Application Note ANC-102
AURATEK for Roof Top Applications

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Introduction

Due to the increased focus on security for buildings structures, the roof has become a primary point of entry for intruders. Gaining access to the roof affords intruders the following benefits:

Hidden - Often intruders cannot be seen as they work at gaining entry.

Time - Because they are hidden, intruder have the needed time to gain entrance through the roof.

By pass or disable indoor security - Often intruders can render indoor security useless by gaining access to the drop ceiling.

Requirements for Roof Applications

ENCLO**SURE** is ideally suited for roof application because it addresses the following basic requirements often sought by people needing roof protection:

Contour Following - The sensor follows the shape of the roof so there are no blind spots.

Aesthetically Pleasing - The sensor offers a high level of protection without changing the outward appearance of the building. This is often important for modern new buildings or historical sites.

Covert – For non-metallic structure, the hidden sensor increases the level of security by decreasing the chances of tampering. A covert sensor also increases the possibility of capture because intruders are not aware they have been detected.

Immunity to Lighting Interference – The sensor cable is based on coaxial cable which presents an electrical ground on the outer shield. This outer shield can be grounded to the roof lightning ground wire using industrial lightning arrestor.

No Maintenance - By having a maintenance free sensor there are no on-going operating expenses. If maintenance is required, the configuration of the sensor can be adjusted over modem link.

Not affected by operating environments or the activities of the organization - When organizations utilize a roof sensor, they do not want nuisance alarms being caused by bird activities. Similarly they do not want nuisance alarms being caused by the activities of people inside the building neither mechanical vibration caused by HVAC equipment. Such alarms affect the confidence users have in the sensor.

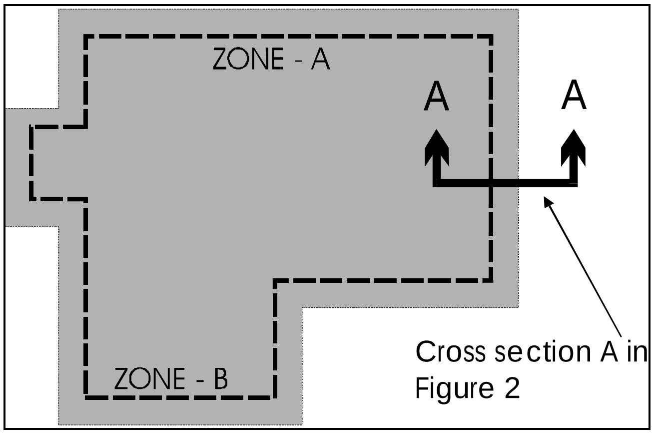

Fig. 1
Outlines typical detection zones to provide sufficient protection while addressing the requirements outlined in the introduction.

1.0 Typical Roof Installation

Roof Zone Profile:

- The maximum zone length for a roof application is 50 m (165 feet) per zone, for a total of; 2 x 50 m (100m, 330 feet) per FSP-100 processor, 4 x 50 m (200m, 660 feet) per FSP-200-V processor and 8 x 50 m (1320 feet) per FSP-400-V processor.
  The possibility to apply the maximum zone length per zone is dependent on the roof structure as followed;
  a) wood structure: 50m (165 ft) maximum
  b) concrete structure: 40m (130 ft) maximum
  c) metal structure: 30m (100 ft) maximum

- The typical zone width is 1.5m (5 feet) by 0.75m (2.5 feet) high. The minimum mechanical bending radius for the sensor and non-sensor cable is 8 cm (3 inches). However, to avoid wider detection at corner area, the minimum-bending radius for the sensor cable is 60cm (2ft).

- When antenna is used, a detection zone of 1m radius (3.3ft) is created around the antenna in all 3 axes. Alarm for such detection will be reported, time simultaneously, to each zones associate to an antenna. Indeed, antenna access is secure and provides a mean to differentiate between zone intrusions from antenna intrusion.

- An important aspect of the detection zone is to clearly define where detection zone start and stop. Detection field are made of RF signal which have tendency to couple and travel to any near-by metal structure. This aspect is even more important for metal roof structure. Ideally a detection zone start and stop following the sensor cable. This ideal situation become practical when sensor cables are surrounded by RF absorbing material, i.e. when surrounded by soil or laid on soil surface. Such soil material is non-existent on roof structure. Therefore special precautions must be taken to prevent (or minimize) RF coupling to surrounding metal structure as discussed further in this application note. In addition, to some extend, ferrite beads material can be used to simulate soil surrounding.

1.1 Installation of Sensor Cable and Transmitters for Varying Roof Structures

a) Concrete Roof

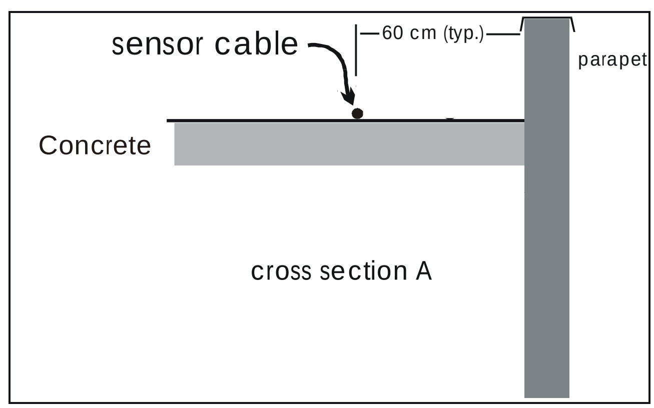

Fig. 2a
Shows a typical cross section where the sensor cable is laid directly over the waterproof membrane.

- The cables are placed at approximately 90 cm (3 feet) from the parapet, where 60 cm (2 feet) will be the closes distance.

- The cable is held in place by placing section of waterproof membrane glued over the sensor cable or by putting tar substance every 3 m (10 feet).

- Transmitter could be just laid on roof structure with cables are attached on both ends.

- Particular attention should be addressed to rebar structure. Although the sensor cable can cross rebar material at 90 (+/- 30 degrees) with no impact, it is not recommended to located sensor cable in parallel to rebar. The presence of parallel rebar will reduce the maximum detection length of the zone. If drawing of roof structure are not available (as in most cases) the exact location of the sensor cable could result from a +/- ½ meter (few feet) cable displacement to find an optimum location. Optimum location is obtained when detection is maintained over the entire length of the zone. Note that this precaution does not apply for zone length less than 30m (100 feet) as it becomes similar to a metal roof structure.

b) Insulation over Corrugated Steel.

- This application is very popular and forms the majority of installations. The maximum zone length is function of the sensor cable spacing to the corrugated steel, which is often defined by the thickness of the insulation layer as followed;
  a) 20 cm (8 inches): no impact
  b) 15 cm (6 inches): 30m (100 ft) max.
  c) 10 cm (4 inches): 25m (80 ft) max.
  d) 8 cm (3 inches): 20m (65 ft) max.

  where for application with cable spacing less than 8 cm (3 inches), it become a "Metal Exterior" application as discussed in next sub-section c).

- For mixture of gravel and tar, the sensor cable can be hold in place by placing spot of tar every 3 m (10 feet).

- For additional mechanical protection of the sensor cable, an industrial quality rubber hose (with no metallic string embedded in the rubber) can be slid over the sensor cable.

c) Metal Exterior

- The cable needs to be raised a minimum distance of 20 cm (8 inches) either vertically from the roof or horizontally from the parapet. (See figure 3c).

- A wide variety of non-metallic material can be used to raise the sensor cable. This include;
  a) An array of concrete block where the cable is placed on top of the block,
  b) A layer of rubber material used to protect wires running across high traffic road,
  c) A wood fabricated structure where the cable is placed on top of the structure,
  d) PVC conduit, which demand less stand-off as opposed to bare sensor cable.

  Auratek can also supply custom standoffs, standoff bases, and cable clips, to meet your special installation requirements.

- As discussed in the above sub-section b), the maximum zone length is function of cable spacing, where same numbers do apply.

d) Shingle on Wood Truss

- Since the VHF signal can penetrate wood and any non-metallic materials, the detection cable can be placed in the attic, strapped to the roof truss.

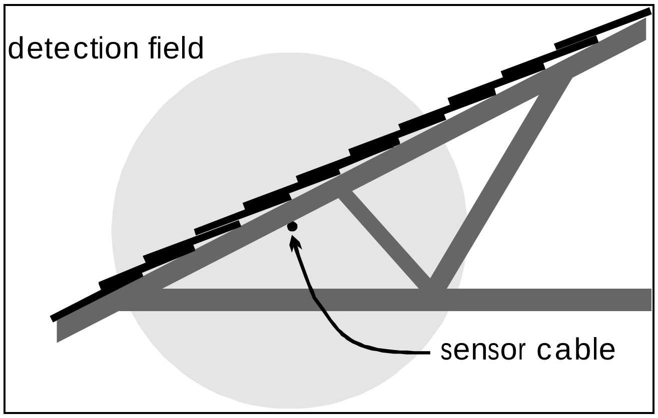

Fig. 2b
The sensor cable is mounted directly on the wooden truss. Note that the detection field penetrates the non-metallic structure, which allows it to detect outside as well as inside intrusion.

- A 2.0 m (6.6 feet) clearance between the detection cable and human activity inside the building should be considered to avoid nuisance alarms.

- If a covert sensor is desired for providing inside detection, the cable should be placed less than 1m (3.3 feet) from the human activity.

e) High Metal Capping Parapet

- Where a high parapet exists, the cable could be installed using an horizontal stand-off on the roof side of the parapet to avoid an intruder using the parapet to jump over the detection zone.

- Alternatively the cable can be installed on the roof the same distance from the parapet as the height of the parapet. Another alternative is to install the cable on the wall side of the parapet to detect intruders before they gain access to the roof edge.

- It is well understood than in an ideal world, the architect could design a non-metallic (i.e. vinyl or PVC) parapet clapping with the sensor cable installed underneath.

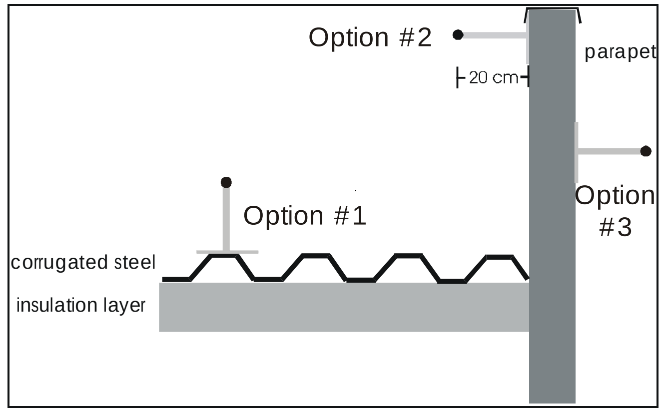

Fig. 2c
The sensor cable is air suspended using a series of non-metallic spacers (standoffs) to keep a minimum distance of 20cm (8 inches) from the parapet's metal cover. Alternatively, the sensor cable could be installed on the wall forming the parapet. Note that in option #2, the base of the stand-off is slide under the side section of the parapet capping to form a press-fit holding point where only one screw can be used to prevent sliding down of the stand-off.

1.2 Installation of Antenna for varying Roof Structures

This application notes does not discuss about the best antenna location in term of system performance, and restrict discussion that address specific antenna installation for roof application. The optimum antenna location is widely covered in the User Manual.

a) Directly on the Roof

- When mounted directly on the roof, it is suggested to mount the PVC base plate material on a "patio" type concrete slab. This approach eliminates the need to perforate the waterproof membrane. In addition, this approach allow ease of displacement of the antenna, which is sometime required to determined the optimum location of the antenna during system calibration.

b) Using Antenna Mast

- When possible, the antenna could be installed on existing mast that offer a “look down” overview of the secure area of the roof. This will allow the use of only one antenna since multiple processor can share only one antenna via RF power combiner in similar way to connect multiple TV sets to one roof antenna.

In all cases, ferrite beads should be installed over the antenna lead-in cable for the 2-meter (6 ft) section of the lead-in cable adjacent to the antenna. Refer to Ferrite Bead Installation sheet for more details.

2.0 Impact of Roof Equipment

a) Metal Object (e.g. HVAC Unit)

- The sensor cable should be routed a minimum distance equivalent to half the height of the object for HVAC equipment that have no moving metal parts and one time the height of the object for HVAC equipment that have large moving metal parts (i.e.: fan).

- Also, precaution should be taken to avoid RF blind spot (RF shadow). Note that RF blind spot are non-existent behind the object for distance more than 3 times the physical dimension of the object even tough they still do appear blind to a human eye.

b) Metal Pipe (e.g. natural gas line)

- The sensor cable can typically cross the pipe at an angle of 90° (+/- 30°) with no negative impact. It is recommend to place ferrite beads on the sensor cable for a section of 30 cm (1 feet) on either side of the metal pipe crossing point. The used of the ferrite beads is to minimize to RF coupling from the sensor cable to the metal pipe.

- If the sensor cable is installed running parallel to the pipe, it should be maintained at a minimum distance of 60 cm (2 feet) from the pipe. Ferrite beads material is useless in this case.

c) Metal Ventilation Stack (ie. sewer vent)

- The sensor should be kept at a minimum distance of 30 cm (1 foot) from the ventilation stack, or any other similar metal object. Low detection in that area is a sign that the sensor cable must be put farther away.

d) Other Large Metal Object (ie. antenna mast)

- The sensor cable should be kept at a minimum distance of 2 m (6.6 feet) from the metal mast.

e) Lightning Rod and Ground Wire crossing

- The sensor cable can typically cross the lightning ground wire at an angle of 90° (+/- 30°) with no negative impact. When possible it is recommended to space both wire a few cm (1/2 inch). It is also recommended to place ferrite beads on the sensor cable for a section of 30 cm (1 feet) on either side of the metal pipe crossing point. The use of the ferrite beads is to minimize the RF coupling from the sensor cable to the lightning ground wire. Lightning rod that are typically 30 cm (1 feet) long have no negative impact.

Handling an Inside Parapet

It is common for large building structure to have an inside parapet that present obstructions to a straightly run sensor cable. The preferred approach is to drill through the parapet wall, install a conduit, water tight both ends of the conduit and run the sensor cable through it. For metal capping parapet, it is recommended to place ferrite beads on the sensor cable for a section of 30 cm (1 feet) on either side of the parapet.

Section of non-detection cable (RG-11 Triple shielded) can be used to bridge over the parapet. However, even when non-sensor cable is used, it is recommended to place ferrite beads along the entire section of the non-detection cable, spaced at every 15 cm (6 inches).

The non-detection cable should be also kept a minimum distance of 2 cm (1 inch) over the parapet capping.

An inside parapet can also be bridged by using either sand bags or a non metallic spacer to keep the sensor cable 20cm (8 inches) from the metal flashing at the top of the parapet. This latter approach is adequate for temporally installation but not recommended otherwise.

Handling Different Roof Elevations

It is not recommended to use the sensor cable to run between different roof elevations.

To run between two minor elevations (less than 1m (3 feet)), a section of non-detection cable should be inserted (RG-11 Triple shielded) to bridge the two roof sections, loaded with ferrite beads every 15 cm (6 inches).

To run between two major elevations (more than 1m (3 feet)), it is recommended to split a zone into two sub-sections. Since the Auratek technology presents a cost efficient solution to have multiple zones per processor, the design of the zone layout should take into consideration such major change in elevation and have new zones at elevation boundary.

Interconnections

a) Processor Unit

A recommended place for the permanent Processor Unit (FSP-100-V, FSP-200-V or FSP-400-V) is inside the electronic room for ease of future maintenance and alarm interconnection. However, since the processor is packaged in Nema-4 rated box, it could also be mounted directly on the roof. If so, the processor box should be raised by about 2feet (60cm), and all incoming cable (RF, data, Power supply) should be also raised for a distance of 2m (6 feet), about 30-60cm (1-2 feet) high, using PVC standoff. While being raised, those cables should be loaded with 5 ferrites beads at each end. It is strongly recommended to feed the connecting cables to the control room using roof flanges, as close as possible to the processing unit.

b) Transmitters

Transmitters are packaged in a tubular shape of 45 cm (1,5feet) long by 4 cm (~2 inches) wide with RF connectors at both ends for cascadable configuration. The transmitters need DC power to operate. Such DC power is cascadable and routed via the sensor cable itself. Transmitters sharing the same roof section could be cascaded together to minimize the DC injection points. Otherwise, it is recommend to supply individual DC injection points for separate roof sections, to avoid long interconnected coaxial cables on the roof that will contribute to increase undesired RF coupling.

Note that when transmitter are grouped in cascade it is recommended to insert 4 ferrite beads at each ends of the transmitter in order to decouple the adjacent zones.

b) Lead-in (Interconnect) Cable

When lead-in cable needs to penetrate a metal roof, a roof flange (see sub-section 3.0) should be used. The roof flange prevents the propagation of the RF field that “travel” on the surface of the coaxial cable to cross inside the building.

When lead-in cable run on the roof, they should be loaded with ferrite beads spaced every 15 cm (6 inches). This applies for the 3m (10 feet) section of the lead-in cable that is both connected to the antenna or sensor cable, and to the processor unit.

Note that for metal roof, there is no need to use ferrite beads for the section of lead-in cable running inside the building. This however implies that proper roof flange has been used.

Local fire and electrical codes might enforce to route internal lead-in cable in a metal conduit or to use plenum rated lead-in cable. Consult your local Fire Department for more details.

c) Antenna

The antenna must have line of sight with each zones (sensor cables) service by the antenna. Please refer to the User Manual for instruction on antenna location. In all case, a minimum setback distance of 15 m (50 feet) from the sensor cable is required. The minimum height of the antenna should be 1 m (3 feet). Antenna, when installed on highest points of a building can be quite prone to lighting attraction, an then, proper lighting arrestor must be installed. The lighting arrestor is equipped with 2 TNC RF connectors, and is simply installed in series with the antenna lead-in cable. Install the lighting arrestor as close as possible from the antenna, along with proper lighting ground. Currents involved during lighting are really high, and electric field can make current use an unpredicted path. Keep the lighting arrestor outside of the building, and properly grounded. Yearly inspection of lighting arrestor is a good practice, as the lighting arrestor's fuse may be blown, and need to be replaced.

d) System Configuration

The mechanical instability (mechanical expansion and contraction due to temperature change) of metal structure in proximity of the sensor cable cause electrical instability of the RF signal. Such instability provide distinct signature in comparison to an intruder signature. Indeed intruder signature is considered by a gradually increase in the detection signal followed by a small "plateau" then ended by a gradual decrease. A signature caused by mechanical instability consists of a sudden (abrupt) increase in the detection signal with permanent change. Such "different" signatures are processed by the algorithm of the processor using the rate of change (the slope) of the detection signal. Such slope is compared to an user defined slope (called step) value and will trigger an alarm only for signatures presenting a slope smaller than the step value. For more information refer to the User Manual, sub-section Step Detection.

d) Shielded cables

Long shielded cables used for data communication alarm reporting, or other purposes, need special consideration during the interconnection process, mainly if they carry balanced signal, such as RS-422, RS-485, or balanced audio. The following recommendations should provide trouble-free performance:

- The shielded cable must include an internal ground wire, connected at both ends.
- The shield itself must be connected at ONE END only. The other end must be left unconnected. This is to avoid ground loop coming from electrical equipments.
- Cables used for balanced data (RS-422 or RS-485) should be of twisted pair, low-capacitance type. The cable can be globally shielded. Typical specifications are as follow:
    - 24AWG
    - Stranded is preferred for reliability.
    - Nominal cable impedance: 100 ohms
    - Nominal capacitance between conductors: 41 pF/m (12,5 pF/ft)
- Install ferrite beads at both ends of the cable, as per the Lead-in installation above.

3.0 Specific Accessories for Roof Installation

a) Roof Flange

A roof flange should be used for metal roof structure to route the coaxial cable across the metal membrane. This applies for all cases:

a) coaxial cable is used to supply DC power to transmitter,
b) coaxial cable is used to supply DC power to processor (when mounted on the roof),
c) shielded cable with multiple internal wire is used to read the alarm relay status of the processor (when mounted on the roof),
d) coaxial cable is used to connect the antenna to the processor (when processor is mounted inside the building).
e) shielded cable is used for data communication between the alarm processor and the control room.

This roof flange prevent the propagation of the RF field that "travel" on the surface of the coaxial cable from crossing inside the building. Internal coupling of the RF signal will increase chance of nuisance alarm caused by indoor activities, and for indoor instability.

a) Lightning Arrestor

Lightning arrestor shall be used for every antenna RF connection. Local buildings codes practices will apply. For more installation detail, please refer to the Lightning Arrestor Installation Sheet supplied with the material.

Conditions Specific to Roofs

Birds - birds are too small (to small electrical cross section) to generate an alarm.

Snow - snow accumulating on a roof will not affect the systems performance. Snow is transparent to RF signals.

Standing Water - proper drainage should be used to ensure water does not accumulate inside the detection field of the sensor cable for more than 2cm (1 inch) thickness.

Operational activities - human activity inside the building and vibration from HVAC fans and motors will not generate alarms when sensor cable is properly installed. Special care must be taken from installing a zone close to a window. In that case, no shielding barrier is provided by the metallic wall, and hence, people inside the building could cause false alarms. Note that window with conductive material (to reflect heat) do provide some kind of RF shielding.

Lightning Interference - RF interference caused by nearby lightning strike does not caused false alarm. However, direct lightning hit could severely damage the electronic if proper lightning arrestors and proper ground return are not installed. Using coaxial cable sensor that present a floating potential as perceived form the exterior, will not contribute to increase the chance of lightning hit normally presents in the area. As well, since the cable installation is normally close to the roof structure, it will not attract lighting. Antenna installation however can be attractive and require proper lighting arrestor installation. See Interconnection section for details.

Conclusion

Intrusion through the roof is rapidly becoming the most common point of entry for thieves since most organizations have greatly increased the security on doors and windows. ENCLO**SURE** is contour following so that it is able to protect the entire roof area and not leave any "blind spots ". Also, it is able to be hidden under or within roof materials for covertness so that the intruders are not aware they have been detected which increases the chances of capture. Further, the system is able to traverse different levels of a roof. In summary, ENCLO**SURE**'s tremendous flexibility makes it on ideal sensor to protect the vulnerability of the roof.