Loudspeakers in video surveillance applications
Table of contents

1. Introduction  3
2. Types of loudspeakers  3
3. Audio in a network video surveillance system  3
4. Area of coverage  5
5. Conclusion  7
1. Introduction

In video surveillance applications, loudspeakers can play an effective role in deterring unwanted activity. Loudspeakers enable a video surveillance operator to remotely communicate orders or requests to intruders and visitors. For instance, if a person in a camera’s field of view demonstrates suspicious behavior, such as loitering near an automated teller machine (ATM), or is seen to be entering a restricted area, a remote security guard can immediately issue a verbal warning to the person. In many cases, this is enough to prevent any unwanted incidents, enabling video surveillance to be proactive by making it possible to prevent crimes before they occur.

Since loudspeakers can play an important role in a video surveillance system, this paper outlines the considerations that should be made when selecting and installing a loudspeaker.

2. Types of loudspeakers

Loudspeakers are devices that translate electrical signals into audible, mechanical waves of pressure and displacement (sound). Loudspeakers come in many different types. In video surveillance applications, the major choice is between a dynamic loudspeaker or a horn loudspeaker.

Dynamic loudspeakers
The dynamic speaker has a lightweight diaphragm—a cone connected mechanically to a voice coil. The dynamic speaker works for a multitude of applications; for example, indoor ceiling speakers, wall-mount speakers and Hi-Fi systems. However, the drawback of a dynamic loudspeaker is efficiency. Only about 1% of the electrical energy sent to the speaker from the amplifier is actually converted to acoustic energy.

Horn loudspeakers
A horn speaker uses an acoustic horn to increase the overall efficiency of the driving element. A horn loudspeaker commonly consists of a so-called compression driver that is attached to the horn itself. This construction increases efficiency by 10 times for a given amplifier output. The horn speaker is, therefore, often used in public address systems. The horn outperforms other speaker types in its ability to increase the distance a sound can travel towards a particular area.

The disadvantage of a horn speaker is that its optimal frequency range is limited. This makes the horn speaker less suitable for music applications. Horn speakers are, however, well suited for speech applications, especially where coverage over long distances is needed.

3. Audio in a network video surveillance system

A digital audio signal sent over the network needs to be transmitted, decoded and amplified before the electrical audio signal can be converted into the corresponding sound. These steps can be performed in a single integrated device or by having several separate devices (transmission equipment, amplifier and loudspeaker).
**Analog powered speakers**

Integrating speakers into a network video surveillance system can be done by connecting an analog speaker to the audio line output of the network camera. In such a setup, the signal from the camera needs to be amplified. If a normal, passive speaker is used, a separate amplifier will also be required. In most cases, the use of a powered speaker is preferred. A powered speaker has a built-in amplifier. The amplifier needs power to work so the analog powered speaker requires an external power supply.

In a network video surveillance system, the analog powered speaker is then connected to a network camera's analog line level output. The analog line level signal is sensitive to disturbances. This makes it necessary to place the speaker close to the camera. Otherwise, there is risk of getting interference from, for instance, power cables. The analog speaker is then reached through the video management software by addressing the camera to which the speaker is connected.

An analog powered speaker can be suitable if it is placed close to a camera and there is easy access to a power outlet. To verify that the speaker is working as it should from a remote location, a microphone needs to be connected to the camera. This would allow an operator to listen while making an announcement.

![Fig. 1. An example of a setup using an analog powered speaker, an outdoor network camera and a PoE switch.](image)

**Network speakers**

A network speaker provides a simple-to-install complete paging solution in a single unit. Compared with a powered analog speaker that is connected to a surveillance camera, a network speaker is a standalone unit that can be placed away from the camera. If the network speaker supports Power over Ethernet, only one network cable is needed for both power and network connection.

Streaming audio over a network provides audio quality and high reliability. With network audio, sound is kept digital all the way to the speaker, giving repeatability and immunity to degradation. It also opens up possibilities for easy operation and automation. Streaming of sound can be done over a local network, the Internet and a wide area network. The entire system can be centrally managed and remotely controlled, and pre-recorded audio files can be triggered to play from anywhere where there is network connectivity. This makes the system suitable for both inter- and intra-facility communications and any combination of the two.

In a network audio system, every speaker is individually addressable. Intelligent speakers also allow for smart functionalities to be included, such as an automatic supervision functionality. Integration with other systems becomes easier with IP. Network speakers, such as those from Axis, can be integrated directly into a video management software. If a network speaker has support for SIP-based voice over IP telephony, it can also create effective solutions for paging.
Network speakers provide great flexibility and scalability. Modular design allows for easier maintenance and system upgrades. It also enables easy modification and expansion of the speaker setup. No specialized hardware is needed. Being able to use an existing network infrastructure makes the installation fast, simple and cost-effective.

Fig. 2. An example of a setup using AXIS C3003-E Network Horn Speaker and a PoE switch.

4. Area of coverage

Once the type of speaker has been decided, a key consideration is the area to be covered. This will determine what is required in terms of the sound pressure level, the throwing distance and the coverage pattern (spread) of the speaker, as well as how many speakers will be required.

Sound pressure
Sound pressure is related to how loudly we perceive sounds. For every 10 dB, the loudness doubles. For example, 120 dB is twice as loud as 110 dB. The following examples give an indication of what different sound pressure levels can equate to: a motorcycle (98 dB), loud rock concert (115 dB), a thunderclap nearby (120 dB) and a jet taking off (133 dB). The human threshold for discomfort is around 120 dB and the pain threshold is around 130 dB. The sound pressure level that is required for an area will depend on the level of background noise and the reach required. It is usually advisable to choose a speaker with a little more performance than needed as the volume can be lowered.

Range and coverage
Different speakers offer different audio coverage and range. Generally, a speaker with a wider angle of coverage also covers a shorter distance. So a speaker with a narrow coverage pattern usually is capable of throwing over a longer distance. More speakers would then be required if a wide area is to be covered. The coverage pattern will vary for different frequencies and it is always an approximate. The intensity will generally be higher in the middle and decrease the further away one moves from the middle. Think of it as a light source that shines brighter in the center than at the sides.
Another consideration to keep in mind is that sound bounces off most surfaces, resulting in reflections. To use the light analogy, it would be like light bouncing off mirrors on walls. Some reflections can affect the sound experience negatively and make it difficult to hear the original sound properly. Speech intelligibility is particularly sensitive to reflections, which can make a spoken message unclear. This means that it is easier to get a good sound in open areas than in areas with many obstacles.

**Directing the speaker**
When the type of speaker has been determined, it is time to look at how it should be placed. The speaker should be directed in the same way as a spotlight. Point the center of the speaker to the place where the listener is likely to be. In a video surveillance installation, the speaker is normally installed at three to eight meters above the ground (above the reach of people) and is directed toward the area that is under surveillance.

As mentioned earlier, sound spreads in a similar way as light from a lamp with the center or middle area having the strongest intensity. Therefore, keep in mind that the higher the speaker is raised, the wider the area of coverage but also the lower the sound pressure will be.

**Covering larger areas**
Several speakers may be required when trying to cover a very large area. In general, the speakers should not face each other. Below is an example of how three speakers can be used to cover a large yard of a building that needs actively monitored perimeter protection.
There should be speakers to cover the same area as the cameras cover. This allows operators to address anyone they see in the video and make a connection between the views from every camera and the speakers covering the same area.

5. **Conclusion**

Having loudspeakers in a video surveillance installation is an effective way to deter crime before it occurs. There are many ways to add speakers to a video surveillance system. Choosing the right solution is important in getting a high-performance, cost-effective installation that meets the requirements. When it comes to installing a speaker, the important considerations are the area to be covered and the sound pressure required.
About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the global market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to its customers and carried through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 1,900 dedicated employees in more than 40 countries around the world, supported by a network of over 75,000 partners across 179 countries. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ Stockholm under the ticker AXIS.

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