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Fenced Perimeter Installations for FD500 series APUs

Application Note

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Contents

1. Introduction

This application note describes how to install, on fences, the perimeter sensing elements for **Fiber SenSys** Alarm Processing Units (APUs) in the **FD500** series family.

2. The FD500 series family

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

1. APUs like the **FD525**, that connect through just two optical ports, and use a field-deployable distribution box, trunk cable, and individual breakout boxes for each zone.

2. APUs, like the **FD508**, that have individual connections for each zone, on the back of the APU.

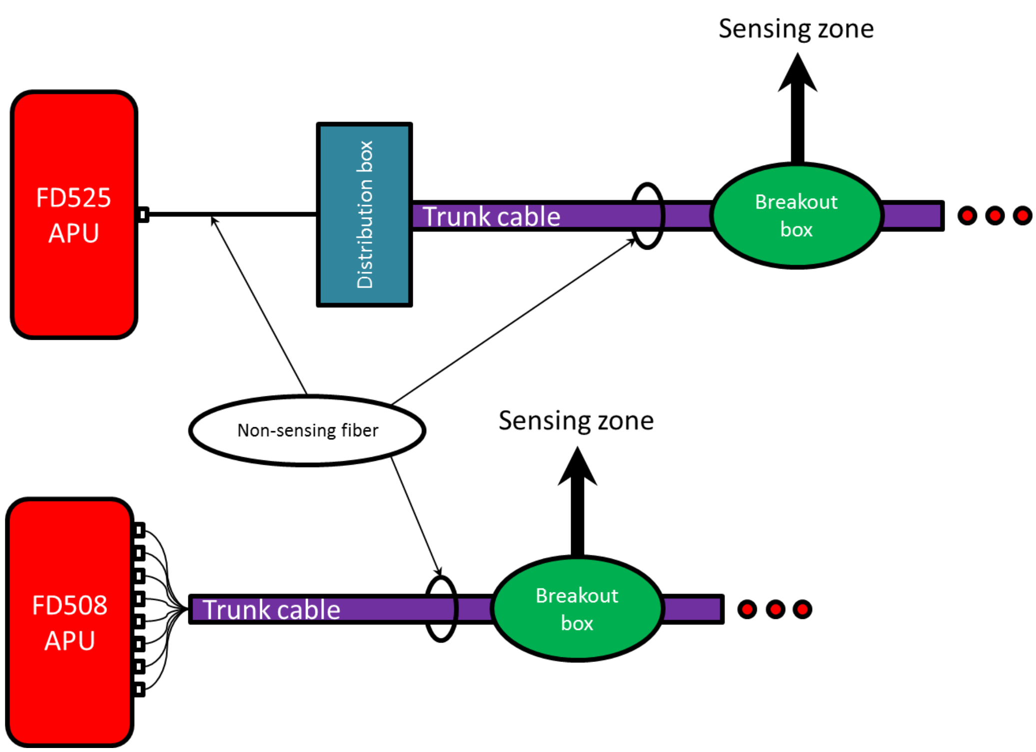

Figure 2-1. The FD525 has two optical ports that connect to the distribution box, and then to the trunk cable and individual breakout boxes and sensing zones. The FD508 does not have a distribution box. Instead, it uses a different optical port for each zone.

Both the **FD525** and the **FD508** 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. Buried applications (FD525 only)
6. Etc.

Figure 2-2 shows the major components in a typical **FD525** system[1]. The cable assembly consists of the insensitive lead-in cable, the distribution box, the trunk cable, the sensor cables, and breakout boxes where the sensor cables for each zone are joined to the trunk cable[2]. 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 for 25 zones and 12 km long for 15 zones or less, allowing for remote APU installation.

The trunk cable contains a single-mode (insensitive)[3] optical fiber for each zone, and is constructed with a rugged, UV-resistant jacket that is about four millimeters in diameter. Each sensor cable contains a strand of multimode optical fiber enclosed in protective conduit.

In the FD525, the single insensitive lead-in cable connects to the trunk cable at the distribution box, which contains a fiber-optic splitter, reference reflector, and all associated fiber-optic splicing. The lead-in cable is spliced to the two input fibers (on the fiber-optic splitter), and 25 of the output fibers are spliced to the trunk cable. The 26th

[1] Not shown are the termination units that are spliced to the ends of the sensing fibers of each zone.
[2] Each breakout box can connect either one or two sensor cables to the trunk cable.
[3] All the insensitive fibers used with **FD500** series APUs are single-mode at 1550 nm.

output fiber is reserved for a reference reflector used for internal calibration. The remaining six output fibers are spares.

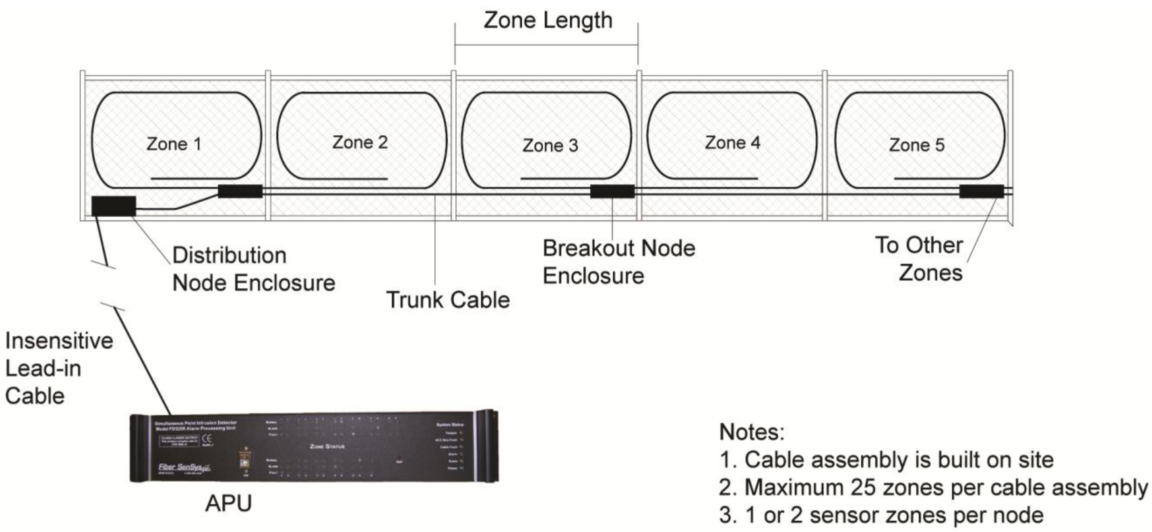

Figure 2-2. Major components in a typical FD525 installation.

In the **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 **FD508**, the individual lead-in fibers for each zone are connected directly to the optical ports on the back of the APU.

Both the **FD508** and the **FD525** use a trunk cable and breakout boxes. The trunk cable is spliced to the sensor cables inside the protective breakout boxes. These fibers are cut from the trunk cable and spliced to the sensor cables, 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[4]. When using the **FD525**, some zones may need to include custom delay coils in some of the breakout boxes, in order to keep the zones from interfering with each other. In the **FD508**, however, the breakout boxes serve exclusively as splice enclosures; delay coils are *never* required in an **FD508** installation.

[4] The sensor cable can be ordered pre-installed in the conduit.

With the **FD508**, 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 **FD508** 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 highest security 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. When installed for high-security applications, with the trunk cable and breakout boxes buried, the **FD500** series provides exceptional protection; even if one zone is completely cut by an intruder, all the other zones continue to work without interruption.

3. Site Assessment and planning

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

- Survey the perimeter, recording:
    - Length of the fenced perimeter, excluding gates
    - Locations, lengths, and types of all gates
    - Width of the longest reinforced section
    - Width of the longest fence panel (area between posts)
    - Type of fence, including the presence of outriggers and 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
    - Other security systems (cameras, lights, etc.)
- 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 & distribution boxes (for **FD525**)
        - Termination encapsulation kits
        - Etc.
- Deployment plan for all system components, including plans for configuration, calibration, and testing.

4. Possible threats against fenced perimeters

There are six 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.

5. General fence/perimeter requirements

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

1. It should not generate excessive vibration and/or noise. For chain-link fences, re-tensioning the fence fabric and adding fence fabric wire ties to eliminate metal-to-metal banging of the fabric (when the wind blows) can quiet 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 entire perimeter. For a chain-link fence, tension all the fabric to the same level.

3. Keep a clear area on both sides of the fence. There should be no tree limbs, large rocks, or structures that might help an intruder climb over the fence. Also, there should be no spots along the fence where an intruder could easily crawl or dig under.

4. Buildings, structures, waterfronts, and other barriers used along the perimeter in place of the fence line should provide adequate protection against intrusion. Ensure there are no windows, doors, openings, or unguarded means of access.

6. Deployment guidelines

Properly deploying the sensing cable ensures that the system will accurately detect threats. When planning the configuration of the system there are three important points about the sensor cables 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.

7. Zone length, sensor length, and system resolution

The lengths and placements of the zones are determined by system requirements related mostly to the accuracy to which the positions of intruders must be known. 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 equals the length of the zone. On the other hand, a high-security application may require two passes along the fence, as well as passes up/down each fence pole and cross brace, and along the outriggers on top of the fence. 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.[5]

Consider the example in figure 7-1, 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, so even though the zones may be 100 meters long, the sensing cable/conduit needs to be about 210 meters long.

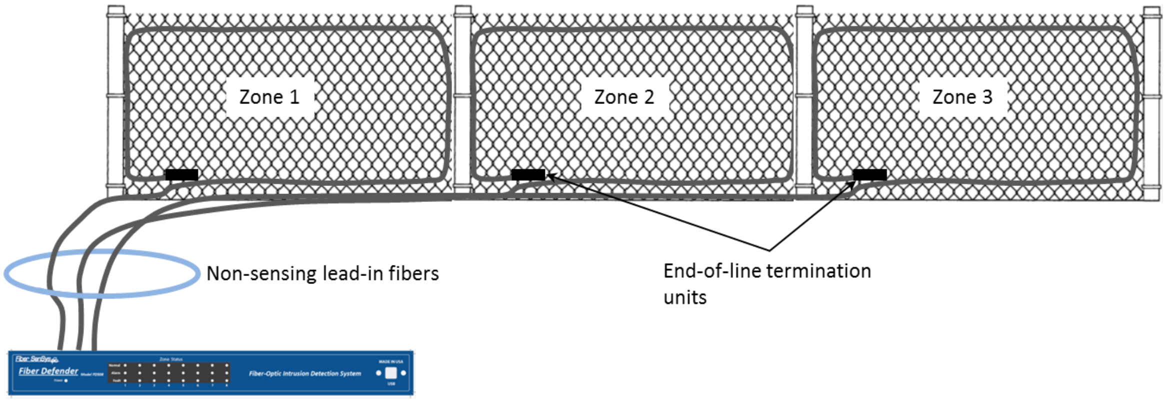

Figure 7-1. Sensor cable deployment and system resolution (FD508 is used in this example).

The size of the zones depends on the type of structure 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[6].

Unlike discrete objects, like gates, long fence-line perimeters must usually 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

[5] Often, because the outriggers have different tension than the fence, a separate zone is used to protect them. 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.
[6] The exceptions being if the structures are protected by more than one zone.

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[7], 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.
- 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 perimeter zones should be about 100 meters.

It is important to use the equation for RPI as a guide, and not a fixed rule. Also, note the ≤ symbol, indicating 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 then turn and focus on the intruder, then the zones must be smaller than the camera's field of view.

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[7] The average intruder's speed includes the time spent climbing or cutting through the fence; it is the average speed that includes the stationary time in breaching the perimeter, and in crossing the inside of the perimeter.

8. Zone placement

Zone placement is generally determined by the requirements of the perimeter's physical layout. Consider figure 8-1, for example, where the presence of a gate requires that a new zone start where the gate is located (because the gate is to have a dedicated zone assigned to it). This is accomplished by decreasing the width of zone 3, which otherwise (in the absence of the gate) would not need to have been shortened.

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).

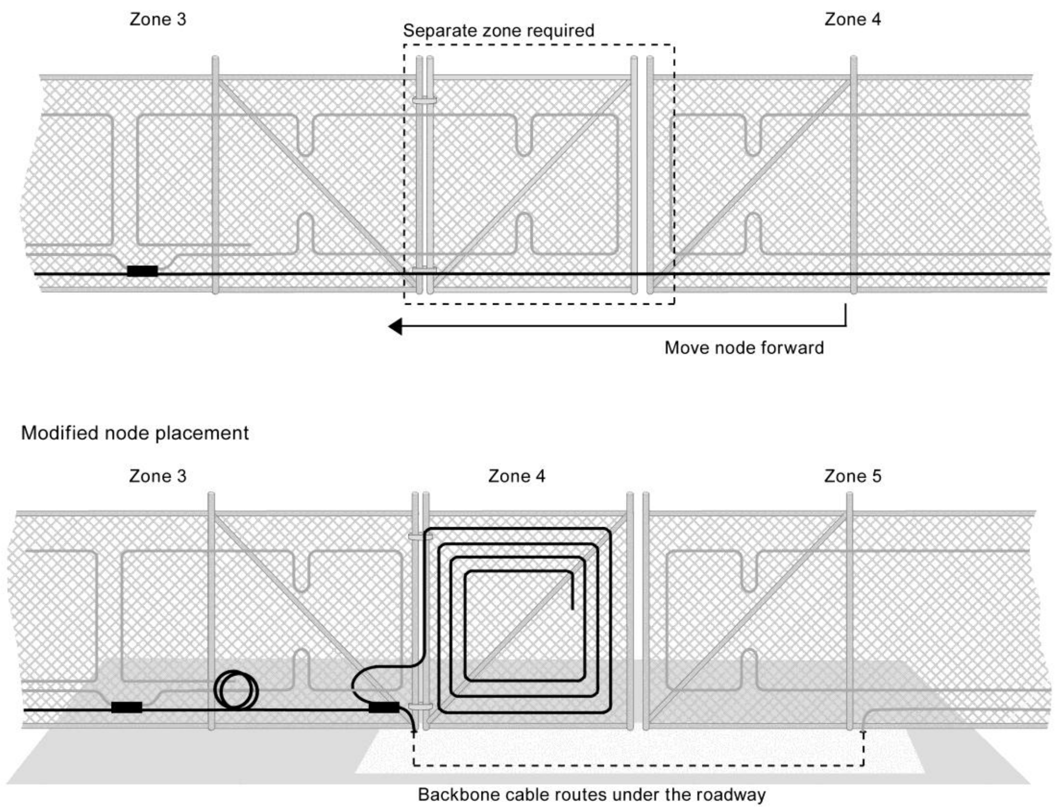

Figure 8-1. Physical site layout, and how it affects zone placement (example using FD525)

9. Chain-link fences

In order to ensure the effectiveness of 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 2 inches (25 cm). Additionally, tension the fabric consistently across its length throughout the protected zone.

Fabric ties. Use steel ties (9 gauge or less). 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 unprotected area. Install at least three strands of barbed wire perpendicular to, and attached to, the top guard. Make sure the barbed wire is well-tensioned and fastened where needed to eliminate mechanical noise.

Height. The height of the fence should be at least 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.

Reinforcement. Install 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.

For more information on these requirements, refer to the **Fiber SenSys** application note, *Security Fence Construction Recommendations*, available at **www.fibersensys.com**.

10. Deployment examples, chain-link fence

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

Loopback Deployment (Medium threat level)

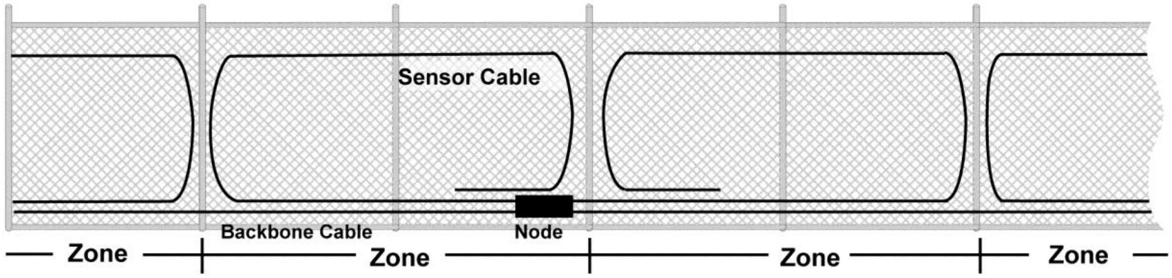

Figure 10-1. Medium-threat deployment.[8]

High Threat Level Deployment

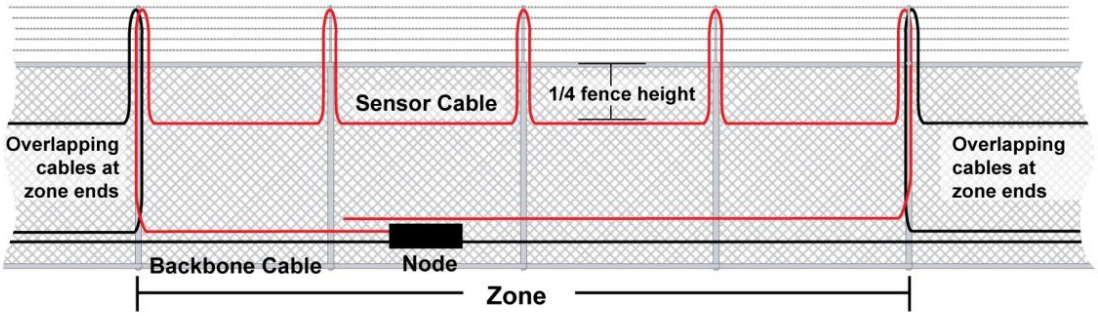

Figure 10-2. High-threat deployment.

The medium-threat deployment protects against relatively sophisticated intrusions by positioning the sensor along the lower and upper levels of the fence places 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.

[8] The "nodes" in these diagrams represent splice points between insensitive lead-in fiber and sensing fiber.

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 that the sensor cable is attached approximately one-quarter of the fence height above the bottom rail. 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 3.3 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.

11. Reinforced sections and outriggers

Because they are stiffer than non-reinforced sections of fence, reinforced fence sections require additional sensor cable. 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.

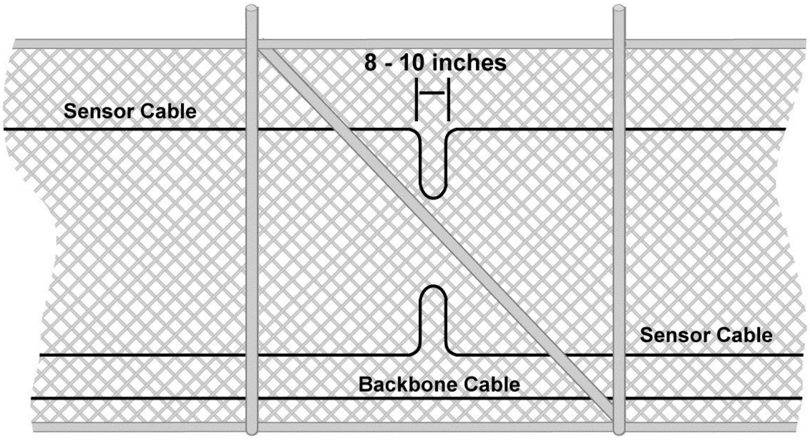

Figure 11-1. Reinforced fence section, chain-link fence

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 11-2). 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 11-3.

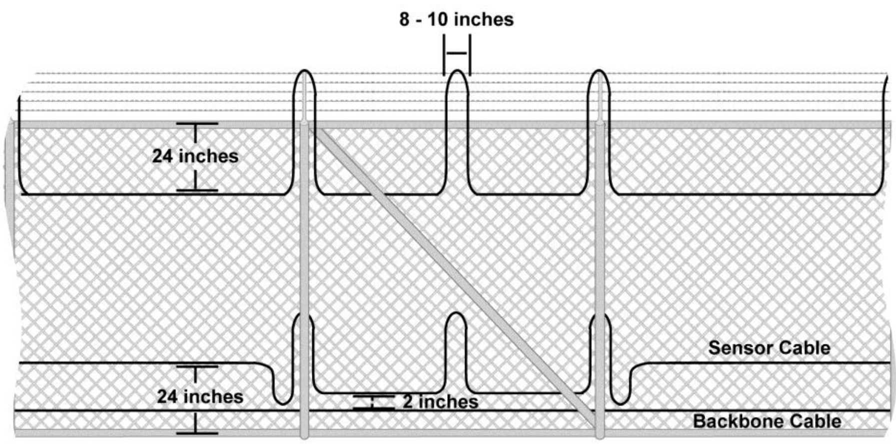

Figure 11-2. Reinforced fence section with outrigger, chain-link fence

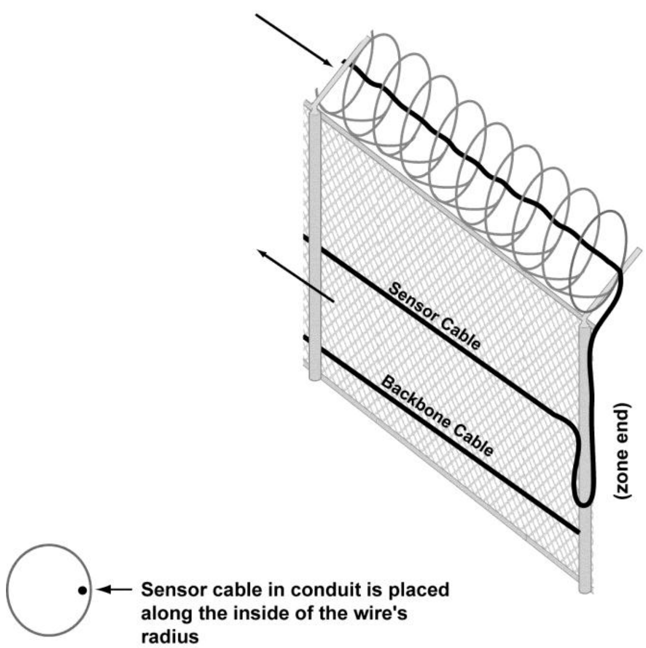

Figure 11-3. Razor wire top guard deployment, chain-link fence

12. 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 12-1.

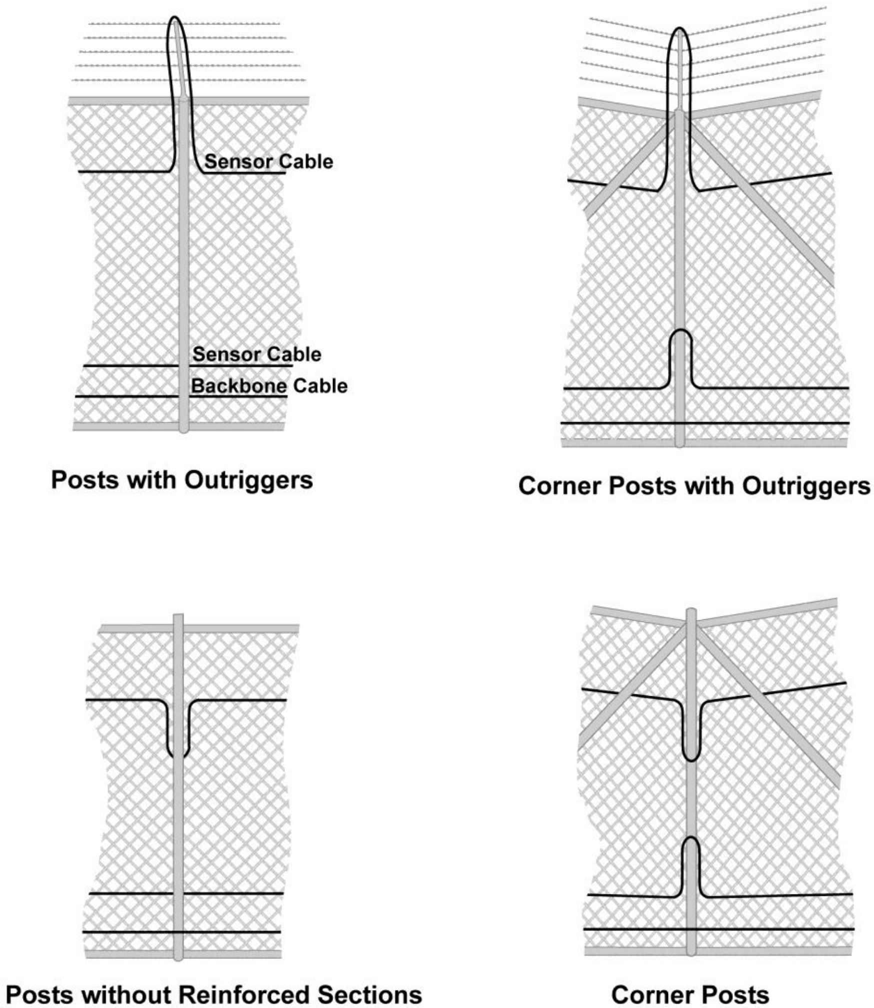

Figure 12-1. Fence post deployment, chain-link fence

For fences with outriggers, extend the cable loop to the top of the outrigger, protecting 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.

13. Wrought-iron fence

With proper deployment, **FD500** 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.

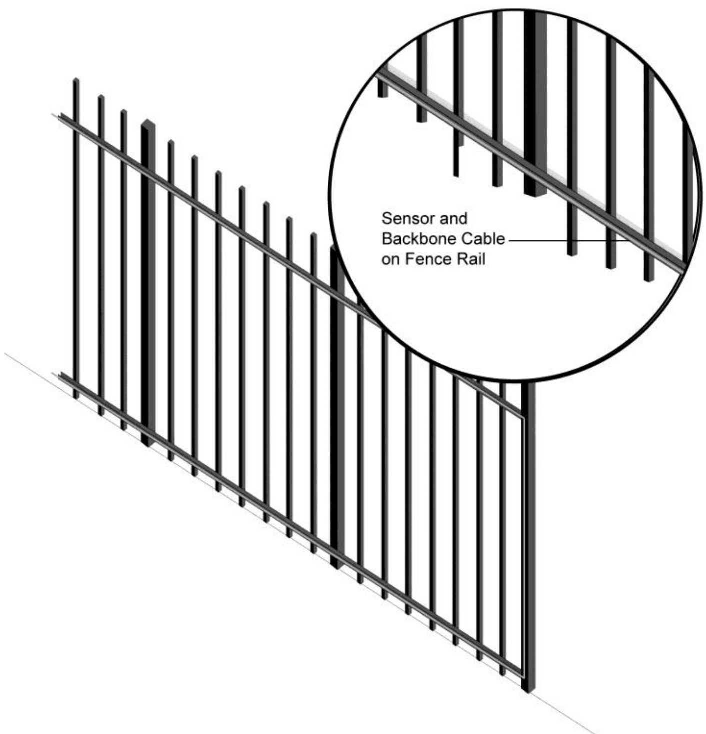

Figure 13-1. Wrought-iron fence deployment

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.

14. 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.

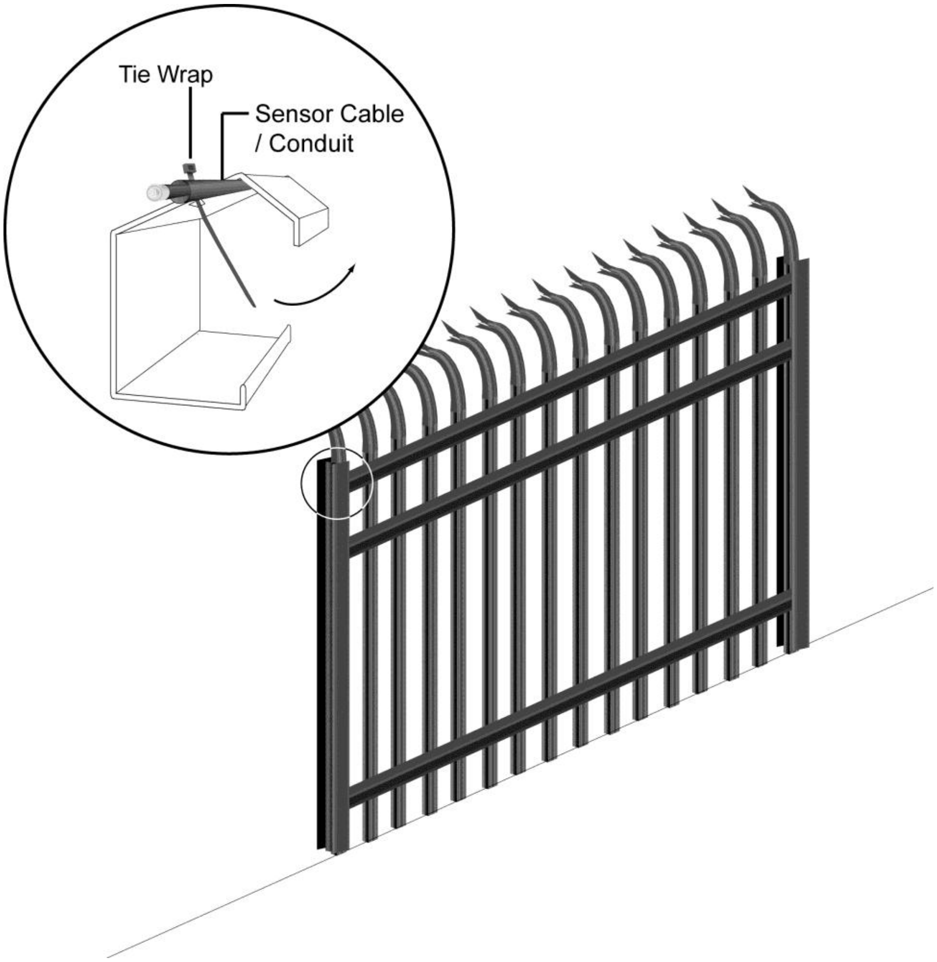

Figure 14-1. Anti-ram barrier fence deployment

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.

15. Protecting gates

Gates can be successfully incorporated into **FD500** 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 15-1.

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.

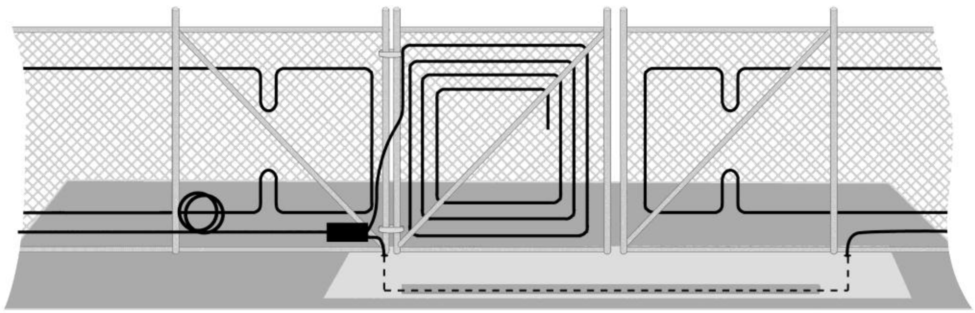

Figure 15-1. Sensor cable deployed on swinging gate

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: www.fibersensys.com .

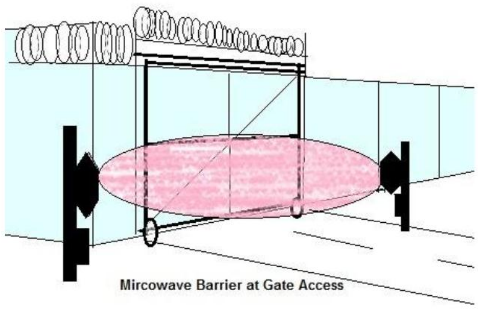

Figure 15-2. Gate protection strategies.

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.

16. 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 these types of nuisances, including 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 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 calibrated to compensate for potential nuisances.

17. Site assessment example

The following example illustrates the circumstances that should be considered during site assessment. In this example, a small power substation is to be protected using an **FD525/FD525R** system installed on a chain-link perimeter fence, as shown in the following figure.

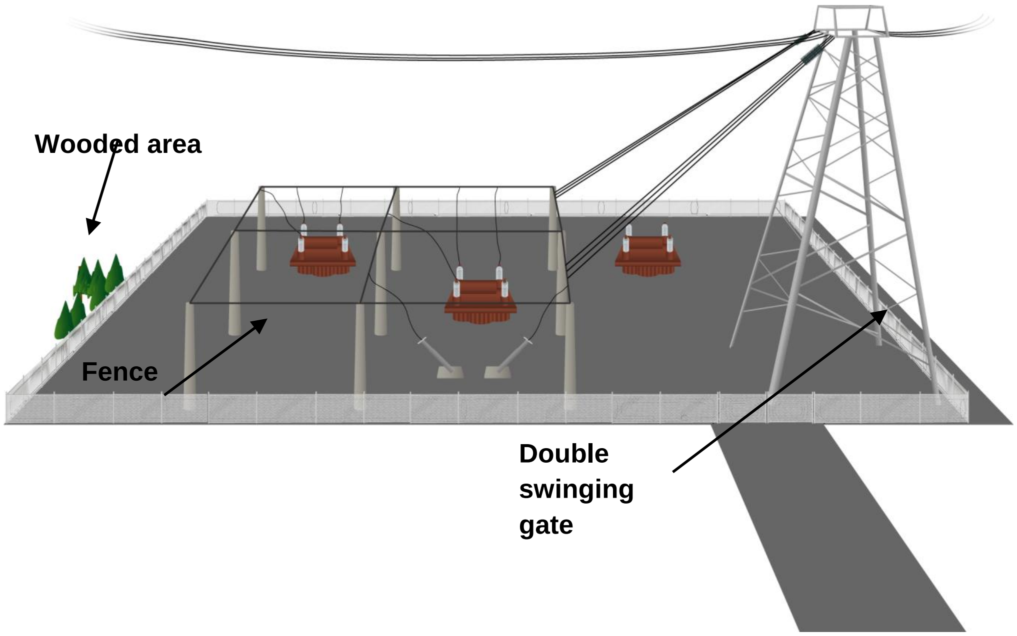

Figure 17-1. Site assessment example: protected power substation

Site requirements

The total perimeter length of the substation is 440 meters. A vehicle gate consisting of double swinging panels guards the entrance to the site. Four cameras monitor the site, each capable of rotating 120º. To make the most effective use of camera surveillance, each camera must be directed to control input to within 10 meters of any detected disturbance. In addition, there is a wooded area along one side of the protected site.

Security solution

To meet camera requirements, each side of the square perimeter is segmented into 25 zones, each measuring 10 meters wide. Two **FD525/FD525R** APUs and two 250-meter cable assemblies must be installed with 10-meter zone resolution and medium threat level sensor cables (25 meters in length). This cable-assembly configuration enables the security system to direct each camera to within 10 meters of any detected disturbance.

Other points to consider

- **The fence.** The chain-link fence forms a satisfactory boundary around the protected site; however, the possibility of an intruder digging under the fence must be prevented in areas where the fence does not cross pavement. One of the best protective measures in this case is to deploy each sensor cable in the loopback configuration for a medium threat level. Another option is to embed a concrete skirt around the bottom of the fence along the entire perimeter to make digging more difficult.

  The fence must meet all chain-link specifications described earlier.

- **The gate.** Create a strategy to ensure the gate is protected. This involves looping a sensor cable on each swinging gate and embedding the trunk cable in the roadway, as described earlier, or using the microwave sensor.

- **Trees.** Because the trees encroach on the fence line, cut them back before system installation, and keep them trimmed afterwards. This prevents tree limbs from touching the fence and triggering nuisance alarms.

- **The environment.** Wind, weather, and wildlife are all factors that can create nuisance alarms. As the last step in the installation process, calibrate and test each of the system's zones to ensure maximum sensitivity to intrusion detection and immunity to nuisance alarms.

18. Installing the Cable Assembly

The cable assembly is built on site; that is, the components are assembled in place along the secure perimeter. Assemble and install the cable assembly as follows.

CAUTION: Some components of the cable assembly are extremely fragile. Pulling on the sensor cables at any point with greater than 60 lbs. force can break optical fibers.

NOTE: The cable assembly is to be installed only by Fiber SenSys personnel or technicians trained and certified by Fiber SenSys. The following pages describe the general procedure used to build and install the cable assembly.

NOTE: Refer to the appropriate Fiber SenSys application notes for detailed cable assembly installation procedures for both fence line and buried installations.

Sensor cable and nodes, fence installation

Each sensor cable consists of a multimode optical fiber with a reflector spliced to the end, housed in weatherproof conduit. Install the sensor cables starting in zone 1 and moving sequentially along the perimeter to the higher-numbered zones.

1. Install the reflector end of the sensing cable first. Place this end 12 inches (30.5 cm) directly above the breakout box location, with the remaining sensing cable routed up the fence and turning either left or right at a distance of 24 inches (61 cm) from, and parallel to, the top edge of the fence fabric. Secure the sensor cable every 12 inches (30.5 cm) using 18 AWG stainless steel wire ties. Twist the tie so that the cable is secure on the fence, but not tight enough to inhibit proper operation of the sensor or compress its protective conduit.

2. Upon reaching a midpoint between nodes, turn the sensing cable down the fence until it reaches a point 2 inches (5 cm) above the trunk cable. Route and secure the sensor cable back to the starting point.

3. Any sensor cable routed past the 29-inch loop in the trunk cable is excess. Remove all but 48 inches (122 cm) of excess sensor cable.

4. Splice the sensor cable to the appropriate color-coded fiber in the trunk cable and place the splice inside the breakout box with the proper strain relief (refer to manufacturer's instructions).

5. Route the second sensor cable for the next zone being fed from this node. Route the second sensor cable in a similar manner, but in the opposite direction from the first, with

the tail ends overlapping approximately 12 inches (30.5 cm). Refer to the sensing-element manufacturer's instructions.

6. After the installation of each sensor cable, at the APU, run a **Config** scan to acquire zone reflection data for the system as constructed to that point. Make sure the heights of all reflections are within 4 dB. Make sure that there are no overlapping reflections.

   Instructions on using **Config** to scan the trunk cable can be found in the **APU User's Manual**. In most installations, one person will be needed at the perimeter for splicing the fiber and one person at the APU running **Config** on a PC. These people will need a means of communication, such as two-way radios or cell phones, when scanning the system.

7. When using the FD525, in the case of an overlap between two zones, use the **Config** scan to determine the length of the delay fiber necessary, and splice this length of fiber to the starting end of the sensor cable represented by the second reflection.
   - Splice the sensor cable again to the trunk cable and perform another **Config** scan to verify that the overlap has been removed prior to closing the breakout and going on to build the next zone.

19. Appendix A. Telecommunication Color Codes

Table A-1. Telecommunication color codes for optical fibers

Sequence	Colors
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua