlight is used to set device modes, such as entering binding mode.

Click and Hold. Click and hold the LED light at the receiving window to wake a wireless device from "deep sleep." If your device is not in "deep sleep," clicking and holding the LED light will put it into "deep sleep." While in "deep sleep" mode, the device does not attempt to transmit to a parent radio and remains in deep sleep until an LED light at the receiving window wakes it up.

Three clicks. Triple clicking at the receiving window puts the device into binding mode. The device binds to the Device ID the master radio is set to. Before putting the device into binding mode, verify the master radio's rotary dials are set to ensure the device will be binding to the correct device ID.

If the device is in binding mode, double click the LED light to exit binding mode.

Model Number: BWA-MGFOB-001

Binding the MultiHop M-GAGEs to Form Networks (M-GAGE Optical Commissioning models)

Binding MultiHop radios ensures all MultiHop radios within a network only communicate with other radios within the same network. The MultiHop master radio automatically generates a unique binding code when the master radio enters binding mode. This code is then transmitted to all MultiHop radios within range that are also in binding mode. After a MultiHop M-GAGE slave is bound, the M-GAGE radio accepts data only from the master to which it is bound. The binding code defines the network, and all radios within a single network must use the same binding code.

Before using the M-GAGE devices, you must bind them to the MultiHop master radio and assign a device ID using the master's rotary dials. There are no physical switches or dials on the M-GAGE radio. To bind and address an M-GAGE, follow these steps.

On the MultiHop Master Radio

Step 1. Apply power to the master radio.

Step 2. Triple click button 2 to enter binding mode.

For the two LED/button models, both LEDs flash red and the LCD shows *BINDNG and *MASTER. For single LED/button models, the LED flashes alternatively red and green.

Step 3. Using the rotary dials, select the Device ID to assign to the M-GAGE. Use the left rotary dial for the left digit and the right rotary dial for the right digit. For example, to assign your M-GAGE to Device ID 10, set the left dial to 1 and the right dial to 0.

On the MultiHop M-GAGE Radio

Step 1. Place the optical commissioning device in contact with the clear plastic housing and pointed directly at the configuration port indicated by the label.

Step 2. Click the button on the optical commissioning device three times to place the M-GAGE into binding mode. (If the M-GAGE is in its "slow scan" mode, this will wake up the M-GAGE as well as begin binding mode.)

After entering binding mode, the M-GAGE LEDs blink slowly, alternating between red and green. After the M-GAGE receives a valid binding code from the MultiHop Master Radio, the red and green LEDs are both illuminated continuously, resulting in a slightly orange light. (See User Interface section on previous page.)

The red and green LEDs simultaneously flash four times to indicate that the M-GAGE accepts the binding code. The M-GAGE enters RUN mode. Note: If the M-GAGE is in binding mode and the user does not accept the binding code with a triple click from the optical commissioning device, the M-GAGE automatically exits binding mode after one hour and returns to the previous binding code.

Step 3. After binding an M-GAGE to the MultiHop Master Radio and assigning it a unique Device ID, write the Device ID on the M-GAGE's label.

Step 4. Repeat this sequence (M-GAGE steps 2 and 3) for as many M-GAGEs as you need to bind.

If two M-GAGEs are accidentally assigned the same Device ID, rerun the binding procedure on one of the M-GAGEs to reassign the ID. The binding sequence may be run on a M-GAGE as many times as necessary.

On the MultiHop Master Radio

Step 1. To exit binding mode, double click button 2 on the MultiHop master radio. The master radio reboots and enters RUN mode.

M-GAGE Installation

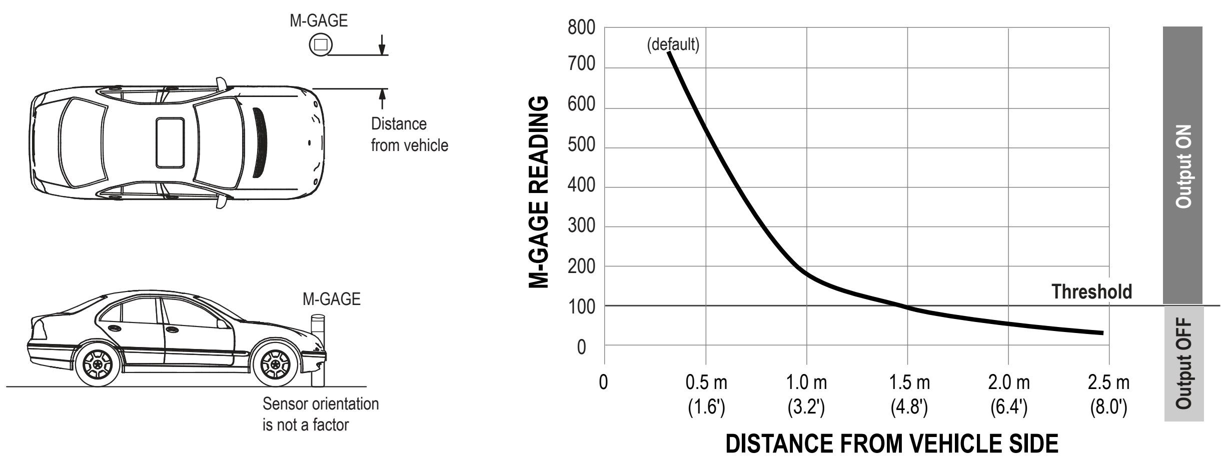


Figure 1. M-GAGE Reading when installed 1 meter above the ground.

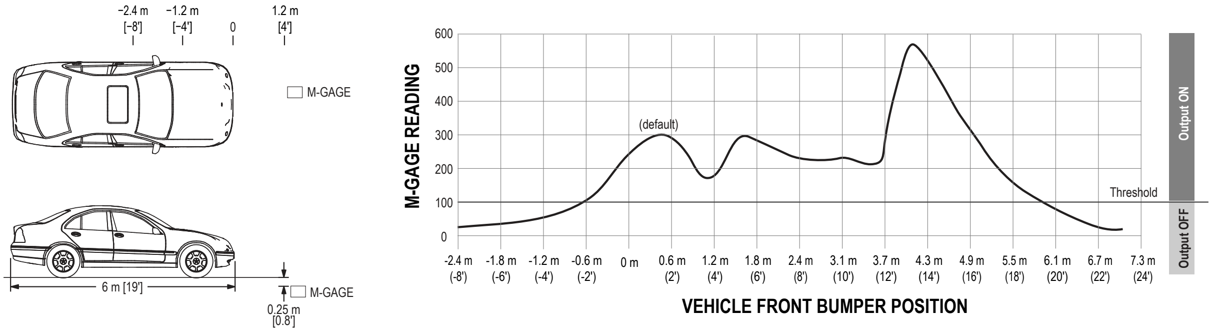


Figure 2. M-GAGE Reading when installed underground.

Placing the M-GAGE for Best Results

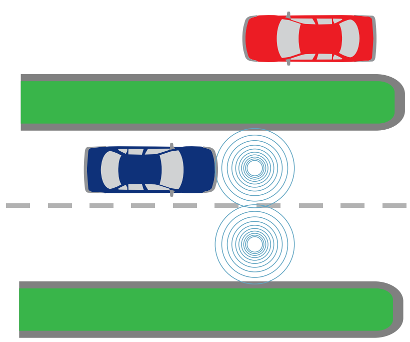


Figure 3. Optimum placement of M-GAGE

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.

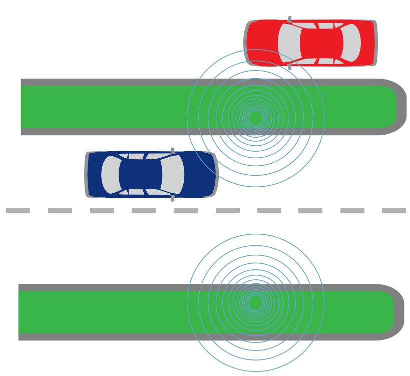


Figure 4. Poor placement of M-GAGE

Although 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 farther 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

- Always wear proper eye protection when grinding or drilling.
- Gloves, hearing protection, and sturdy boots are highly recommended.
- Always read and follow all specific instructions and safety precautions provided by the manufacturer of all equipment.

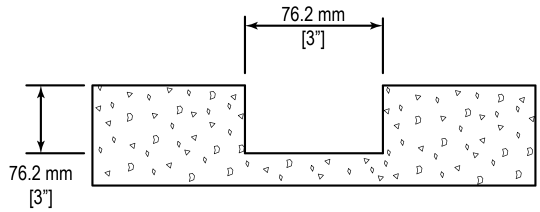
Required equipment includes:

- 3” Coring equipment. Many options exist; choose what works best for the conditions of your installation site.
- Sealer. We recommend using a flexible, weather-proof liquid asphalt/concrete repair compound suitable for your needs. Banner Engineering used Fabick Protective Coatings joint sealers for test installations.

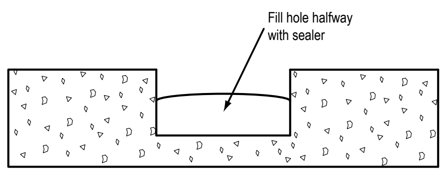
The installation objective is to fully encapsulate the M-GAGE sensor in sealant.

1. Bind and configure all devices before continuing.

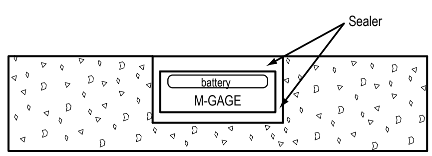
2. Drill a 3 inch diameter hole to a depth of about 3 inches. Use a chisel to break off the plug of material and remove any loose material remaining in the bottom of the hole.



3. Verify all surfaces inside and near the hole are free of debris, warm (consult sealer manufacturer data for temperature threshold data), and thoroughly dry.
4. Repeat steps 1 through 3 for all locations.
5. One hole at a time, pour enough sealer into the hole to halfway fill the hole.



6. Battery side up, place the M-GAGE into the hole and press down until the sealer material flows up and around the M-GAGE and begins to pour onto the top.
   The top of the M-GAGE should be about 1.5 inches below the surface.
7. Immediately fill the spaces surrounding the device with sealer. Completely fill the hole with sealer to avoid leaving a recess that collects water and dirt.



Modbus M-GAGE Input Register Table

Register (4xxxx)	Input #	I/O Type	Holding Register Representation	
			Min. (Dec.)	Max. (Dec.)
1	1	M-GAGE	0	65535
2	2			
3	3			

Modbus Addressing Convention

All Modbus addresses refer to Modbus holding registers. When writing your own Modbus scripts, use the appropriate commands for interfacing to holding registers. Parameter description headings refer to addresses in the range of 40000 as is customary with Modbus convention.

Modbus Register Configuration (M-GAGE)

The factory default settings for the inputs and device operations can be changed by the user through the device Modbus registers. To change parameters, the data radio network must be set to Modbus mode and the data radio must be assigned a valid Modbus slave ID. The following sections provide the basic parameter descriptions and register locations. For a complete Modbus register map, refer to the MultiHop Radio Product Manual, Banner p/n *151317*.

I/O Parameter Section	Groups	4xxxx Registers	Parameters
Input	Input 1	1001–1003	1xx1 Enable 1xx2 Sample Interval (high word) 1xx3 Sample Interval (low word)

Factory Default Settings for M-GAGE Inputs

Register	M-GAGE Parameter	Default Value (dec)
x1001	Enable	1
x1002	Sample Interval (High Word)	00
x1003	Sample Interval (Low Word)	13
x4501	Set Baseline	0
x4502	Disable Axes	0
x4503	Disable Compensation Median Filter	0
x4504	Disable Sensing Median Filter	0
x4505	Low Pass Filter	3

Register	M-GAGE Parameter	Default Value (dec)
x4506	Sample High	6
x4507	Sample Low	6
x4509	Delta	0
x4510	Threshold	150
x4511	Hysteresis	40
x4512	Baseline (Drift) Filter Time	20
x4513	Baseline (Drift) Filter Threshold	30
x4514	Baseline (Drift) Filter Tau	12

Specifications

Radio Range[1]
900 MHz: 300 m (1000 ft)
2.4 GHz: 150 m (500 ft)

Radio Transmit Power
900 MHz, 100 mW: 20 dBm (100 mW) conducted
2.4 GHz, 65 mW: 18 dBm (65 mW) conducted, less than or equal to 20 dBm (100 mW) EIRP

900 MHz Compliance
FCC ID TGUDX80 - This device complies with FCC Part 15, Subpart C, 15.247
IC: 7044A-DX8009

2.4 GHz Compliance (MultiHop)
FCC ID UE300DX80-2400 - This device complies with FCC Part 15, Subpart C, 15.247
ETSI EN 300 328: V1.8.1 (2012-04)
IC: 7044A-DX8024

Operating Conditions
–40 °C to +85 °C (–40 °F to +185 °F)
95% maximum relative humidity (non-condensing)

Environmental Rating
IEC IP67; NEMA 6

Certifications
CE

Supply Voltage
Lithium battery (D cell) integrated into the housing, 19.2 Ah

Housing
ABS
Weight: 0.24 kg (0.55 lbs)

Interface
Indicators: One bi-color LED

Spread Spectrum Technology
FHSS (Frequency Hopping Spread Spectrum)

M-GAGE Inputs (MultiHop Models)
Input: Internal Magnetometer
Sample Rate: 1 second
Ambient Temperature Effect: Less than 0.5 milligauss/°C
Sensing Range: See figures on previous pages

Radiated Immunity HF
10 V/m (EN 61000-4-3)

Shock and Vibration
IEC 68-2-6 and IEC 68-2-27
Shock: 30g, 11 millisecond half sine wave, 18 shocks
Vibration: 0.5 mm p-p, 10 to 60 Hz

[1] Radio range depends on the environment and line of sight and is lower when buried.

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