

## iProx™ Inductive Proximity Sensors — Field Saturation

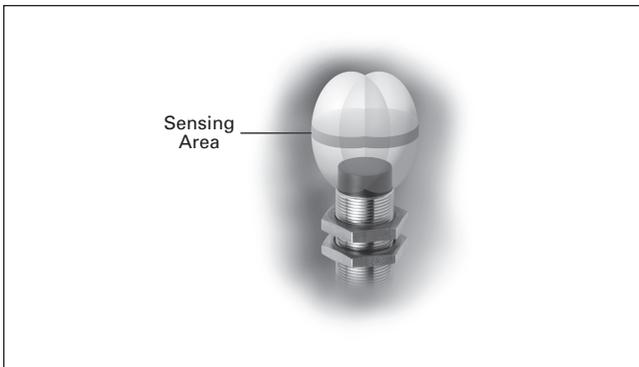
Technical Data

Maximize Application Reliability  
by Understanding iProx  
Field Saturation

October 2005  
Supersedes August 2002

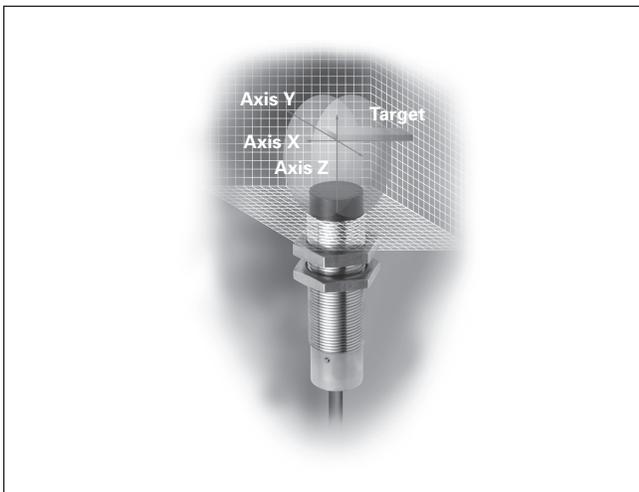
### Description

The iProx family of inductive proximity sensors utilizes an embedded microprocessor to deliver powerful, intelligent sensing capabilities. This means the iProx can solve applications where standard proximity sensors fail. One such feature unique to iProx is the ability to sense metal objects within a specific distance, or *band*, while ignoring targets in areas closer or further away (see **Figure 1**).



**Figure 1. Band Sensing**

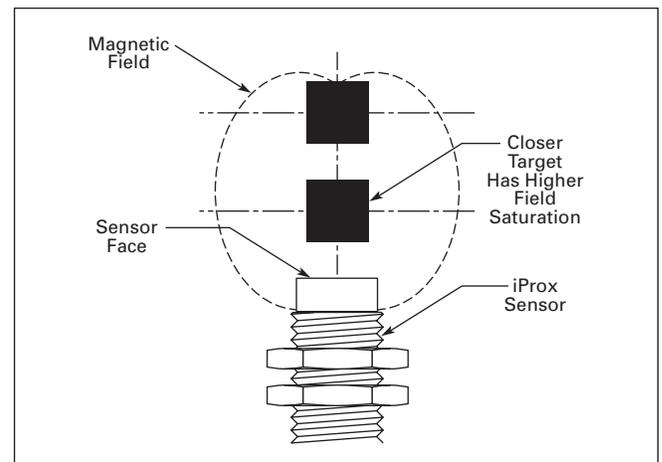
Another capability is *position sensing*, where the sensor is set up to operate only when a target reaches a specific point in the X, Y or Z coordinates as shown in **Figure 2**.



**Figure 2. Position Sensing**

### How It Works

The sensor is able to perform these feats by carefully monitoring very small changes in *field saturation* as the target moves within the sensing field, then comparing these changes against specific values programmed by the user. In simple terms, field saturation can be defined as the relative strength of the signal produced by the target at different positions within the inductive sensing field. A target closer to the sensor face will cause a higher level of field saturation than the same target further away (**Figure 3**). The microprocessor monitors the field saturation level and produces an output when the current saturation level is equal to the level set when the target was in the desired operate position during programming.



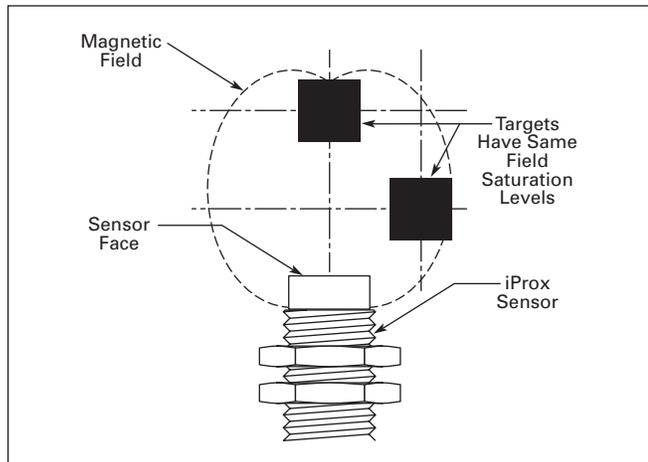
**Figure 3. Target Position Affects Field Saturation Level**

Note that ***there are situations when the field saturation is at the desired level and the sensor produces an output, even though the target is not in the desired position.*** By understanding the theory of how iProx works, a user can ensure high reliability in the sensing application.

**Limits to the Technology**

The main point to remember is that the sensor doesn't know the precise location of the target. But, it is able to calculate the target position based on the field saturation readings that it is monitoring. In most cases, this will produce highly accurate results, but there are limits to the technology.

If we look at the inductive sensing field in two dimensions as shown in **Figure 4**, you can see that a target that is farther from the sensor face, but closer to the center line of the sensor, may yield the same field saturation level as the same target closer to the sensor face, but farther away from the center. This is simply due to the fact that the magnetic field emanating from the coil in the face of the sensor is stronger nearer to the coil, and gets weaker in all directions as you move farther from the coil. In fact, for any given target, there are several points in this field that would yield the same field saturation level.



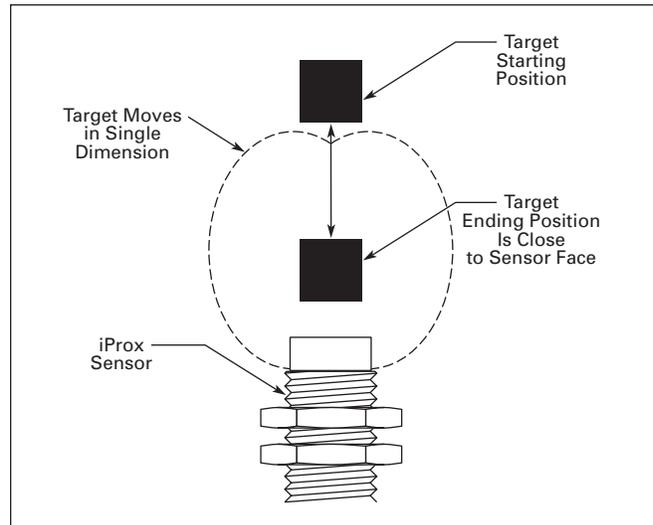
**Figure 4. Same Field Saturation Levels at Different Positions**

**Planning for High Sensing Reliability**

If the target is moving to and from the sensor in one axis, both band and position sensing will be successful. If the target is moving in two axes, identical saturation points are possible and must be avoided. If the target is free to move in three axes, the application will likely not be reliable. Certainly, the more predictable the path of the movement, the more reliable the application.

Listed below are a few basic application guidelines. By following these whenever possible, you can increase the reliability of your sensing application (see **Figure 5**):

1. Whenever possible, limit the target movement in the application to a simple path in a single dimension so that field saturation is a series of different values.
2. Orient the sensor such that the movement is coming toward the sensor from the front rather than the side.
3. Position the sensing point as close as possible to the sensor face. This will maximize repeatability due to the increased strength of the inductive field near the face.



**Figure 5. Ideal Target Movement**

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## iProx™ Inductive Proximity Sensors — Mounting Close Together

Technical Data

Ensure Reliability When  
iProx Sensors Are Mounted  
Close Together

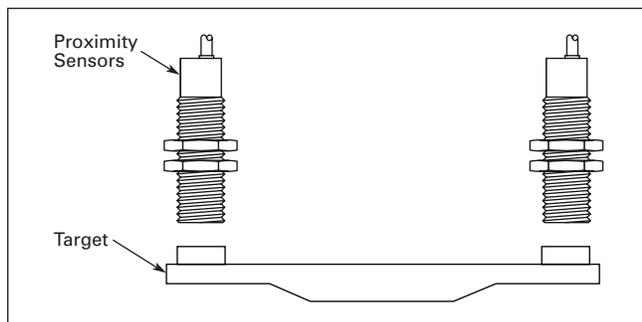
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### Description

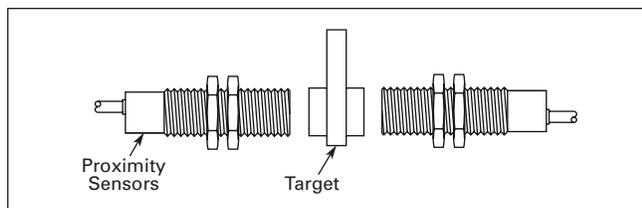
The iProx is a powerful family of inductive proximity sensors featuring high sensing performance right out of the box. What makes the iProx unique from other inductive sensors is the ability to extensively customize the operating characteristics to suit a particular application.

### Mounting Sensors Close Together

When mounting iProx sensors close together, it is necessary to take into consideration problems that can be caused by two or more sensors communicating with each other (also known as “cross-talk”). This problem can arise when two or more sensors are mounted side-by-side (as shown in **Figure 1**) or facing each other (as shown in **Figure 2**).



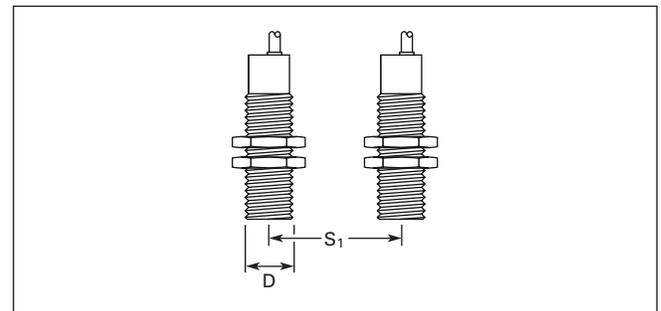
**Figure 1. Prox Sensors Mounted Side-by-Side**



**Figure 2. Prox Sensors Mounted Facing Each Other**

Standard inductive proximity sensors have a similar frequency and will interfere with each other when operated close together. Until iProx, your best solution may have been to buy special sensors designed to operate on different frequencies. The disadvantage of this solution is that your choice of sensing range and body style is usually very limited.

The DC versions of iProx have three different noise immunity settings, while the AC versions have two settings. See **Figures 3, 4, 5** and **6** for optimum noise immunity settings based upon center-to-center spacing between mounted sensors. Note that in some cases, more than one noise immunity setting is available. In this case, the operator can choose the combinations of noise immunity settings most desirable for the application. The iProx breaks many of the traditional rules of inductive proximity sensors. For instance, it is possible to mount the sensors in a manner so that the sensing fields overlap, so long as the proper noise immunity settings are chosen.



**Figure 3. DC iProx Side-by-Side Configuration ( $S_1$ )**

**Table 1. DC iProx Side-by-Side Configuration ( $S_1$ )**

Diameter (D)		Side-by-Side	High Noise Immunity	Factory Default
12 mm	Shld.	0 – 19 mm at 50 Hz	0 mm – Infinity at 10 Hz	30 mm – Infinity at 580 Hz
	Unshld.	0 – 40 mm at 50 Hz	0 mm – Infinity at 10 Hz	100 mm – Infinity at 300 Hz
18 mm	Shld.	0 – 35 mm at 50 Hz	0 mm – Infinity at 10 Hz	80 mm – Infinity at 390 Hz
	Unshld.	0 – 75 mm at 50 Hz	0 mm – Infinity at 10 Hz	130 mm – Infinity at 150 Hz
30 mm	Shld.	0 – 65 mm at 50 Hz	0 mm – Infinity at 10 Hz	110 mm – Infinity at 240 Hz
	Unshld.	0 – 75 mm at 50 Hz	0 mm – Infinity at 10 Hz	130 mm – Infinity at 90 Hz

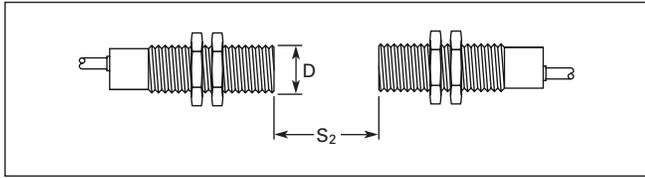


Figure 4. DC iProx Facing Configuration (S<sub>2</sub>)

Table 2. DC iProx Facing Configuration (S<sub>2</sub>)

Diameter (D)		Side-by-Side	High Noise Immunity	Factory Default
12 mm	Shld.	0 – 25 mm at 50 Hz	0 mm – Infinity at 10 Hz	50 mm – Infinity at 580 Hz
	Unshld.	0 – 55 mm at 50 Hz	0 mm – Infinity at 10 Hz	120 mm – Infinity at 300 Hz
18 mm	Shld.	0 – 45 mm at 50 Hz	0 mm – Infinity at 10 Hz	100 mm – Infinity at 390 Hz
	Unshld.	0 – 90 mm at 50 Hz	0 mm – Infinity at 10 Hz	160 mm – Infinity at 150 Hz
30 mm	Shld.	0 – 80 mm at 50 Hz	0 mm – Infinity at 10 Hz	130 mm – Infinity at 240 Hz
	Unshld.	0 – 90 mm at 50 Hz	0 mm – Infinity at 10 Hz	160 mm – Infinity at 90 Hz

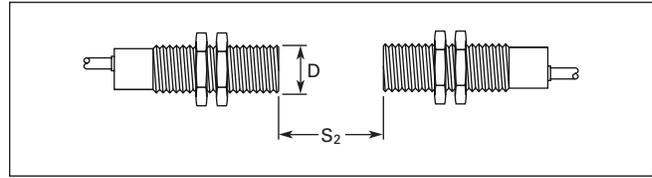


Figure 6. AC iProx Facing Configuration (S<sub>2</sub>)

Table 4. AC iProx Facing Configuration (S<sub>2</sub>)<sup>②</sup>

Diameter (D)		Factory Default	High Noise Immunity
12 mm	Shld.	0 – 25 mm/50 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
	Unshld.	0 – 55 mm/120 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
18 mm	Shld.	0 – 45 mm/100 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
	Unshld.	0 – 90 mm/160 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
30 mm	Shld.	0 – 80 mm/130 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
	Unshld.	0 – 90 mm/160 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz

<sup>②</sup> These specifications may not meet final product specifications.

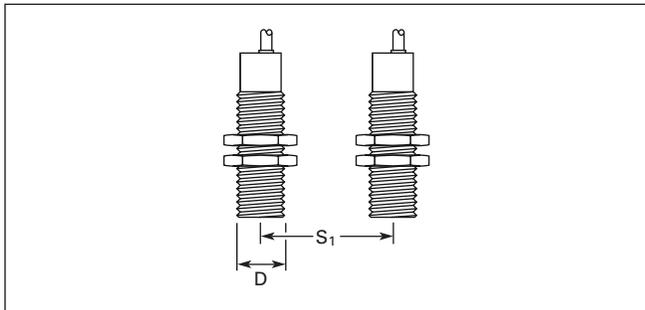


Figure 5. AC iProx Side-by-Side Configuration (S<sub>1</sub>)

Table 3. AC iProx Side-by-Side Configuration (S<sub>1</sub>)<sup>①</sup>

Diameter (D)		Factory Default	High Noise Immunity
12 mm	Shld.	0 – 19 mm/30 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
	Unshld.	0 – 40 mm/50 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
18 mm	Shld.	0 – 35 mm/80 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
	Unshld.	0 – 75 mm/130 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
30 mm	Shld.	0 – 65 mm/110 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz
	Unshld.	0 – 75 mm/130 mm – Infinity at 30 Hz	0 mm – Infinity at 10 Hz

<sup>①</sup> These specifications may not meet final product specifications.

Note that there is a correlation between noise immunity and operating frequency. When setting the sensor for Side-by-Side sensing or High Noise Immunity, the operating frequency of the sensor will be reduced. Refer to the *iProx Programming Software User Guide* (P50228) for details.

### Setting iProx for Side-by-Side or Facing Sensing

To set up iProx sensors for side-by-side or face-to-face operation, just follow the simple procedure below. This process requires that the iProx Programming Software be installed on your computer. Consult the *iProx Programming Software User Guide* (P50228) for detailed installation and operating instructions.

1. Connect the programming device to your computer. If using a Remote Programmer (E59RP1), connect it to your computer's serial port. If using the Tray Programmer (E59TP1), you have the option of connecting through serial or USB ports.
2. Launch the iProx Programming Software from the Start menu.
3. If using the Remote Programmer, affix the magnetic puck to the face of the iProx sensor. If using the Tray Programmer, securely mount the iProx sensor(s) in the programming receptacles. To ensure proper mounting, it may be necessary to remove the mounting nuts from the sensor.

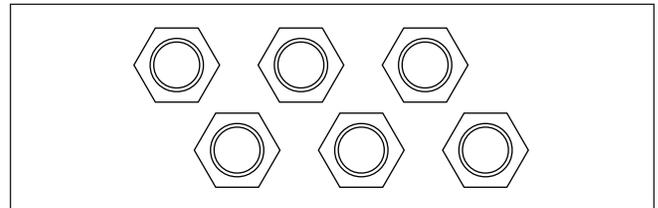
4. Ensure the sensor(s) you intend to program are powered on.
5. The iProx Programming Software should automatically detect the sensor(s). See the "Connection Status" information displayed at the bottom of the "Getting Started" window to confirm the software has detected the sensor(s). If the software does not detect the connected sensor, you may need to select a wider COM port range in the software settings. For more troubleshooting information, consult the *iProx Programming Software User Guide* (P50228) by clicking on the "Help" window and selecting "Contents/FAQs."
6. From the Getting Started window, click "Configure iProx" to modify the parameters of your iProx sensor.
7. Under "Step 1: Select Sensor to Modify," click the drop-down menu and select the sensor you want to modify. It may take a few seconds to communicate with the sensor. Once this is complete, the rest of the screen should become enabled, allowing you to modify the parameters of the selected sensor.
8. Under the "Response Time/Noise Immunity" section at the top-right of the screen, drag the slider until you see the Side-by-Side value enabled.
9. Click the "Program" button at the bottom of the screen. Repeat this process for each sensor.

### Side-by-Side vs. Array Sensing

Although this procedure allows sensors to be operated close to other sensors in a side-by-side configuration (see **Figure 7**), Eaton does not recommend that iProx sensors be used in an array (**Figure 8**). It is possible that cross communication can occur between sensors in an array. If the requirements of your application call for this arrangement, please contact Eaton's Sensor Application Engineering Department at 1-800-426-9184. They will work with you to find a solution.



**Figure 7. Sensors Oriented Side-by-Side**



**Figure 8. Sensor Oriented in an Array**

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## iProx™ Inductive Proximity Sensors — Optimizing Hysteresis

Technical Data

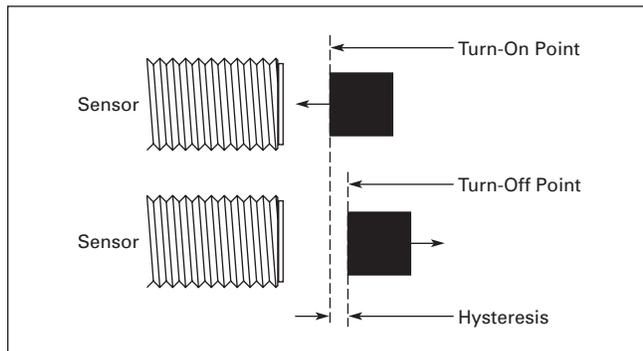
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### Description

The iProx family of inductive sensors feature extremely high sensing performance. Like many sensors, the various operating characteristics, such as range, hysteresis and output, have been preset from the factory to be ideal for a wide variety of sensing applications. Where iProx differs from other sensors is in the ease of changing these default operating characteristics to suit your specific application. This document will cover hysteresis — what it is, the benefits of modifying it, and how to change it.

### What Is Hysteresis and Why Is It Important?

All sensing devices incorporate some level of hysteresis. Hysteresis is the difference between the signal levels at which a sensor turns off and turns on. This difference can usually be observed by slowly bringing a target toward the sensor until it turns on and then moving it away until it turns off. The point where the sensor turns on will be slightly closer to the sensor than the point it turns off (see **Figure 1**).



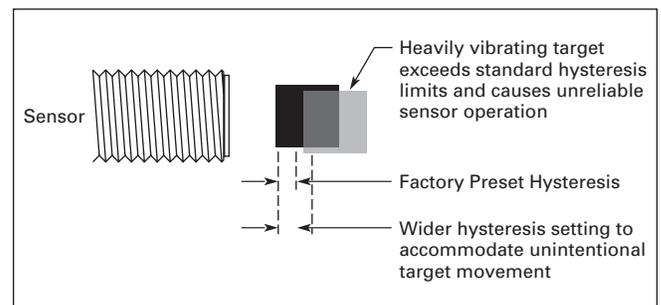
**Figure 1. Hysteresis in Presence Sensing**

This difference, usually in the area of 10 to 15 percent, is necessary to reduce the sensor's sensitivity to noise and vibration. It also eliminates multiple transitions (called "chattering") at the point where the output switches. A mechanical version of this effect can be found in many electrical switches. For instance, as you move the handle just past the center point, a spring in the switch will pull the handle all the way over, ensuring that the switch ends up in a definite "on" or "off" state.

### When Is It Necessary to Adjust Hysteresis?

As stated before, the factory preset hysteresis setting is appropriate for most sensing applications. But for some, the ability to fine tune the sensor hysteresis setting will greatly increase reliability. For others, it may be the only way to solve the application.

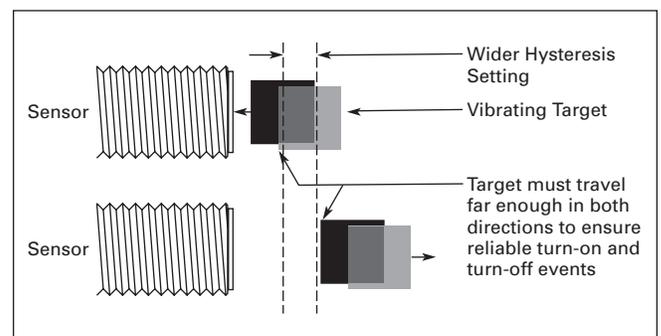
For sensing applications that occur in areas of high shock or vibration, a wider hysteresis setting may be necessary to ensure reliable machine operation (see **Figure 2**).



**Figure 2. An Example Requiring Increased Sensor Hysteresis**

By increasing the hysteresis, you can accommodate unintentional movement of the target due to shock or vibration without causing multiple output signals during one sensing event.

When widening the hysteresis, it is important to ensure that the normal travel of the target will take it far enough in both extremes to ensure reliable turn-on and turn-off events (see **Figure 3**).



**Figure 3. Target Travel Considerations with Increased Hysteresis**

On the other end of the spectrum, you may have an extremely precise and stable application where you desire highly accurate results. In this case, setting the hysteresis to a tighter setting than the factory preset will provide this high accuracy.

### Setting iProx Hysteresis

To adjust the hysteresis on your iProx sensor, follow the procedure listed below. For more detailed instructions on adjusting hysteresis with the software, consult the *iProx Programming Software User Guide* (P50228) included on your software CD-ROM.

1. Connect the programming device to your computer. If using a Remote Programmer (E59RP1), connect it to your computer's serial port. If using the Tray Programmer (E59TP1), you have the option of connecting through serial or USB ports.
2. Launch the iProx Programming Software from the Start menu.
3. If using the Remote Programmer, affix the magnetic puck to the face of the sensor. If using the Tray Programmer, securely mount the iProx sensor(s) in the programming receptacles. To ensure proper mounting, it may be necessary to remove the mounting nuts from the sensor.
4. Ensure the sensor(s) you intend to program are powered on.
5. The iProx Programming Software should automatically detect the sensor(s). See the "Connection Status" information displayed at the bottom of the "Getting Started" window to confirm the software has detected the sensor(s). If the software does not detect the connected sensor(s), you may need to select a wider COM port range in the software settings. For more troubleshooting information, consult the *iProx Programming Software User Guide* (P50228) by clicking on the "Help" window and selecting "Contents / FAQs."
6. From the "Getting Started" window, click "Configure iProx" to modify the parameters of your iProx sensor.
7. Under "Step 1: Select Sensor to Modify," click the drop-down menu and select the sensor you intend to modify. It may take a few seconds to communicate with the sensor. Once this is complete, the rest of the screen should become enabled, allowing you to modify the parameters of the selected sensor.
8. The "Modify Sensing Range" section at the bottom of the window displays Operate and Release Points as well as a graphic depiction of the sensing attributes. The "Operate Point" is the distance at which an incoming target is first detected. The "Release Point" is the point at which the target is beyond the detection range of the sensor. The difference between these two points is the hysteresis. To add hysteresis, simply widen the distance between the Operate Point and Release Point (by reducing the Operate Point or increasing the Release Point). Notice the sensing range graphic will dynamically change as you modify the hysteresis. Conversely, to reduce hysteresis, just decrease the distance between the two points (by increasing the Operate Point or decreasing the Release Point).
9. When you are satisfied with your changes, click the "Program" button at the bottom of the screen. Repeat this process for each iProx sensor.

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