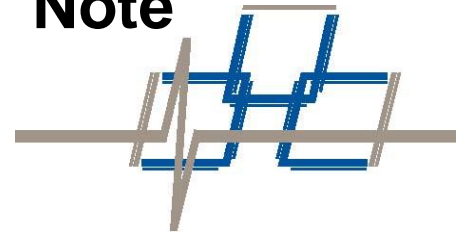


# Site Design and Assessment

For fence applications using  
FD500™ Series Alarm Processing  
Units

## Application Note



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## 1. Introduction

The successful installation and operation of a fiber optic security system requires a thorough understanding of the security needs of the site to be protected as well as proper deployment of the sensor cable. This application note will lead the reader through the site design and assessment procedures for fenced perimeter applications using an **FD500 Series** system.

Prior to installing the **Alarm Processing Unit (APU)** and deploying the sensor cable, the site to be protected must be assessed carefully so that all security needs are met and all potential threats against it are accounted for.

Ultimately, the method by which the sensor cable is installed and deployed is up to the end user. Fiber SenSys does not mandate one particular installation design over another; however, the general procedure for installing the fiber optic perimeter security system is as follows:

1. **Assess:** Survey the site to be protected and record all information needed for the site design phase
2. **Design:** Create a strategy for protecting the site. This includes planning the level of security, choosing the location of the APUs, provision of electrical power, and planning cable routing
3. **Install:** Proper deployment of the fiber optic sensor and correct installation of the Fiber SenSys system

## 2. The FD500 Series Family

The **FD500** Series family consists of two types of APUs:

1. APUs, like the **FD525** and **FD525R**, that connect through just two optical ports and use a field-deployable distribution box.
2. APUs, like the **FD504** and **FD508**, that have individual connections for each zone on the back of the APU.

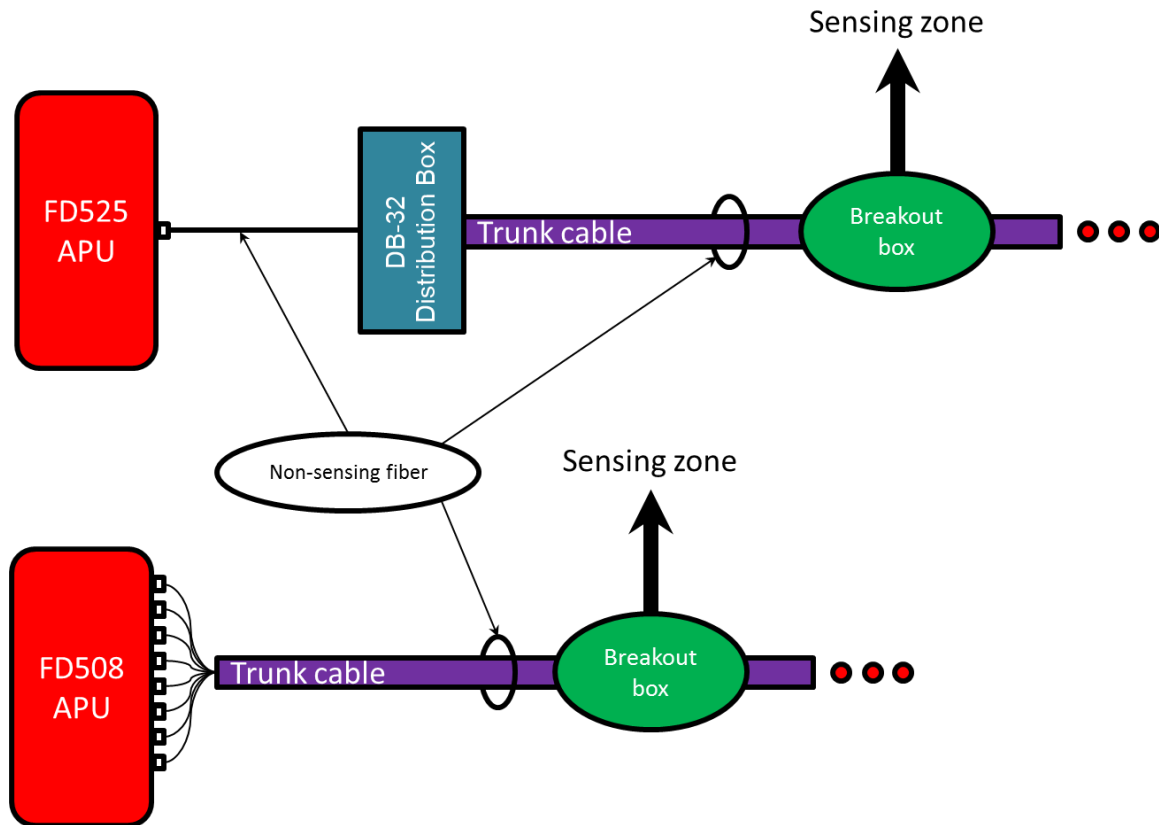


Figure 2-1. The FD525 has two optical ports that connects first to the distribution box, then to the trunk cable and finally to the breakout boxes before outputting to sensing zones. The FD508 does not have a distribution box; instead, it uses a different optical port for each zone.

Both types of 500 Series APUs use a trunk cable to house the individual non-sensing lead-in fibers to each zone. And, for both APUs, the individual non-sensing lead-in fibers are removed from the trunk cable and connected to the individual zones through breakout boxes (see figure 2-1).

The APUs in the **FD500** Series can be used for a wide assortment of applications, including:

1. Flexible wire fences
2. Wall tops
3. Rigid fences
4. Rigid gates
5. Etc.

The sensor cable configuration is determined by the requirements of the secure area and is built on site by Fiber SenSys technicians or those trained/certified by Fiber SenSys.

The insensitive lead-in cable consists of two single-mode fibers and can be up to 3.1 miles (5 km) long, allowing for remote APU installation. See figure 2-2.

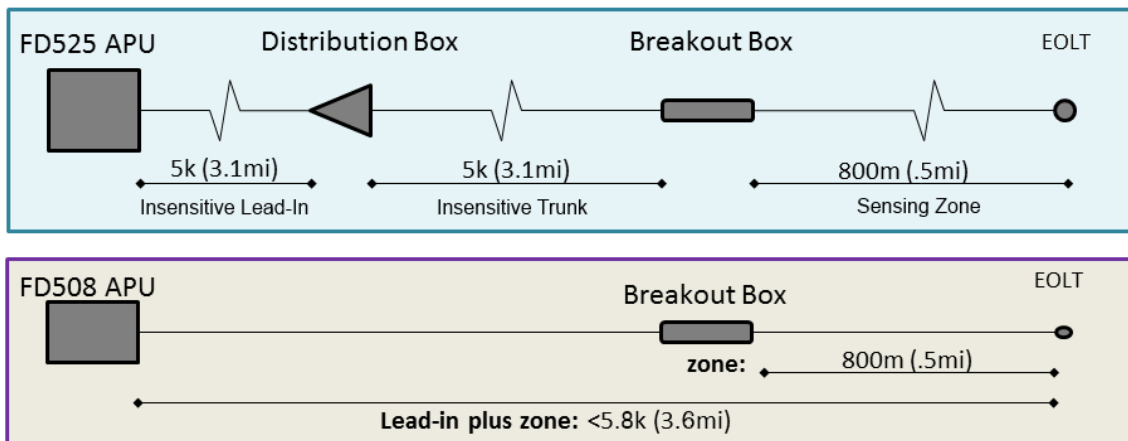


Figure 2-2. Visual representation of lead-in length and zone length specifications for 500 Series systems.

The trunk cable contains a single-mode (insensitive)<sup>1</sup> optical fiber for each zone, and is constructed with a rugged, UV-resistant jacket that is about 12mm in diameter. Each sensor cable contains a strand of multimode optical fiber enclosed in a 3mm jacket. The sensor cable is typically deployed within a protective, flexible conduit.

With the **FD525**, a **DB-32** distribution box is used with separate trunk and sensor cables.

The **DB-32** distribution box is a field-mounted signal distribution center that divides the APU's laser radiation from the pair of lead-in fibers into 32 discrete optical fibers or zones. This distribution center serves as a test point for evaluation of each sensing element and lead-in cable while also allowing site engineers and technicians to manage zone lengths and resolve conflicts through length specific port assignments. The **DB-32** contains a 34 port bulkhead (2 input, 32 output) along with a factory assembled passive optical splitter array (with included reference reflector) and partially assembled demarcation tray capable of housing up to 40 fusion splices. The installed demarcation splice tray allows field technicians to fusion splice the lead-in and trunk cables to pre-connectorized pigtailed.

In the **FD50x (FD504 or FD508)**, the reference reflector (used for internal calibration) as well as the distribution box are built into the APU, and are transparent to the user. Thus, in the **FD50x**, the individual lead-in fibers for each zone are connected directly to the optical ports on the back of the APU.

Both the **FD50x** and the **FD525** typically use a trunk cable and breakout boxes (though there can be multiple trunk cables if the site requires non-linear zone layouts). The trunk cable is spliced to the sensor cables inside the protective breakout boxes. For each zone a fiber is cut from the trunk cable and spliced to the zone's sensor cable; leaving the remaining uncut fibers to exit the opposite end of the breakout box, and feed the remaining zones. A color-coded fiber-splicing matrix is used to identify which fibers are spliced at any given breakout box (see Appendix A).

The sensor cables are single ended and variable in length, depending on the requirements for each zone<sup>2</sup>. When using the **FD525**, some zones may need to include custom delay coils in some of the breakout boxes, to prevent the zones from interfering with each other. In the **FD50x**, however, the breakout boxes serve exclusively as splice enclosures; delay coils are never required in an **FD50x** installation.

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<sup>1</sup> All the insensitive fibers used with **FD500** Series APUs are single-mode.

<sup>2</sup> The sensor cable can be ordered pre-installed in the conduit.

With the **FD50x**, the individual insensitive lead-in fibers are connected to individual optical ports on the back of the APU. There are eight of these optical ports, and each optical port is connected to just one zone (refer back to figure 2-1).

The primary difference between the **FD525** and **FD50x** APUs is the fiber-optic architecture used to connect the APU to the sensing zones. Besides these differences, the remaining aspects of installing the zones on the fence are the same for the entire **FD500** Series of products.

For medium-security installations, the trunk cable and breakout boxes can be tied to the secure side of the fence using stainless steel wire ties. For high-threat-level installations, however, the trunk cable and breakout boxes should be buried on the secure side of the fence to a depth of at least 6 inches within a conduit and vault structure. When installed for high-security applications, with the trunk cable and breakout boxes buried, the **FD500** Series provides exceptional protection; if one or more zones are cut by an intruder, all the other zones continue to work without interruption.



## 3. Site Assessment

Site assessment is used to evaluate the security needs of a site and to gather important information for the site design. This process involves the following:

- Survey the perimeter, recording:
  - Length of the fenced perimeter, excluding gates
  - Fence type (chain link, palisades, decorative, etc.)
  - Locations, lengths, and types of gates
  - Presence of outriggers or top guard
  - Security strengths and weaknesses
  
- Collect the system requirements:
  - Zone resolution/length (the number of zones is a function of this)
  - Level of required security (high, medium, etc.)
  - Types of possible security threats
  - Additional layers of security (cameras, lights, etc.)

## Possible Threats against Fenced Perimeters

There are six primary types of threats against fenced perimeters:

1. Climbing the fence fabric
2. Climbing the fence posts
3. Cutting through the fence fabric
4. Digging under the fence
5. Lifting the fence fabric
6. Ladder-assisted climbing over the fence

Your site can be effectively protected against all of these types of threats through the proper installation of the cable assembly and calibration of the APU.

## Nuisances

As part of the assessment of the site, take into account possible non-threatening trespasses that could trigger an alarm, such as animals, wind, and tree limbs.

Before system installation, take all steps necessary to eliminate nuisance causing elements by trimming or removing tree branches and shrubs that encroach on the fence line, removing oversized signs hung on the fence fabric, and restricting guard dogs and other wildlife in the area.

In many cases, some sections of fence may be more prone to nuisances than others, because of higher winds, nearby traffic or trains, or more heavily wooded areas. If all possible nuisances cannot be removed before system installation, the affected zones can be tuned to resist potential nuisances.

## General Fence/Perimeter Requirements

To ensure the system successfully detects intrusions, the fence should meet following requirements prior to installation:

1. The fence should not generate excessive vibration and/or noise. For chain-link fences, re-tensioning the fence fabric and adding additional tie wires to eliminate metal-to-metal banging of the fabric when the wind blows effectively quiets the fence. Make sure the fabric is secured firmly to all fence posts.
2. The fence should be composed of the same material (similar gauge and construction) along the length of each zone. Perimeters with multiple types of perimeter media should plan their zone breaks at these transition points.
3. Keep a clear area on both sides of the fence; all climbing aids such as tree limbs, large rocks, and structures should be removed or secured. Also, there should be no spots along the fence where an intruder could easily crawl or dig underneath without disturbing the sensor.
4. Buildings, structures, waterfronts, and other barriers used along the perimeter in place of the fence line should provide adequate protection against intrusion. Ensure that there are no windows, doors, openings, or unguarded means of access.

## Chain-Link Fences

In order to ensure the highest performance of our sensors installed on chain-link fences, make sure the fence conforms to the following specifications before installing the sensing cables:

**Fabric.** The fence fabric should be composed of steel chain mesh (9 gauge or less) with openings not larger than 3 inches (7.62 cm). Additionally, tension the fabric consistently across its length throughout the protected zone.

**Fabric ties.** Use steel ties (9 gauge or thicker). The ties should be electrolytically compatible with the fence fabric to prevent corrosion. Attach the fence fabric to the posts using at least four evenly spaced ties. Ensure that all ties are tight enough against the post to eliminate or significantly reduce mechanical noise.

**Top guard outrigger.** Outriggers, when used, should angle out in the direction of the unsecured area. Install at least three strands of barbed wire attached perpendicular to the top guard posts. Make sure the barbed wire is well-tensioned and fastened where needed to eliminate mechanical noise.

**Height.** The height of the fence should be a minimum of 7 feet (2.1 meters).

**Fence posts, supports, and hardware.** Pin or weld all posts, supports, and hardware to prevent disassembly of the fencing or removal of gates. Locate all posts and structural supports on the inner side of the fencing. Secure posts in the soil with cement to prevent shifting, sagging, or collapse. Additionally, place posts every ten feet or less to maintain adequate tension.

**Reinforcement.** Install horizontal rails or taut reinforcing wires, interwoven or affixed with fabric ties along the top and bottom of the fence for stabilization of the fabric.

**Ground clearance.** Ensure that the bottom of the fence fabric is within 2 inches (5 cm) of firm soil or buried sufficiently in soft soil.

**Culverts and openings.** Any culverts under or through a fence must consist of pipe 10 inches (25 cm) in diameter or less; larger openings should be secured with protective grates and monitored with sensing fiber or third party sensing technology.

For more information on these requirements, refer to the **Fiber SenSys** application note, *Security Fence Construction Recommendations*, available at [www.fibersensys.com](http://www.fibersensys.com).

## Zone Length, Sensor Length, and System Resolution

The lengths and placements of the zones are determined by the site requirements. The zone lengths need to be set such that the location of intruders can be determined accurately within the needed response time of the site. Other factors might include requirements for gates, culverts, and other discrete structures to be individually alarmed with their own zones. The length of sensing fiber required for a given zone depends on the following:

1. Length of the zone
2. Security level for the zone
  - High
  - Medium
  - Low
3. Fence construction
4. Number of poles and cross-braces

For example, a low-to-medium security application may require a single pass of the sensor cable down the middle of the fence, in which case the length of the sensing cable will be approximately the length of the zone. On the other hand, a high-security application may require two passes along the fence, as well as vertical loops up and down each outrigger. In this sort of application, the length of the sensing cable may be more than 3 times as long as the physical length of the zone.<sup>3</sup>

Consider the example in figure 3-1, where the zones are 100 meters long. In this installation, the sensor cable passes the length of the zone two times and the height of the zone twice. Even though the zones may be 100 meters long, the sensing cable/conduit needs to be about 210 meters long.

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<sup>3</sup> When concertina wire is secured with sensing fiber, the top guard may have a differing tension than the fence and a separate zone can be used to protect the differing regions on the fence line. In this case, two zones may cover the same physical length of the perimeter, with one zone installed on the fence and the other zone installed on the outriggers.

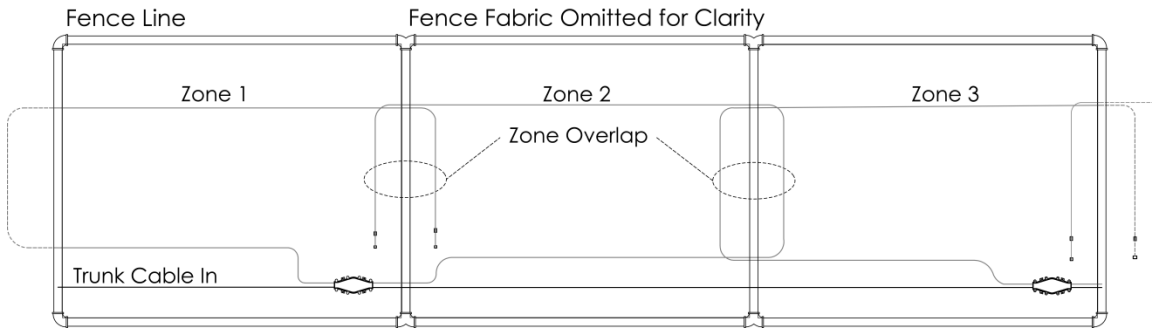


Figure 3-1. Sensor cable deployment and system resolution.

Zone lengths depend on the type of structure or valued merchandise being protected, and how security threats are responded to. For example, sometimes a gate may be assigned its own zone. In the case of personnel gates, the zone may be only a few feet wide, and contain less than 10 meters of sensing cable. Other structures that may be assigned their own zones include building walls and doors. In cases such as these, the length of the zone is typically dictated by the physical size of the object being protected<sup>4</sup>.

Unlike discrete objects, like gates, long fence-line perimeters should be divided into multiple zones in order to be effectively protected. The lengths of these zones are determined by how the security system will respond to intruders. When estimating the sizes of the zones, it is helpful to use the concept of the Response Perimeter of Influence (RPI). RPI is the length of the perimeter that can be effectively secured once an alarm is activated, and it is a function of the speed of the intruder and the security response time:

$$Zone \leq RPI \leq V_{Intruder} \cdot T_{Response}$$

In words, the RPI is less than, or equal to, the product of the average intruder's speed<sup>5</sup>, multiplied by the response time. To help understand this equation, let's look at two examples:

Example 1:

- A remote site has no on-site security.

<sup>4</sup> The exception being when structures are protected by multiple zones.

<sup>5</sup> The average intruder's speed includes the time spent climbing or cutting through the fence; it includes the stationary time in breaching the perimeter and crossing to the inside of the perimeter.

- Alarms are relayed to security personnel by phone, after which they must travel for several hours to reach the site.
- If we conservatively estimate the intruder is on foot, traveling 7 meters per second (15.7 mph), and the response time is one hour, then the RPI is many km, and the perimeter may need only one zone, even if the entire length of the fence is more than one km long.

### Example 2:

- An industrial facility.
- On-site security.
- Response time, anywhere on the perimeter, is less than 60 seconds.
- Intrusion type: Cut through fence.
- Time of intrusion: 45 seconds.
- Speed of intruder: 7 meters/second.
- RPI = 109 meters.
- In this example, the zone lengths should be about 100 meters so that the security team is provided with the proper resolution for determining the point of intrusion.

It is important to use the equation for RPI as a guide and not a fixed rule. Also, note the  $\leq$  symbol which indicates that the zones should be less than, or equal to, the RPI. Finally, remember to keep other aspects of the security system in mind. For example, if the fiber sensors are going to be used to alert a camera system which will locate and focus on the intruder, then the zones must be smaller than the camera's field of view.

## 4. Site Design

Site design is used to design the security system and the cable assembly. This process involves the following:

- Develop an overall strategy for protecting the site, including:
  - Integration of perimeter security components
  - Response plan for alarms
- Define the system layout:
  - Number and locations of all APU
  - Interface of APU to power and system integration
  - Locations of zones
  - Placement of sensing cable on perimeter
  - Location/placement of insensitive lead-in cables
  - Placement of other system components:
    - Break-out and distribution boxes
    - Termination encapsulation kits
    - Etc.
- Deployment plan for all system components, including plans for configuration, calibration, and testing.

### Zone Placement

Zone placement is generally determined by the requirements of the perimeter's physical layout.

Consider figure 4-1, for example. It is recommended to plan on dedicating a zone to the gates, separate from the fence zones on the left and right. This gives the most configurability and assures ideal detection and nuisance alarm rejection will be achievable. Alternatively, if the gate has low usage, such as an emergency exit, and is isolated from wind vibration, the gate may be included with either of the adjacent zones or in the middle of a zone. In this situation, it is important to understand that the fence and gate probability of detection may differ.

Other perimeter components that can require similar zone adjustments may include buildings, reinforced fence sections, fence corners, or sections of the perimeter where the fence type changes (from chain link to wrought iron, for example).

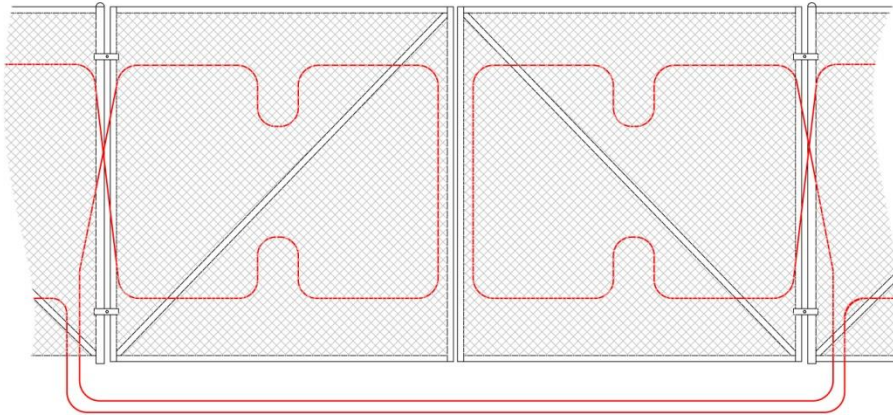


Figure 4-1. Installation pattern for gates

It is generally simplest to route the trunk cable in a linear fashion around the perimeter, however with some sites it may be necessary to split the trunk cable in two or more directions. It is possible to have multiple insensitive trunk cables leaving any given breakout box should the need arise.

## Deployment Guidelines

Properly deploying the sensing cable ensures that the system will accurately detect threats. When planning the sensor cable configuration of the system, there are three important points to keep in mind:

1. The sensor cable detects physical vibration and should be deployed so that it's subject only to vibrations caused by an intruder.
2. Each sensor cable has a consistent level of sensitivity along its entire length. Sections of fence that are easily affected by vibration may need a single, straight pass of the sensor cable, but places where intruders will cause less vibration (such as fence posts or reinforced fence sections) should have more passes/loops of cable in order to increase sensitivity in those areas.
3. The system resolution is determined by the physical length of each zone; the system locates an intrusion only by zone, and not within a zone.



## Chain-Link Fence

The figures below show the two deployment configurations recommended for chain-link fences for medium and high security installations.

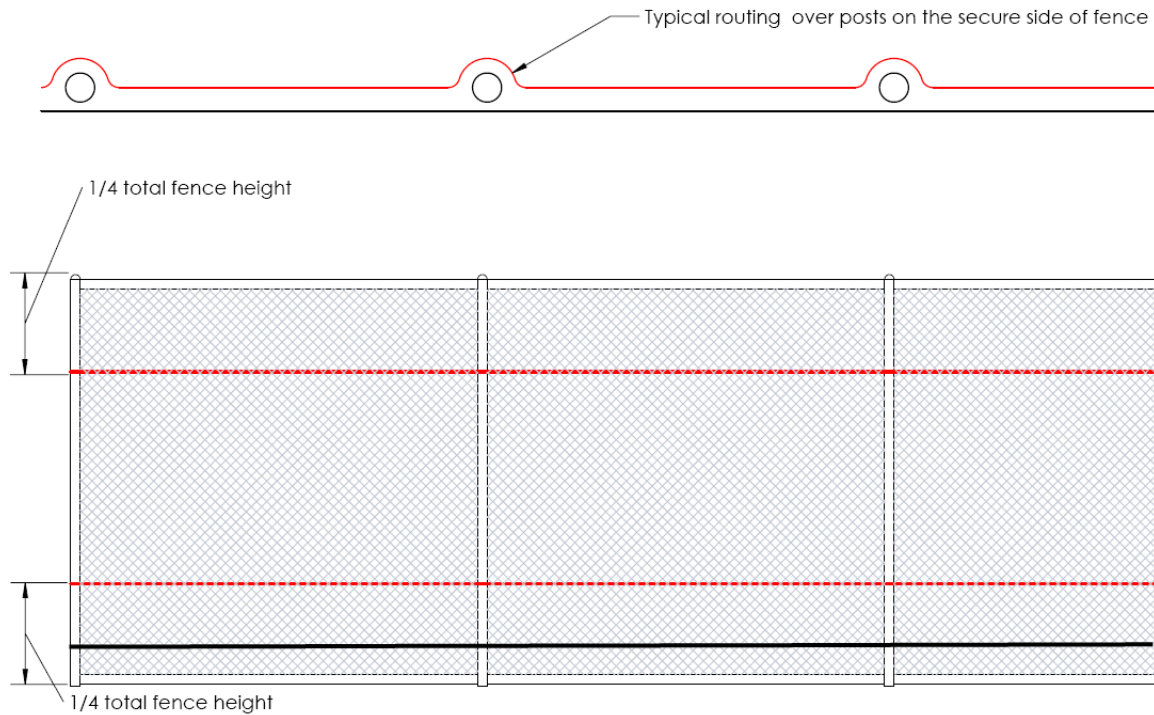
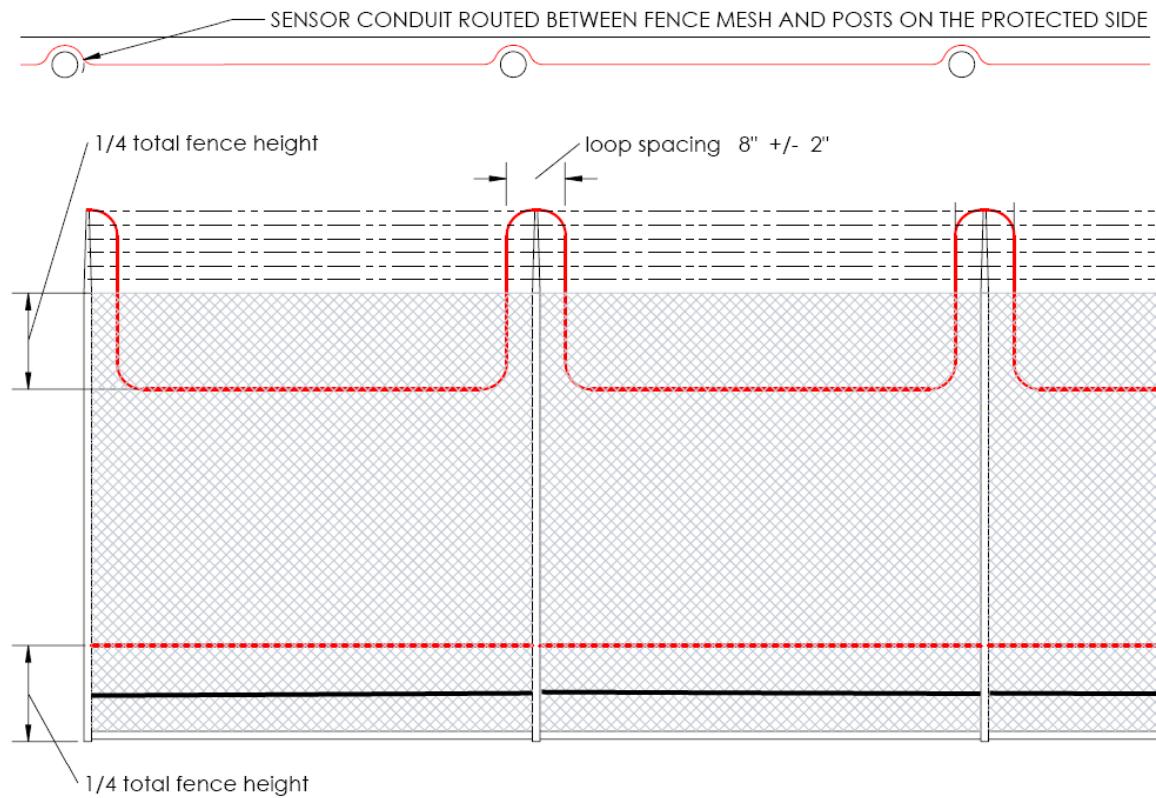


Figure 4-2. Medium-threat deployment.



**Figure 4-3. High-threat deployment.**

The medium-threat deployment protects against relatively sophisticated intrusions by positioning the sensor along the lower and upper levels of the fence so as to place it close to the intrusion. For example, intruders attempting to tunnel under the fence or climb a fence post will disturb the fence close to the sensor, generating an alarm.

The high-threat deployment provides maximum detection capability for the highest-security facilities. Sensor cable added to the fence outriggers raises the system sensitivity to detect intruders trained in security-system penetration.

In both deployments the sensor cable is routed along the fence in a wide loop encompassing the length of the zone and is attached approximately one-quarter of the fence height above the bottom rail and again one-quarter of the fence height down from the top. This configuration is known as “loopback” deployment. The advantage of loopback deployment is that it increases the system’s sensitivity to stealthy intrusions.

As illustrated, the deployment configuration determines the required sensor cable length. A high-threat deployment, for example, requires a sensor cable that is roughly 3.5 times the length of the zone, to account the extra loops running to and from the top of each outrigger. For a standard, medium-threat loopback configuration, the sensor cable is about 2.5 times the zone length.



Note: It is highly recommended to install the trunk cable on the bottom rail of the fence, buried underground, or inside rigid conduit.

## Reinforced Sections and Outriggers

Because they are stiffer than non-reinforced sections of fence, reinforced fence sections require additional sensor cable to equalize the sensitivity throughout the zone. The recommended way to accomplish this is to add an additional loop of sensor cable in the reinforced section, as shown below. Adding the additional loop increases the amount of sensor cable per unit of area, resulting in an increase in vibration sensitivity in the reinforced section.

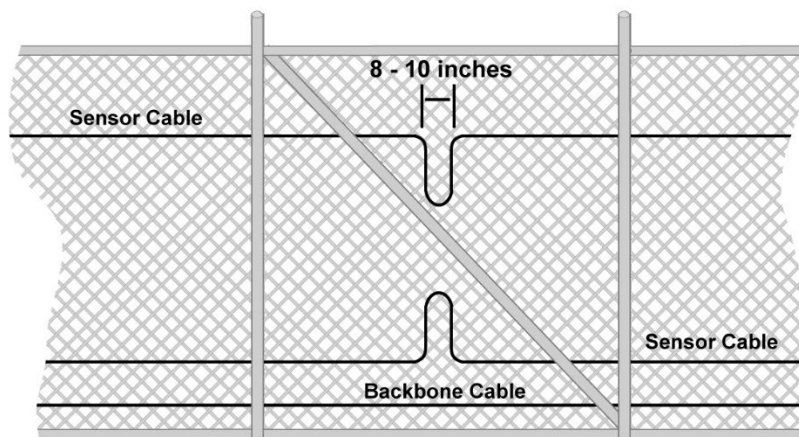


Figure 4-4. Reinforced fence section, chain-link fence

Add the loop to both the top and bottom, for medium-threat loop-back installations. The width of the loop should be between 8 to 10 inches (20 to 25 cm).

Sensor cable deployment for reinforced sections differs when outriggers are present (see figure 4-5). In this case, extend the sensor loops (in the top run of the sensor cable) to the top of the outriggers, and run the sensor cable between the fence fabric and the reinforcement bar where possible. For highest security applications, loop the sensor cable along the fence posts (as shown below) to increase sensitivity of the system to intruders that might be using the post as a climbing aid.

If razor wire (also known as concertina or C-wire) is used as a top guard, the sensor cable should be attached to the inside of the razor wire coils, as shown in figure 4-6.

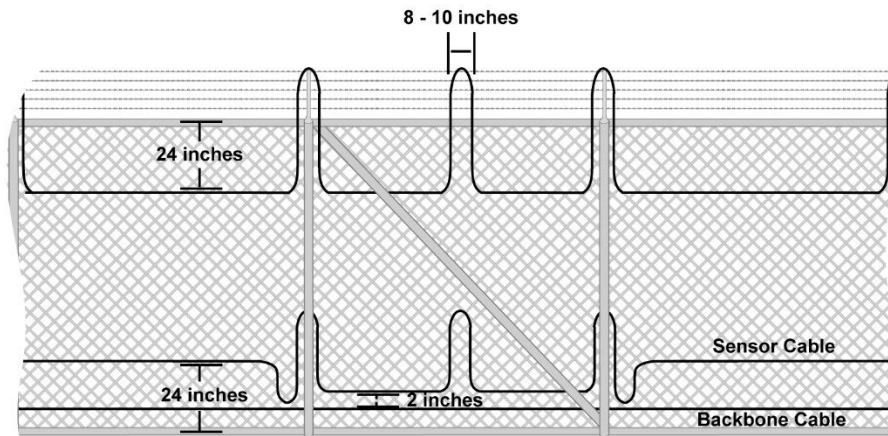


Figure 4-5. Reinforced fence section with outrigger, chain-link fence

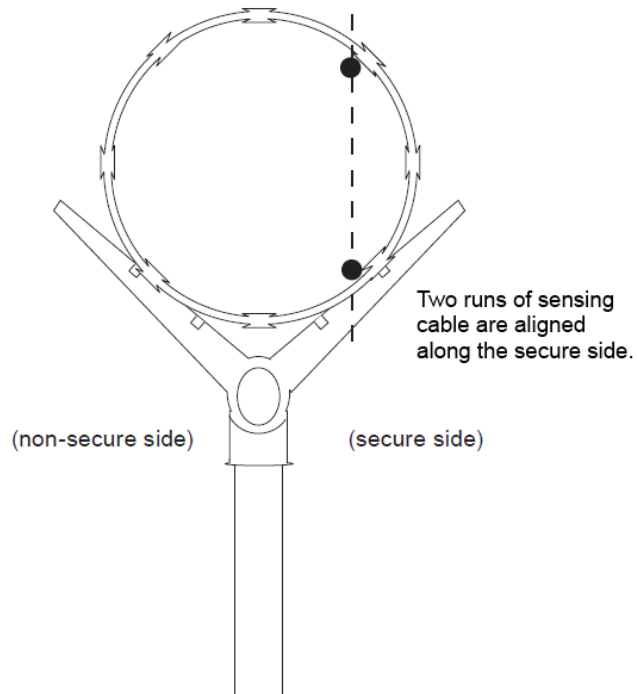
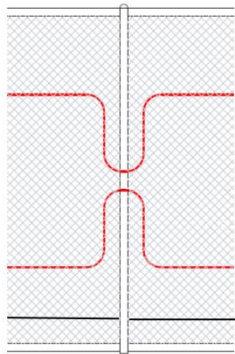


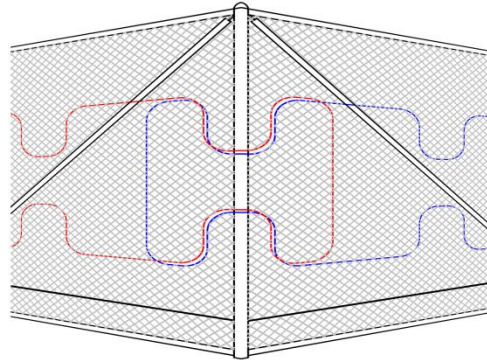
Figure 4-6. Razor wire top guard deployment, chain-link fence

## Corners and Posts

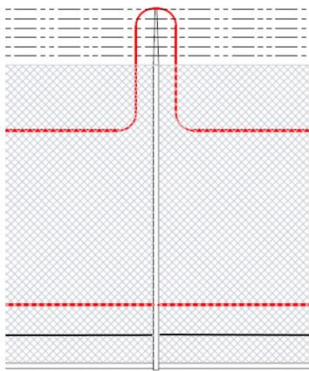
Because corners and posts are rigid and less likely to transmit vibration than the fence fabric, they should be protected by adding extra sensor cable in a loop, as shown in figure 4-7.



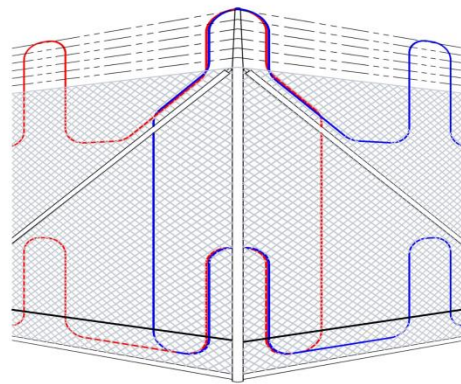
Posts



Corner Posts



Posts with Outriggers



Corner Posts with Outriggers

Figure 4-7. Fence post deployment, chain-link fence

For fences with outriggers, extend the cable loop to the top of the outrigger, which protects both the post and the outrigger. Because fence sections at corners are normally reinforced, follow the method described earlier for deploying sensor cable on reinforced sections of fence.

## Service Loops

Loops should be added at periodic intervals to allow the sensor cable to be re-spliced with the excess cable should there be an accidental break. A good rule of thumb is to use one service loop every 91 meters (300 feet) or so. In general, plan on using an additional 1.5 meters (5 feet) of cable with each sensor loop.

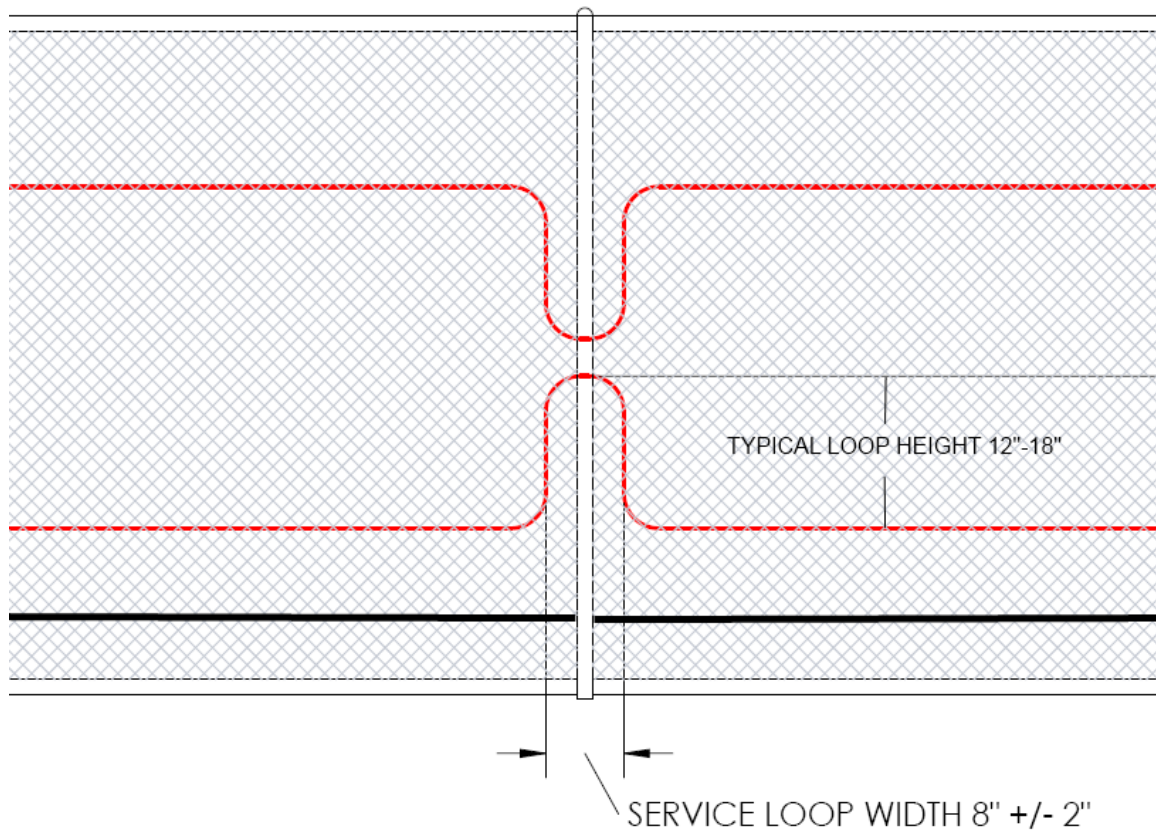


Figure 4-8. Service loop in sensor cable

Extra cable should also be left in junction boxes but be cautious, storing too much sensing fiber creates hot spots.

## Wrought-Iron Fence

With proper deployment, **FD500** Series systems can protect wrought-iron fences. In this case, deploy the sensor cable along the top and bottom fence rail. Because a wrought-iron fence is designed to be rigid, calibrate the system carefully to ensure that sources of nuisance alarms have minimal effects, while maintaining maximum intrusion protection.

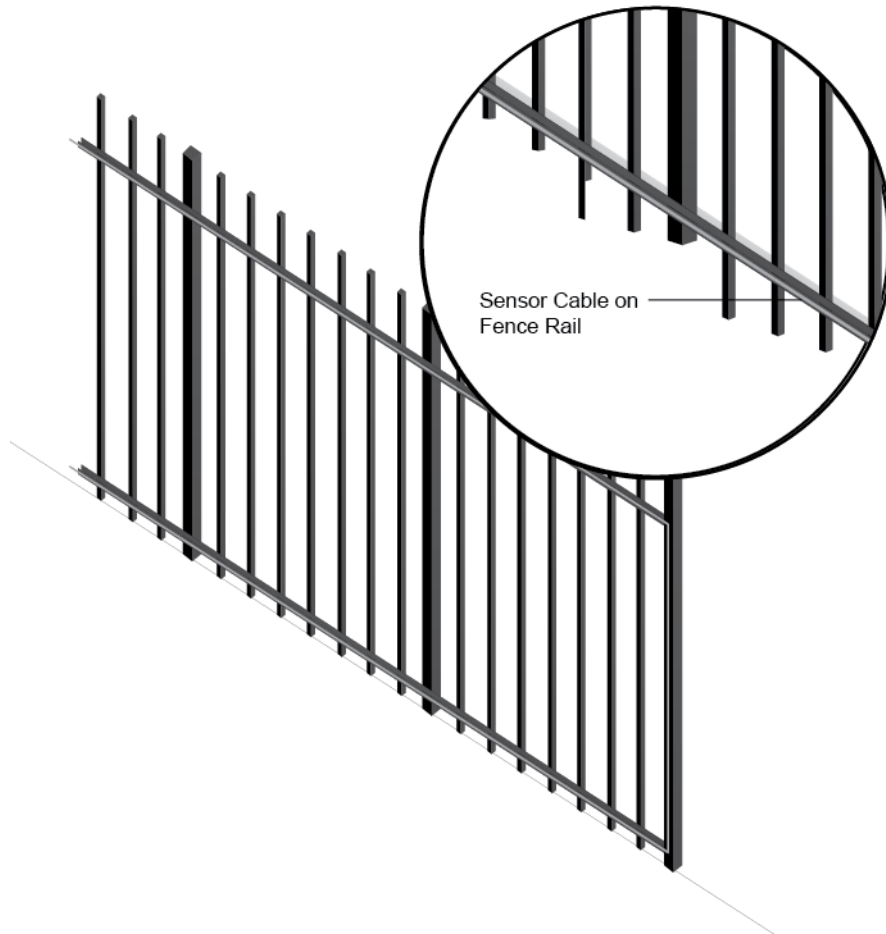


Figure 4-9. Wrought-iron fence deployment

For wrought-iron fences that have only two rails, one top and one bottom rail as shown in the illustration above, bury the trunk cable below ground to make room for the sensor cable on the bottom rail of the fence.



## Anti-Ram Barrier Fences

Modern fence manufacturers have created various versions of anti-ram barrier fences. These barriers, which resemble wrought-iron fences in appearance, are made to withstand direct impacts from heavy vehicles. Such barriers are successful because they have built-in channels, allowing for the insertion of heavy, rolled-steel reinforcement cable. These channels are also ideal for inserting sensor cable. These channels are also ideal for inserting sensor cable.

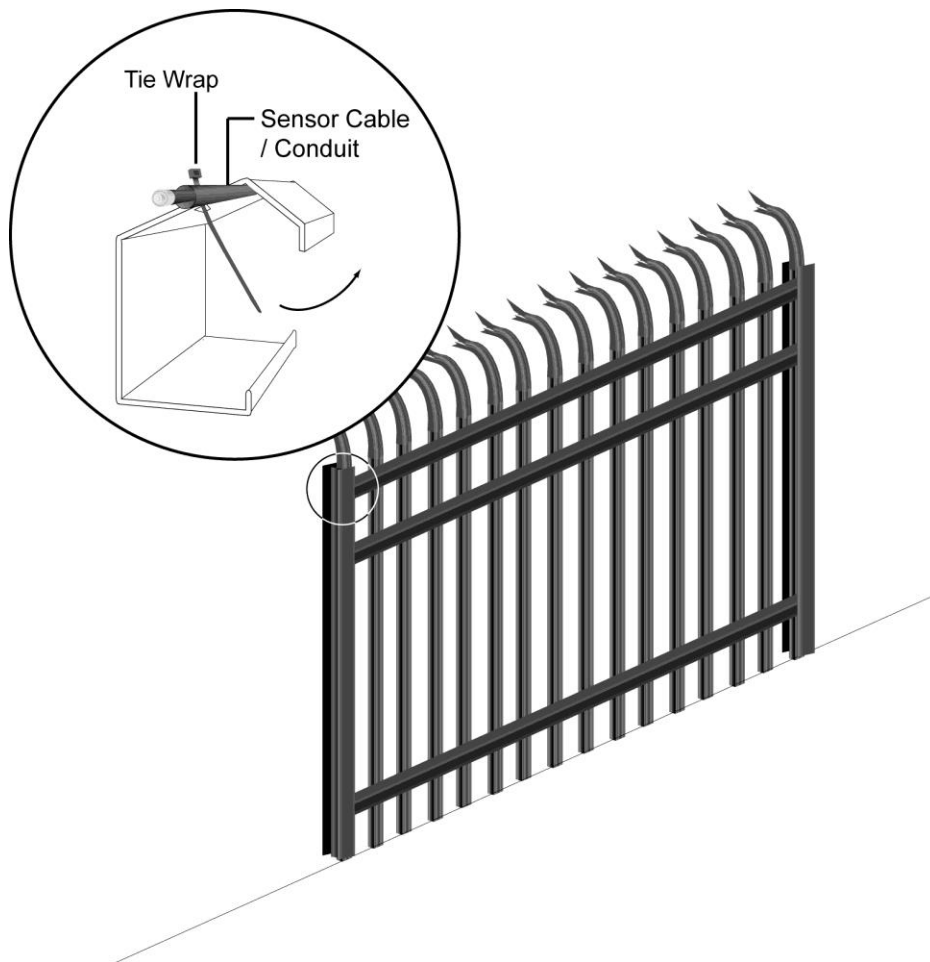


Figure 4-10. Anti-ram barrier fence deployment

Secure the sensor cables to the top and bottom rails, laying the sensor cable in the fence channel and securing it with UV-resistant cable ties as shown in the figure above.

On most anti-ram barrier fences the channels have cutouts every 6 inches (15 cm) to allow cable ties to be threaded through.

## Protecting Gates

Gates can be successfully incorporated into **FD500** Series systems. However, keep in mind that gates can cause nuisance alarms during high winds if they are allowed to swing on their hinges and bang into restraining posts, locking mechanisms, or their own latches. Secure all gates against as much unintended movement as possible.

Gates that are used to go in/out of the perimeter should also be equipped with an alarm-disabling circuit so that alarms are not generated during normal use. Establish a separate zone for each gate in order to maintain a secure perimeter while the gate is open. Reinforce sections of fence adjacent to the gate by adding additional posts or other structural support. Separate the gate hinge post, fabric, and supporting posts as necessary to reduce vibration transmitted from the gate to adjacent sections of the fence with active sensor cable.

## Single or Double Swinging Gates

The simplest method for protecting a swinging gate is to run the sensor cable from the fixed frame to the gate, and attach it to the gate fabric in successive loops, as shown in figure 4-11.

Route the trunk cable below the gate in a sand-filled trench approximately 4 inches (10 cm) below the roadway surface for protection. If traffic from heavy vehicles is expected to pass through the gate, bury the cable 1 foot (0.3 m) below the roadway surface.

To create the sand-filled trench, **Fiber SenSys** recommends cutting a groove in the existing pavement at least 8 inches (20 cm) deep and laying a bed of sand 4 inches (10 cm) deep in the groove. Lay the trunk cable into the groove on top of the sand. Press gently into place using a screwdriver. Cover the cable with an additional 4 inches (10 cm) of sand, and then repave the groove.

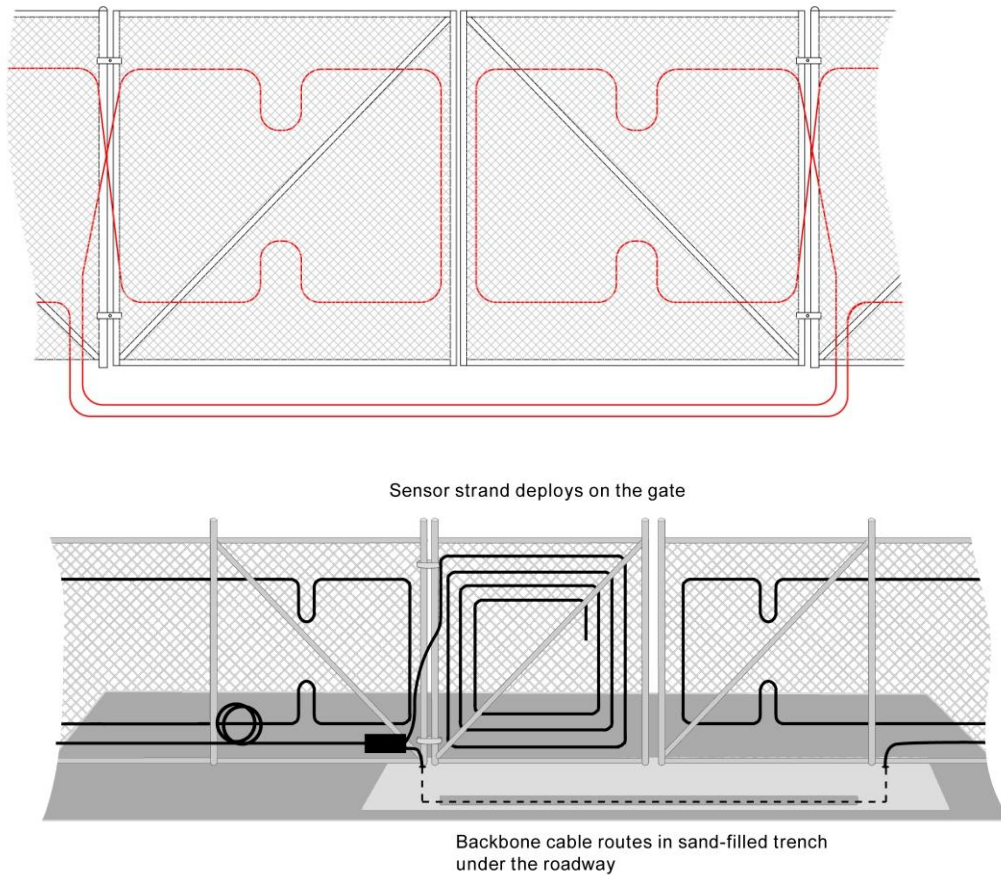


Figure 4-11. Sensor cable deployed on swinging gate



**NOTE:** Make sure the sensor cable crosses the hinged side of the gate at a 45-degree angle, as shown above. As long as the sensor cable crosses the hinge posts at a 45-degree angle, its half-inch conduit protects it from damage when the gate is opened and closed.

## Sliding Gates

Movement of sliding gates can sometimes be detected if sensor cable is mounted on the support rail or a fixed frame next to the gate. In this configuration, an intruder attempting to climb the sliding gate transmits vibrations to the sensor on the adjacent frame. In this type of installation (as with swinging gates) route the trunk cable below the gate, buried at least 4 inches (10 cm) below the roadway for protection. If traffic from heavy vehicles

is expected to pass through the gate, bury the cable 1 foot (0.3 m) below the roadway surface.

Fiber SenSys also provides microwave sensors that can be used to establish an invisible curtain across gates. The microwave sensor is an example of a volumetric system that operates much like the IR transmitter and receiver found commonly on garage doors; when an intruder breaks the beam (in this case, a microwave beam), the sensor detects a drop in signal level and generates an alarm. Microwave volumetric sensors are easy to install, especially for existing facilities where protection is desired without a re-design of the fence system. With this solution, precautions are necessary to prevent interference from nearby electrically conductive items. For more information on using Fiber SenSys' microwave sensors, see the Microwave Perimeter Security Application Note, available for download from the FSI website: <https://www.fibersensys.com/> .

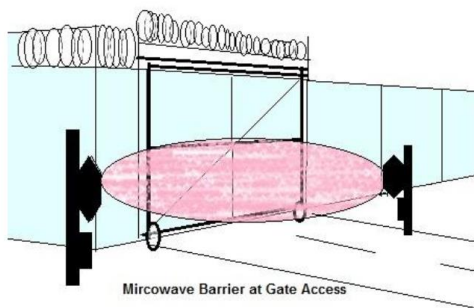


Figure 4-12. Gate protection strategies.

## Unprotected Gates

For gates that don't require protection, bury the trunk cable 1 inch (2.5 cm) below the roadway. Cut a groove 1 inch (2.5 cm) deep into the roadway surface, and clean dirt and debris out of the groove. Lay the trunk cable into the groove and gently press into place using a screwdriver, then repave or caulk over the groove.