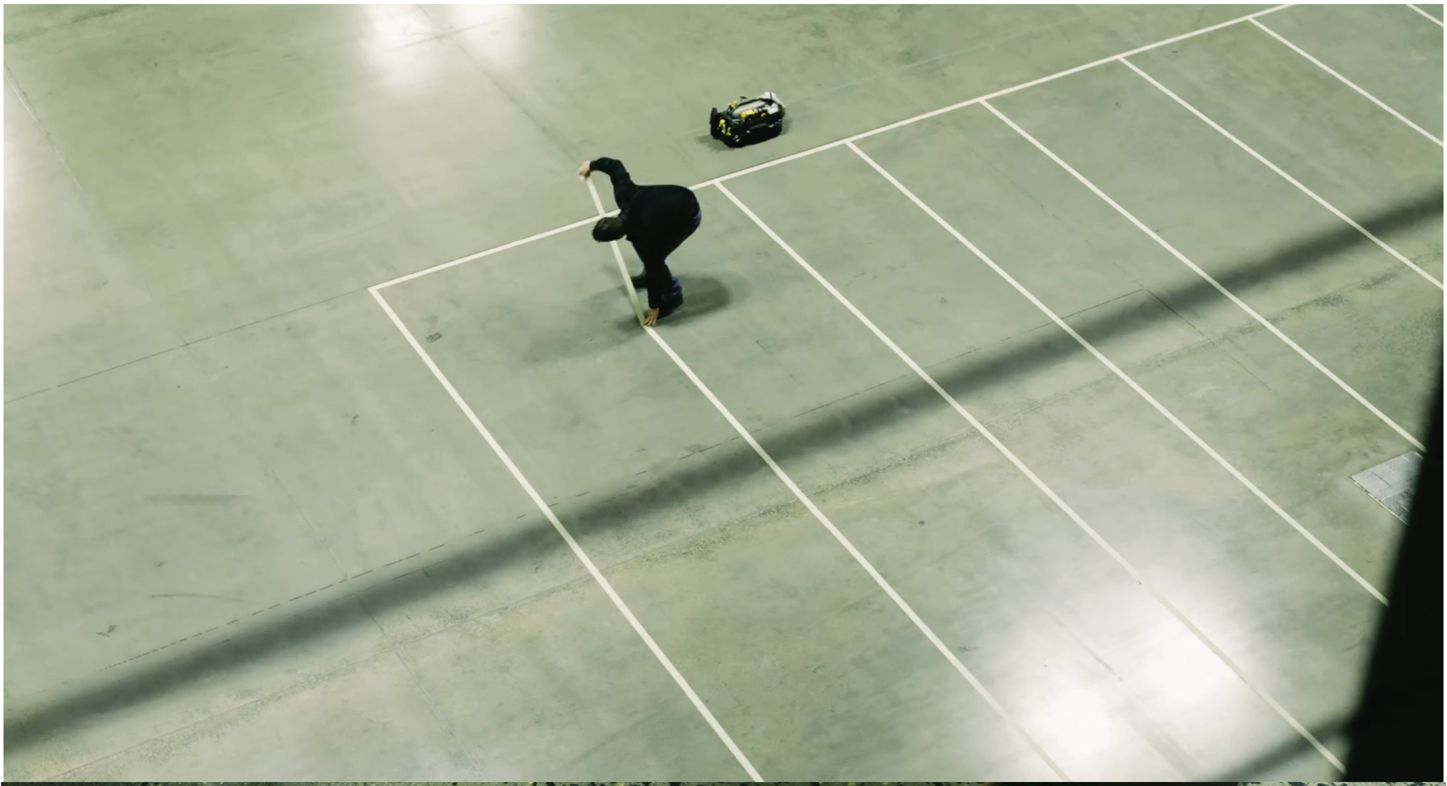
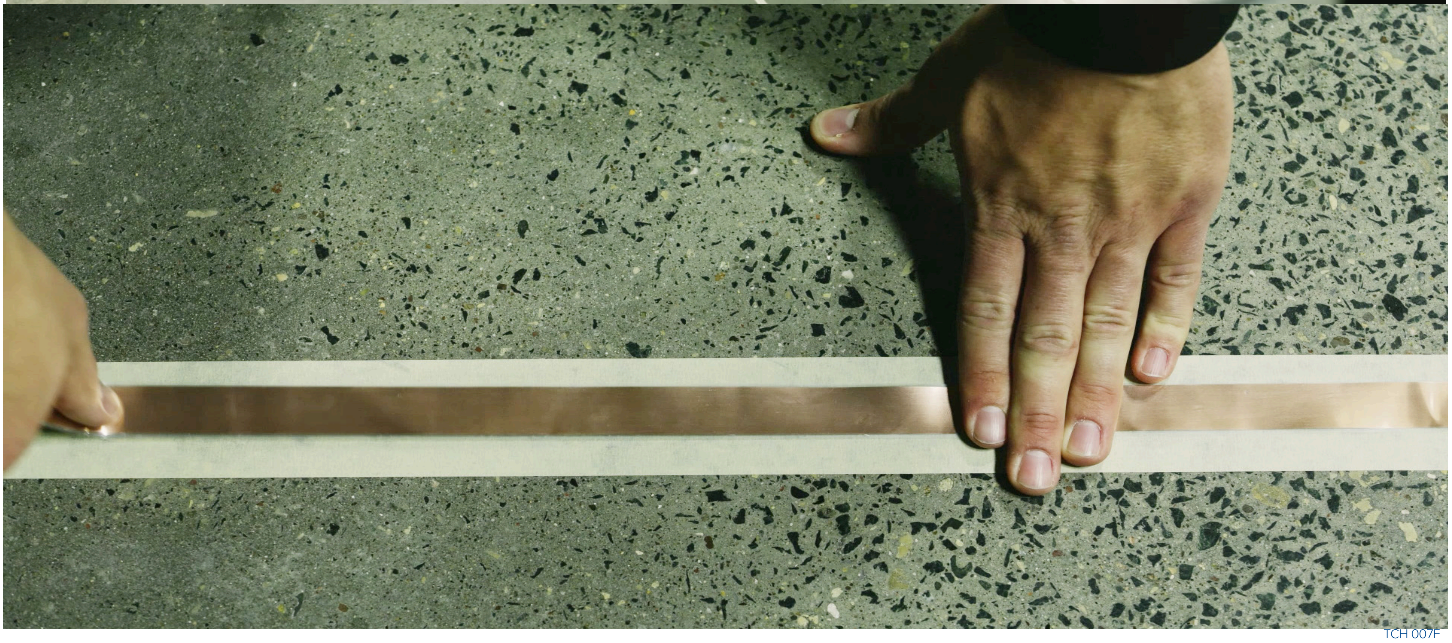
Design Guide

INDUCTION LOOP SYSTEMS





TCH 007F

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Design Process

Designing a loop system is a process with many steps. A successful outcome depends on how carefully each step is performed. These steps are explained in detail in this guide. The order of these steps generally follows the order of the table of contents.

Basic Concepts

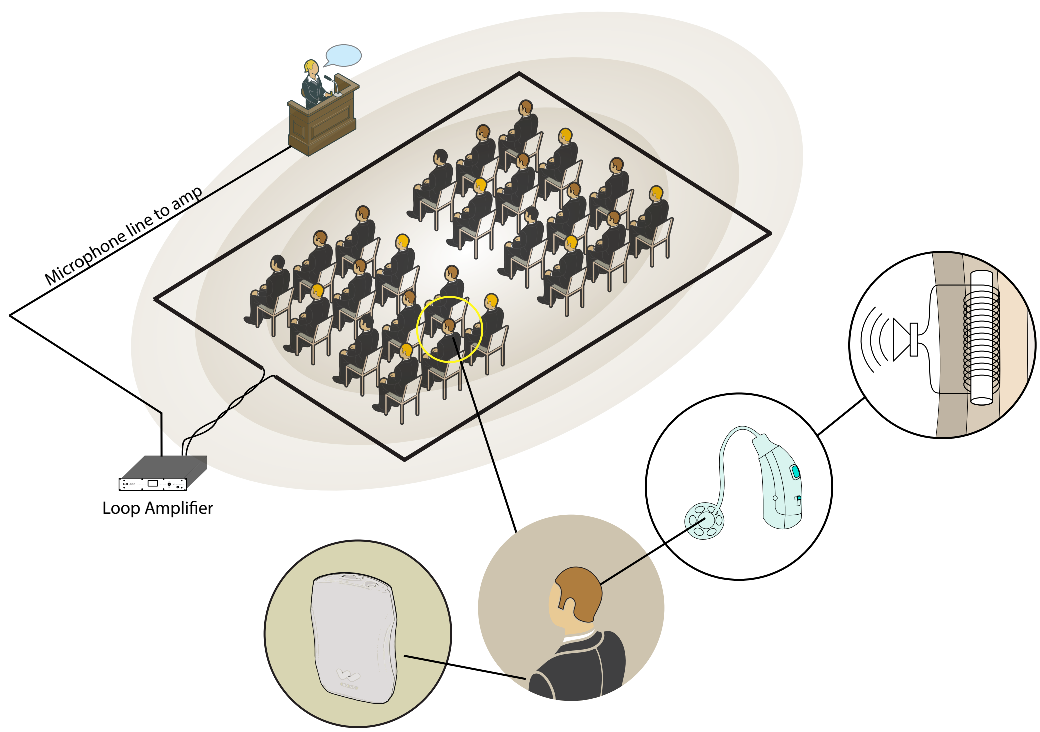
What is an induction loop system?

An induction loop system consists of one or more loops of wire, driven by an amplifier, to produce a magnetic field. When audio is input into the amplifier, this magnetic field fluctuates. These fluctuations, or magnetic waves, are picked up by t-coil equipped devices (such as a hearing aid or loop receiver), which amplify the signal and turn it back into sound waves that the ear can hear.

Below is one example of a loop system called a **perimeter loop**, because it is usually installed around the *inside perimeter* of a room. Here is how it works:

Audio from a microphone (or an audio system) is input into the loop amplifier. The audio is amplified and sent through the loop in the form of current that fluctuates (goes in one direction then the other direction). This alternating current, when flowing through the wire, produces an electromagnetic field that is radiated into the listening area. Devices with t-coils pick up this magnetic energy, amplify it, and turn it into sound waves that the ear can hear.

If a person requires hearing assistance and they do not have a t-coil equipped hearing aid, they can use a induction loop receiver to hear the audio.



NOTE: The illustration above is shown as an example of a perimeter loop, illustrating the principles of how an induction loop system works. Perimeter loops work well on older traditional buildings with wood floors on wood beams. However, modern construction methods often use concrete floors, incorporating the use of re-bar or steel-pan decking onto which the concrete is poured. The presence of steel in these floors results in **metal loss**, where the magnetic field is absorbed by the field-grounding effect the steel creates. These types of floors will require a phased-array design, as perimeter loops will not provide system performance to the IEC 60118-4 Specification.

Do you need a loop system?

A loop system is one method, or technology, for providing assistive listening. There are other methods too, such as FM, Digital, Infrared, and Wi-Fi. So, choosing an effective technology that is appropriate for the venue and the audience is very important. There are several advantages to using a loop system for assistive listening:

1. People with t-coil equipped devices including hearing aids or cochlear implants) are able to hear the audio program without additional equipment such as a separate receiver, headphones or earphones. These people not only hear the audio at the level they need, but it is processed through the DSP in the hearing aid with their corrected EQ for their individual hearing loss.
2. Some people are sensitive to being “singled-out” for being hearing impaired. With a loop system, all they have to do is switch on the t-coil in their hearing device, making it a very discreet form of assistive listening.
3. Since the audio program is sent directly into the amplifier, the audio is isolated (background noise is reduced or virtually eliminated), drastically improving the intelligibility of the audio. For this to work correctly, the source audio itself must be free of noise. If using a microphone, the type of microphone and the direction of pickup are important. An omnidirectional microphone will not work well because it will pick up background noise along with the speaker’s voice thus defeating the purpose of an assistive listening system.
4. By sending program audio content (microphones or other sources) from the loop to the t-coil-equipped device, the listening experience is improved by bypassing the effects of the acoustical space of the venue. Multi-flutter echo and reverberation can reduce speech intelligibility and negatively affect the overall listening experience.

The area of use

The loop system has to deliver a tight range of signal strength and frequency response to the hearing devices in the listening area. The listening area is often called the listening plane or “area of use”. To determine the area of use, the following information must be gathered:

1. **Range of heights**

   The following table gives typical distances from the floor to the ear. Use this table to determine the area of use (listening plane). The loop wire can be at ceiling height or on the floor, but should never be within the area of use. The t-coil requires a perpendicular (vertical in this case) orientation to the loop wire or it will not pick up the loop signal.

	Adults	Children
Standing	4’-7” to 5’-7”	3’-11” to 5’-11”
Seated	3’-11” to 4’-7”	2’-11” to 3’-11”

   Warning: The wire cannot be placed at ear height.

2. **Listeners in fixed positions vs moving**

   If listeners are in fixed positions, the field strength and frequency response must meet IEC 60118-4 Specifications at the ear height locations. Aisles or empty area between rows may have less signal or frequency response, as long as the ear height positions meet the IEC Specifications.

   If listeners will be moving around the room, consistent coverage is required to reduce nulls (drop-out) and changes in frequency response as the listeners move.

3. **Where is the system required**

   It is important to evaluate where the listeners need to use the system, and where it is not required. Hallways, entry/exit locations, or even sections of certain seating areas may not require hearing assistance, depending on the venue. The loop system is only required to meet specifications where hearing assistance is required.

NOTE: Be aware of state and local requirements as well. For example, the California Building Code (CBC) requires 100% coverage of the venue. These situations are known as ‘Authority Having Jurisdiction” (AHJ), as California laws stipulate that their CBC supersedes the authority of the Americans with Disabilities Act (ADA).

Site Survey

A site survey is performed in an existing structure, prior to installing the loop system. Site surveys should take many things into consideration.

Reminder: Any equipment that will likely be operating when the loop system is on, should be operating during the testing. This includes things like lighting, dimmers, audio, video, projection systems, etc.

Testing for Electromagnetic Background Noise

Using a field strength meter (Williams AV model PLM FSMP), hold the device at 5 feet above the finished floor, in a vertical position, to align the telecoil with the component of the magnetic field you are testing. On the meter, press the top switch in and the bottom switch out (which sets the device to A weighted and -20dB).

An acceptable reading is less than -32dB on the -20dB scale of the FSM.

Readings should be taken throughout the area the loop will cover to pinpoint any localized magnetic background noise. Again, any equipment likely to be operating when the loop system is on should be operating during the testing.

Field of coverage (also referred to as Volume of Use)

The site survey should consider the desired area of coverage. Where does the customer and venue need and allow coverage? This will help the designer recommend a loop layout that will satisfactorily cover the desired area. Considerations must be made to tiered seating, overspill control, types of floor or surfaces where the loop wire is to be installed, and size of area to be covered. Aisles generally do not need to have coverage, so the center of aisles are often a good area to place the wire.

Is there more than one area that needs coverage?

If installing more than one looped area at the venue, low-spill phased array designs may need to be developed.

Wire Considerations

What type of wire will be utilized? Select from flat wire, single conductor or Direct Burial Cable (DBC). Determine whether this wire needs to be buried in the concrete floor or placed under carpet, wood or tile.

Williams AV does not provide Direct Burial Cable (DBC). We recommend using Belden’s 14 AWG stranded Hook-up/Lead Wire Direct Burial cable (9438).

All amplifiers have a specification for recommended load. The length and gauge of the wire determine the load on the amplifier output. Longer wire runs may require thicker wire to stay within the amplifier load specification. The lead wire from the amplifier to the loop is also part of the total load (impedance) on the amplifier.

When installing loops into large venues, consider the DC resistance of the selected wire in your assessment as to how many amplifiers will be required. Williams AV amplifiers require a DC resistance of 0.5 - 3.0Ω.

Amplifier Location

Where will the amplifier(s) reside? The amplifier(s) often are not located in the same room as the listeners, because amplifiers often have fans that create noise. Please refer to each amplifier specification sheet to find out the correct heat ratings (BTUs), as this will assist with factoring in the needed airflow to the rack.

Audio Source

How and where will I access the audio source? What types of connections do I need? Is it digital, line level, microphones, 70V distributed audio?

Noise-free Source Audio

There are many different types of sources that may be used with a loop system. Music or a pre-recorded program may be used, or a person using a microphone. The loop system is only as good as the source audio. If the source has noise, this noise will be broadcast to the loop. In the case of a person speaking, different choices should be made for the microphone, depending on if the person is stationary or moving. Some microphones may pick up too many surrounding sounds, and therefore would not be a good choice for the loop system.

Below is a chart to assist in choosing the correct microphone and/or audio source that should yield the best results for a loop system.

Figure 2: Typical source audio requirements

Type of Input Audio	Typical Input Requirements
Fixed Talker (Examples: Podium, courtroom microphone)	**Directional Microphone** A directional microphone is designed to pick up voice and reduce or eliminate background noise. Omnidirectional microphones are not recommended, as they pick up too much surrounding noise.
Moving Talker (Examples: Standing/walking presenter on a stage, classroom teacher)	**Mobile microphone** These microphones typically include a radio transmitter/receiver. Some examples include lapel microphone, headset microphone, or handheld microphone. These microphones should be as directional as possible, and the transmitter/receiver system should not introduce additional noise.
Audio System (Examples: CD, DVD or Blu-Ray Player or Computer fed through an Analog or Digital Mixing board, or Audio Switcher/Preamplifier)	**Audio system with clean output** The original source material should be as clean (free of noise) as possible. The system by which the audio is input into the loop amplifier should not introduce additional noise including hum, background noise, pops/clicks or any other form of noise.
Multiple Fixed Talkers (Examples: Conference Room, Courtroom with multiple mics)	**Directional boundary microphones. Special mixing.** Multiple speakers at fixed positions require directional microphones that should reduce background noise and not pick up nearby speakers. Each microphone should present an individual's voice as isolated and clearly as possible. Special mixing may be required to improve the intelligibility of each individual speaker when blended with other speakers (such as compression, equalization, gating, etc).
Multiple Moving Talkers (Examples: Large Conference, Live Theater)	**Multiple mobile microphones. Special mixing.** Multiple speakers in moving positions require directional mobile microphones with radio transmitter/receiver systems. All microphones must reduce background noise and not pick up nearby speakers. The radio transmitter/receiver system must not introduce any additional noise. Special mixing may be required to enhance or reduce the intelligibility of each speaker when blended with other speakers (such as compression, equalization, gating, etc).

If doing a site survey of an existing venue, find out what existing sources will be used. Microphones, audio sources, mixing systems, audio switchers, preamplifiers, and even connectors, wire, and adapters all need to be reviewed. Any of these items can be a potential source of noise or distortion. Noise checks or simple listening tests can help to identify potential problems and solutions before a loop system design is started. Contact Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com if you would like advice on conducting a site survey.

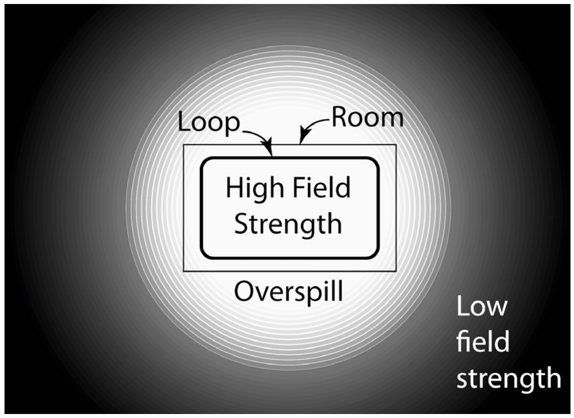
Overspill, Interference and Confidentiality

Overspill occurs when the magnetic signal from a loop travels beyond the listening area into other areas where the signal is not intended or required. A perimeter loop can radiate as much as 4 times the loop width away from the loop itself.

This can cause problems if multiple rooms have active programs and listeners are on the border of a listening area. They may hear two programs at once. If a program is not intended to be heard outside of a room for confidentiality reasons (such as a courtroom case), the spill of the signal can allow any user with a t-coil or loop receiver to eavesdrop on the program.

In some cases, this may not be a concern, as in the case of a church service or city council meeting. The use of the space will aid in determining the appropriate loop design. Following is a diagram of what the overspill looks like from a simple perimeter loop system.

Figure 3: **Perimeter loops spill signal outside the loop (white = strongest, black = none)**



The following needs to be determined:

1. Is there or will there be another loop system to the side, above or below this loop, within 4x the width of this loop?
2. Are there confidentiality concerns that would require the overspill of the loop to be contained?

If yes in either case, a perimeter loop cannot be used. Loop designs that help contain spill are called **phased arrays** (or more specifically low-spill phased arrays) which use a series of interwoven loops to reduce spill from the loop. With a well-designed phased-array system, spill can be reduced to up to 4 ft. (1.2 m) from the loop edge and 12 ft. (3.7 m) above and below the loop plane.

Metal structures and magnetic absorption (metal loss)

Most commercial buildings contain metal as part of the structure (I-beams, steel re-bar and/or steel pan decking in floors and ceilings, and metal ceiling grids). These fixed metal structures have a grounding-effect to magnetic signals. They absorb the magnetic energy, reducing it (sometimes greatly) as the signal travels past the structure. Most of this effect is seen at higher frequencies (5 kHz and above). This is commonly referred to as “Metal Loss”.

In an existing building, an approximate amount of metal loss can be determined through a site survey (see the section on site surveys). By laying down a figure-8 test loop, then sending test tones through the loop and measuring the field strength with an FSM at different frequencies, you determine where the metal loss is occurring, at what frequencies, and how much field strength is being lost.

Simply providing more power from the loop amplifier will not solve the problem of metal loss. In fact, supplying more power to the loop can make the problem worse by causing low-frequency distortion (due to too much power at these frequencies), while mid and high frequencies will then suffer from a lack of power. Williams AV amplifiers can correct for metal loss and low frequency adjusting the equalization built into the signal processing.

Providing more power *at the frequencies where metal loss occurs* can help, but it is only part of the solution. In terms of the loop design itself, tighter (narrower width) loops help control metal loss by lowering the variation of the magnetic signal, providing a more consistent magnetic field throughout the loop area. More power from the amplifier will be required in all cases where there is metal loss, but the effect of metal loss to the listener, and the demand on the amplifier, can be reduced by a well designed loop array.

One of the nice features of the PLA DL210NET is the Metal Loss Compensation setting. This parametric EQ provides attenuation/gain adjustment from 0 dB to +12 dB in the frequency range between 500 Hz to 9 kHz to aid in achieving flat frequency response in the presence of metal.

"Table 2: AWG Chart" on page 14 shows maximum allowable loop wire lengths for different wire gauges.

Contact Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com if you would like assistance or advice on conducting a site survey.

Design Requirements and Best Practices

The loop system must meet performance requirements set by the international standard for loop systems IEC 60118-4. The system must meet these requirements for the loop system to be certified, and ensuring the loop system provides a benefit.

NOTE: We recommend that all field strength meter measurements are taken at five (5) feet above the finished floor to account for both seated and standing height(s).

1. Background Noise = < 32 dB (reference 400 mA/m with a calibrated field strength meter, A-weighted, -20 dB scale)

Background noise here refers to electromagnetic interference (EMI), or unwanted magnetic signal (noise), from sources of magnetic energy within the room. Florescent lights, motors, incandescent lighting, dimmers, audio, video and projection systems and anything with a high amount of current running through it, can generate magnetic noise.

With the loop amplifier turned ***off***, and all possible EMI sources turned ***on*** (this includes all lighting, dimmers, audio, video and projection systems, etc.), EMI is then measured with a field strength meter relative to the 400 mA/m reference point. This energy should not be higher than -32 dB from reference, anywhere in the area of use.

Since EMI is usually generated by the environment, rather than the loop system itself, this can often be measured *before a loop system is ever installed*. Part of the site survey includes the determination of how much magnetic noise exists in the room. Field strength measurements are taken with the lights on, and all other typical equipment running as it would normally when the loop system would be in use.

Sometimes the high levels of EMI can be caused by bad electrical wiring, improper grounding, or motors (like a vacuum cleaner, etc.). If the EMI source can be determined, and the cause is related to improper wiring/grounding, contact the venue owner and have them hire a licensed electrician to correct the problem. If the EMI is being generated by older lighting dimmer packs, or bad ballasts, the venue owner may need to have these replaced prior to having the loop wire installed. When the loop area has been tested to be free of EMI, the loop wire installation can commence.

NOTE: Testing for EMI should be done during the initial site survey *and also* **on the day of installation of the loop wire, to ensure that EMI levels are still acceptable.**

2. Field Strength = 400 mA/m ±3 dB @ 1 kHz

At this point the loop wire has been installed. Using the internal 1 kHz test tone in the loop amplifier, the magnetic field strength must be 400 mA/m ± 3 dB throughout the area of use. The Digi-Loop product line has a built-in test tone generator for this purpose.

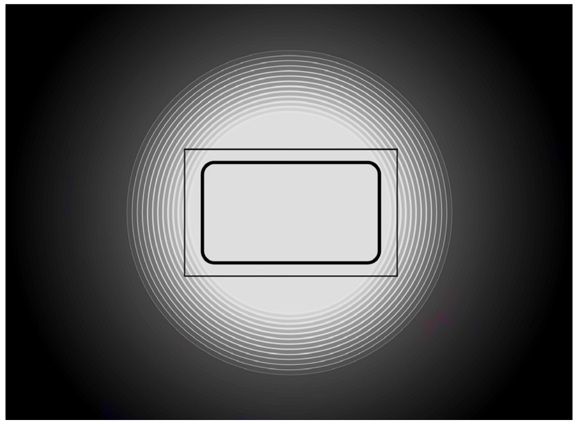
3. Frequency Response = ±3 dB at 100 Hz, 1 kHz and 5 kHz (1 kHz Reference)

Using the 400 mA/m at 1 kHz as the reference point, the field strength must not vary more than ±3 dB when measuring at 100 Hz and 5 kHz within the area of use. In order for the human voice to be intelligible, the system must have flat frequency response between 100 Hz - 5 kHz (even though harmonics of the human voice can be outside of this range).

Types of Loops

There are five basic types of loop layouts for an induction loop system. The type of loop chosen depends on system requirements, metal loss (environment), and a thorough site survey that includes electromagnetic interference (EMI) testing.

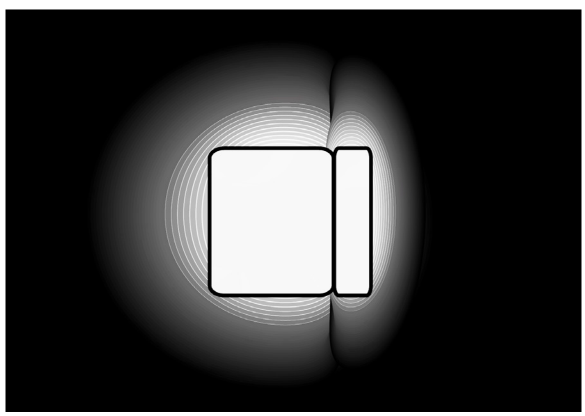
Perimeter Loop



This is one loop of wire around the perimeter of the room or listening area.

A perimeter loop can be used in rooms/areas from 65 - 82 ft. (19.8 - 25 m) wide with no metal present, or rooms/areas 6 - 16 ft. (1.8 - 4.9 m) wide with minimal metal present. This type of loop is usually only possible for smaller rooms in modern buildings. If overspill is a concern, a perimeter loop is generally not recommended. Perimeter loops are typically installed on wood floors with wood beams, brick, or stone (no metal) in the supporting structure.

Cancellation Loop

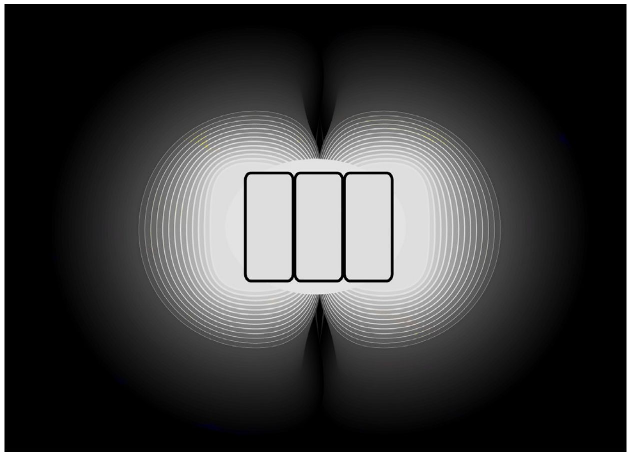


This is single run of wire overlaid in an offset figure-8 pattern, with one large loop, and a small loop on the side where spill needs to be restricted.

This type of loop is used when spill needs to be controlled in one direction only.

NOTE: Like a Perimeter Loop, the cancellation loop should be used on wood floors with wood beams, brick, or stone (no metal) in the supporting structure.

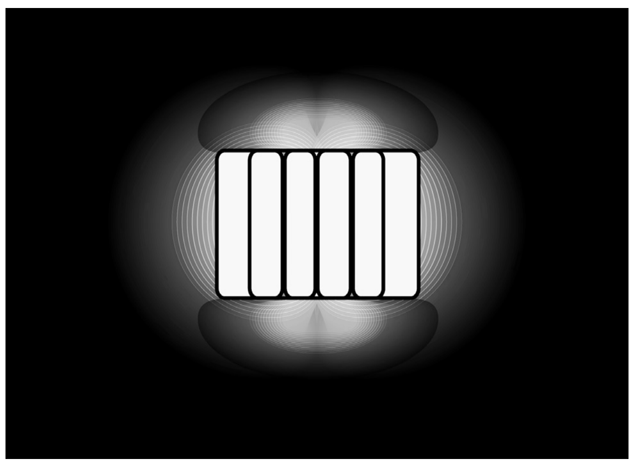
Single Array



This is a single run of wire, overlaid back and forth to create equal-width segments.

This type of loop is often used when there are minimal to no metal losses in the room, as it provides more even coverage than a simple perimeter or cancellation loop. This loop works well for fixed-seating applications. It is generally not recommended if listeners will be moving.

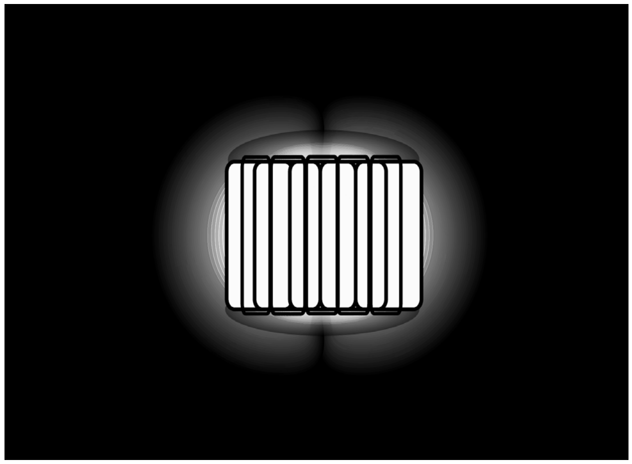
Phased Array (low overspill)



This is similar to a single array except there are 2 runs of wire, forming a primary array and a secondary array. These two arrays are overlaid in an offset pattern, each driven by separate amplifiers 90 degrees out of phase with each other.

A phased array can be used in rooms/areas of various sizes where metal loss is present. This type of array controls overspill more tightly than a single array. It also provides more even coverage within the listening area. If people will be moving, a phased array may be sufficient, depending upon the room/area.

Ultra-low overspill phased array



This is a phased-array with narrower segments.
This type of array provides the greatest possible spill control and most consistent coverage within a room. An ultra-low spill phased array can be used in rooms/areas of various sizes where metal loss is present. This type of array also controls overspill around the entire loop area more tightly than a phased array - as close as 5 ft. (1.5 m) from the loop edge, and 12 ft. (3.7 m) above and below. This design is excellent for confidentiality and adjacent loop systems. It is also excellent for metal loss.

Loop Design

The following design techniques are crucial to designing a successful induction loop system.

Perimeter loop design

The following must be considered when designing a perimeter loop:

Location

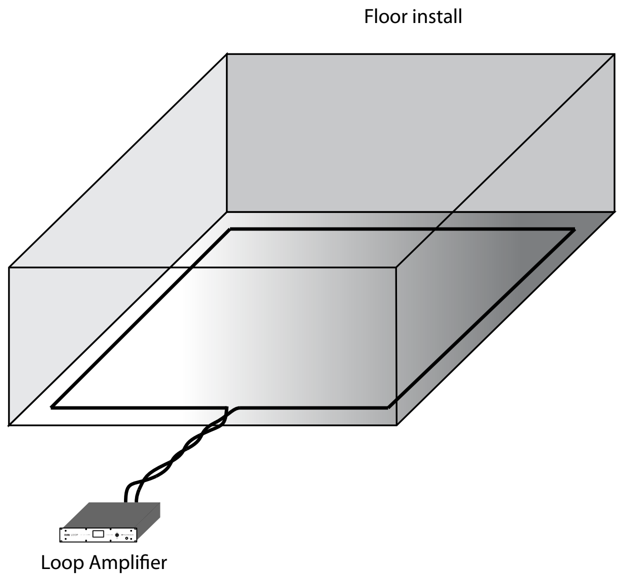
The loop should be installed below the user. As long as there is no metal that may interfere with the loop, it can be installed on top the floor, as well as under carpet, linoleum or tile. Installations can also be done within cement flooring, with special considerations. Installing the loop above the user should be avoided. The loop should never be installed at a user's height.

Metal Interference

Metal can affect the sound quality of the loop. Metal structures, such as reinforced concrete or rebar, must be considered when placing the loop. Metal loss is not always predictable, and a thorough site survey should be performed to ensure the loop will be efficiently placed. Different loop patterns, such as a phased array, may also help avoid metal interference. Contact Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com for advice on avoiding metal interference or performing a site survey.

Audio Leaks

Audio from a perimeter loop will e able to be detected a notable distance from above, below, and around the looped room. This can affect audio quality or other loops in surrounding rooms and hallways. For less audio leaks, a different pattern of loop should be used to contain the audio within a room.



Loop Displacement

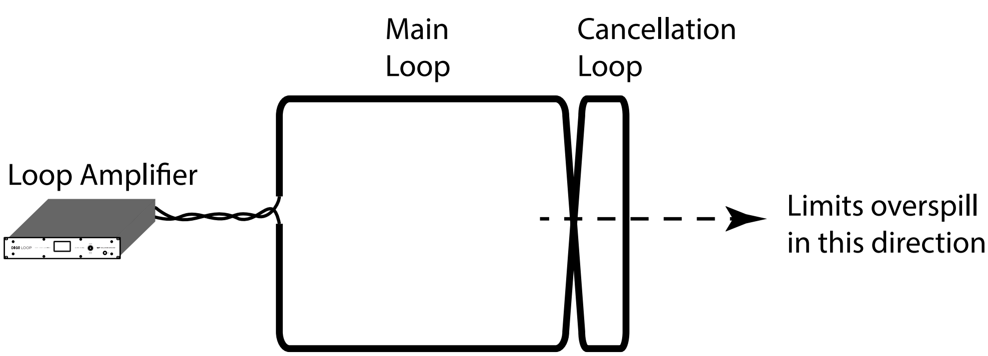
The distance between the loop height and the listening (hearing aid) height is called Loop Displacement. The loop should be placed between 8 to 25 % of the width of the room, usually 2 ft. (0.6 m) and 8 ft. (2.4 m) below head height (about 4 ft.[1.2 m]). The loop could be placed below the floor, ranging 1 ft. (0.3 m) to 4 ft. (1.2 m) beneath the flooring.

Cancellation loop design

Cancellation loops are a normal perimeter loop with a smaller loop at one end, making an uneven 'figure-8' at one end. These loops reduce loop audio leaks in one direction, which may be needed where there are adjacent rooms.

Sizing the smaller loop is not an exact science, and will require trying several different sizes or a computer simulation. Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com will help you to design a cancellation loop.

Figure 4: Cancellation Loop



Single array design

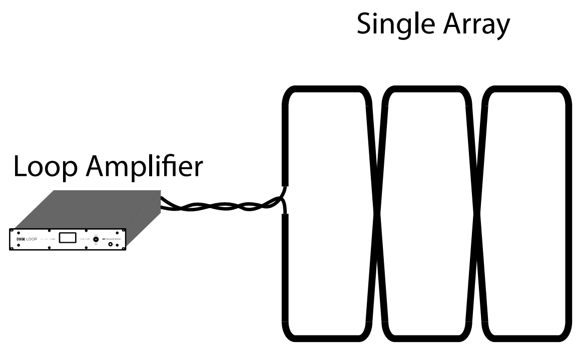
Single arrays are multiple smaller figure-8 shaped loops made from the same loop cable. In a single arrays, there must be

•Loop segments that are all the same width.

•A minimal amount of metal interference.

•Current flowing in the opposite directions to the adjacent loops.

Figure 5: Single Array



Phased array (low overspill) design

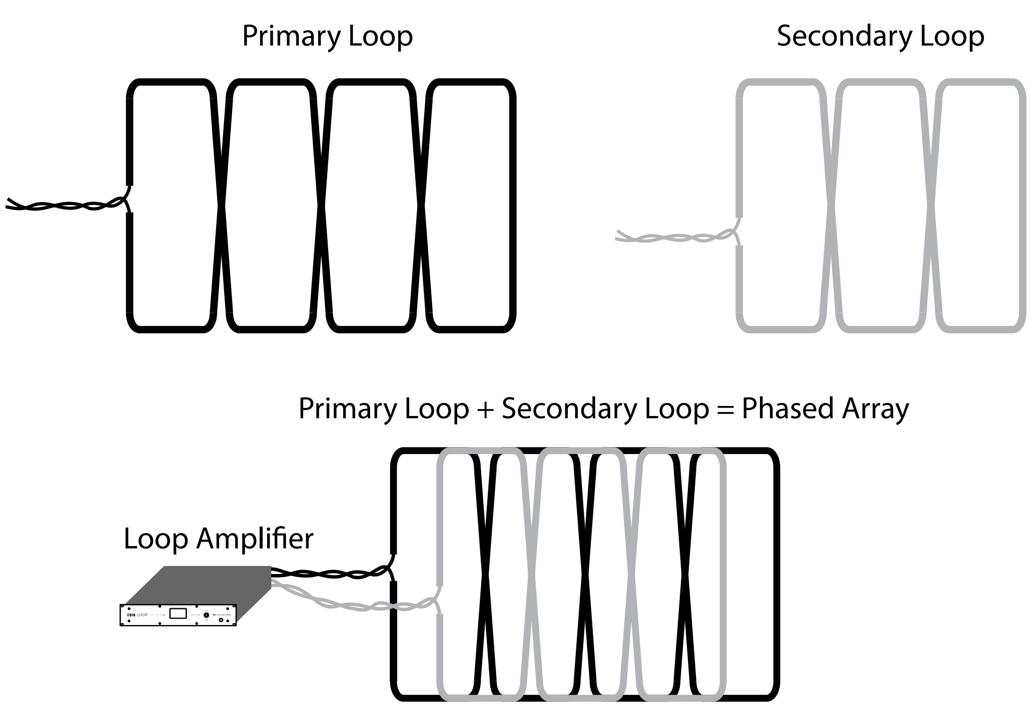
Low loss arrays are best used for an even audio reception across a large area, or in an area with metal interference, such as concrete over steel pan decking.

Two loops with several figure-8 shaped segments that are driven by two amplifiers. A phase shifter sets the amplifiers to be 90 degrees out of phase with one another. The first array has segments of equal size that are separated by a gap. The second array's equally-sized segments are placed in the gaps of the first array.

The length of the longest side of the room, and the desired width of the loop segments are needed to design a phased array. A 4 in. - 8 in. (10.2 - 20.3 cm) gap around the edge of a room is needed for proper quality. Segments can be between 6 ft. (1.8 m) to 12 ft. (3.7 m) wide, although metal interference can require that the segments be smaller.

Call Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com to assist with the design work.

Figure 6: Phased Array

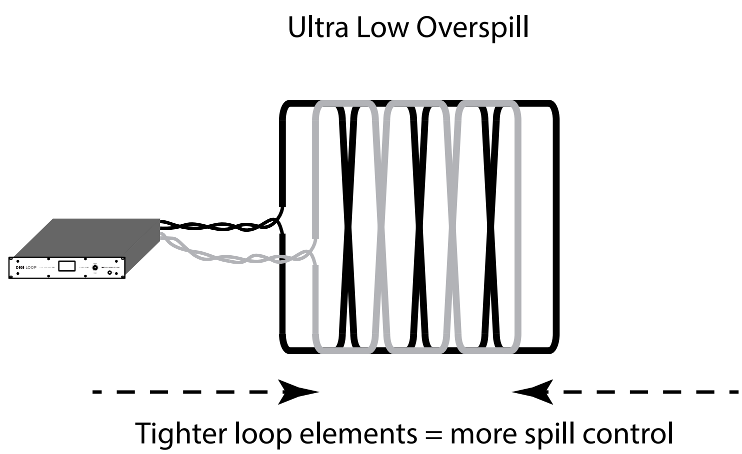


Ultra-low overspill loop design

Ultra low-spill arrays require thoughtful design. Audio leaks can be restricted to 5 ft. (1.5 m) of the loop edge, and 12 ft. (3.7 m) above and below with the proper design tools and experience. This still may not be sufficient for adjacent rooms or maintaining confidentiality.

You must provide dimensioned drawings and some basic information about the installation and Williams AV will return a fully marked up set of drawings (loop design) and comprehensive notes at no charge for our dealers, consultants and customers. Contact Williams AV TechBlue (technical support) at 800.328.6190 (ask for TechBlue) or techblue@williamsav.com for assistance with the design.

Figure 7: Ultra Low Overspill



Cable Choices and Selection

Length Limits

Determine the total length of cable that needs to be driven by the amplifier in your system. For an array system, use the longest of the two array cable lengths. This typically will be the Primary Loop.

Compare the length required against the maximum length for your Williams AV amplifier. For a maximum cable length to be used, the amplifier must be outputting close to its maximum current. Reference "Table 2: AWG Chart" on page 14.

If you need help optimizing your amplifier's output, contact Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com for a more accurate calculation of amplifier capability.

To select the proper wire for the loop(s), refer to the following chart. Wire resistance of each loop needs to be 0.5 - 1.5 Ω as required by the amplifier.

Table 2: AWG Chart

Wire type	**AWG** (CSA)	DCΩ **1000 ft** (305 m)	Max length (DL107/207/210) **Approx ft @ 3 Ω**	Min length (DL107/207/210) **Approx ft @ 3 Ω**
Single conductor	18 (0.82 mm^2)	6.4	468 (142.6 m)	78 (23.8 m)
	16 (1.3 mm^2)	4.2	720 (219.5 m)	120 (36.6 m)
	14 (1.9 mm^2)	2.4	1260 (210 m)	210 (64 m)
	12 (3.3 mm^2)	1.5	2000 (609.6 m)	333 (101.5 m)
	10 (5.26 mm^2)	1	3000 (914.4 m)	500 (152.4 m)
Flat 3/4" copper	~14 (1.9 mm^2)	2.4	1260 (210 m) *	210 (64 m) **

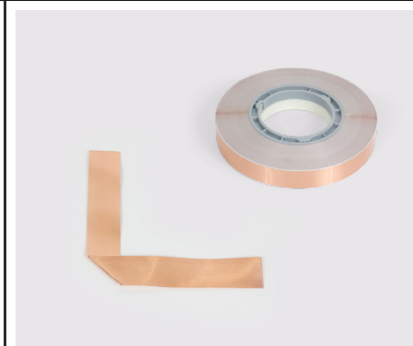
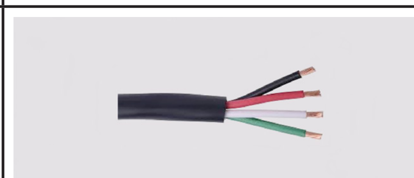
* Flat copper wire is more efficient than single conductor stranded wire at audio frequencies. This allows the maximum length to be greater than the length calculated using the DC resistance.

** In order to present a minimum resistance of 0.5 Ω to the amplifier, the DC resistance must be used.

Wire Options

Use this table to determine which type of wire suits your application.

Table 1: Wire Guide

Cable Type	Description	Image
Multi-strand single conductor	Multi-strand Single Conductor wire can be easily sourced from many wire distributors. This can be found in various gauges and colors dependent upon system needs. *Williams AV p/n: PLW 014; 14 ga. stranded wire*	
Flat wire	Flat Wire (or ribbon cable) from Williams AV is offered in ¾" width and is equivalent to 14-gauge wire. Flat wire can be installed under carpet or glued to the wall. See our installation videos for examples of flat-wire installation. When laying on a concrete floor, be sure the concrete is sealed before laying the flat-wire, as the alkaline in the concrete will eat into the wire. Flat wire can be secured using double sided tape, glue or flat-wire tape. *Williams AV p/n: PLW F300; 3/4 in x 300 ft spool (1.9 cm x 91.4 m)* *PLW F500; 3/4 in x 500 ft spool (1.9 cm x 152.4 m)*	
Direct burial cable	Direct Burial Cable (DBC) is required when burying cable in concrete, bitumen or soil. This type of wire will resist the heat effect of curing, as well as the caustic effect over time. DBC should be used even when scoring and laying into dry concrete because of the alkaline effect from the concrete over time. *Not provided by Williams AV. We recommend Belden p/n: 9438; 14 ga.* (1.9 mm^2) *stranded hook-up/lead - direct burial wire*	
Lead wire	Lead wire is the wire connecting the amplifier to the loop wire. Sometimes this lead wire is just an extension of the loop wire (unless using flat wire cable as pictured). If so, both leads should be twisted with about 1 twist per inch of cable from the amplifier to the loop. The twists will prevent the lead wire from creating additional EMI areas and cancellation. The resistance of the lead wire is also part of the wire load applied to the amplifier, so keep the lead length as short as possible. *This is a very common wire type and is easily sourced.*	
Other wire types	Two-conductor speaker wire can be utilized for a standard single loop install. For a Phased Array loop configuration, four conductor star wire can be used. This star wire has four color-coded wires tightly twisted together and sheathed. This can be soldered to flat wire or single strand at the loop. *This is a very common wire type and is easily sourced.*	

Cable Type	Description	Image
Williams AV flat wire tape	Use to secure and protect flat copper wire when installing a loop under carpet, wood floors or tile. The flat wire tape is applied over flat copper wire. *Williams AV p/n: FWT 001; 2 in x 180 ft roll (5 cm x 55 m)*	

Installation Considerations

Once the loop design has been completed, the loop wire installation should be carefully planned before proceeding. Here are some things that need to be considered pre-install, and will make the installation much smoother.

Experienced installers usually can find a suitable wiring path without much trouble. If it is not obvious where the cable can go, you should either contact Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com for advice, or start with these essential notes:

- The position of the loop cables will depend on the type of loop system being installed. Make sure you understand the loop layout. Some loop types, such as the ultra-low spill array, have tight tolerances around the element size and placement. Make sure these measurements are worked out before installing the loop wire. Many installers will mark the installation surface with these measurements prior to install, to (1) make sure the wire can be installed as the design calls for, and (2) guide them during installation.
- Loops should be positioned below the listening plane (the height of the receiving device or hearing aid). The loop must not be installed at the same height as the receiving device or hearing aid, as this causes massive fluctuations in signal loudness across the area of use. If there are loop receivers *and* hearing aids with t-coils being used, the range of *both* of these heights should be taken into consideration, and the loop wire cannot be placed within this range of heights. Ceiling installations are not recommended.
- It is possible for loop wire to be installed in basements, at floor level, around the wall at high level, in ceiling cavities, or even in the room above, depending on the factors involved (such as metal loss). Perimeter loops can *sometimes* be placed outside the building or room where the system is being used.
- Cables can often be placed behind or along decorative features such as baseboard trim, cove moldings, or columns.
- Cables can be placed under carpets, tile and other floor coverings. For this purpose, flat copper wire is available (Williams AV PLW F300 or PLW F500). For securing flat copper wire to the surface, consider using cloth-based flat wire tape, which also contains a warning about loop wire underneath (Williams AV FWT 001).
- Use Direct Burial Cable for cables buried in concrete, in the ground outside, or underneath the building. Standard cable will degrade over time.
- The dimensions for low audio leak systems is important – Measurements as specific as 2 in. (5 cm) can be required, be sure you understand how precise your measurements need to be before installing a loop.
- Loop cables can get damaged by drilling or cutting during work on the floor, such as when installing carpet. Cables should always be clearly marked with labeled tape, such as Williams AV FWT 001.
- Heat, tears or any wetness could damage the loop when installed; try to prevent any environmental factors from interfering with your loop during and after installation. This is especially a risk with unsealed concrete. If there is any moisture present, unsealed concrete can destroy flat copper wiring. When installing copper tape on top of concrete, the surface should sealed by painting the concrete with a suitable sealant prior to installation. Alternatively, use Direct Burial Cable which is resistant to alkaline. When installing Direct Burial Cable, slots are usually cut into the concrete with a concrete saw.
- Ensure the loop is installed and secured so it s not a trip hazard or other safety issue.
- Loop wire should not be run parallel to other wire. If a loop is located near any voice or data cables, the cords should be kept at least 24 in (61 cm) away to meet current wiring standards in the UK (although this is also recommended in other locations). If loop wire must

cross other wires, keep it as far away as possible and always cross at 90 degrees.

- Always keep the loop plane constant. Never install wire over a doorway or window, or change direction in a way that is inconsistent with the loop design.
- If the loop needs to be installed over steps, or if you have other installation concerns, please contact Williams AV TechBlue (technical support) at 800.328.6190 (Ask for TechBlue) or techblue@williamsav.com for assistance.

Field Strength Meter

There are three purposes for a field strength meter.

1. Site Survey. During the site survey, it is used for measuring EMI background noise and checking the performance of the test loop.

2. Calibration. During the calibration phase, the field strength meter is used to calibrate the amplifier to the loop, and to check the performance of the system with a live source running.

3. Maintenance/Checking. Periodically the system should be checked with a field strength meter to verify that the performance of the system is (a) within specifications and (b) within calibration.

Tone Generator

The tone generator inside the entire Williams AV Digi-Loop amplifier series can be used for the site survey and to set levels on the test loop and test performance.

The tone generator must be used for the calibration and commissioning phase of the loop system using a Williams AV Digi-Loop amplifier. An external test tone generator should not be used to calibrate the amplifier. Calibration must be performed with the amplifier's internal test tone generator.

Testing and Maintaining Induction Loop Systems

Site Survey, Commissioning, Regular System Checks, and Auditing are an integral part of achieving and maintaining compliant loop systems that provide a genuine benefit to the user.

Site Survey

A Site Survey - including testing for electromagnetic background noise (EMI) and any metal used in a building's construction - should be performed prior to the specification of any induction loop system. If present, both these factors will have an effect on loop design, amplifier selection and occasionally will determine if the project is even feasible. We recommend laying a figure-8 test loop in the area, (or multiple figure-8 loops for a larger venue) and evaluate it's performance.

Commissioning

All induction loops should be commissioned after installation to ensure that they comply with the IEC 60118-4 standard for performance. This task is often performed by the installer; however, consultants and/or engineers may be required on complex projects.

The commissioning procedure is designed to identify and rectify any faults in a system and provide the opportunity to address them. When the system is tested and meets IEC standard, the commissioning installer completes and presents an Induction Loop Certification Form to the facility owner/manager. The Induction Loop Certification Form is available on the Williams AV website.

Always use a field strength meter to verify loop system operation. Use a loop receiver with the actual audio source that will be used to verify the quality of the audio delivered through the loop.

Regular System Checks

An induction loop system is invisible and inaudible to anyone without a hearing aid; therefore, system faults can go unnoticed if they are not reported by a hard-of-hearing user.

Hard-of-Hearing users may find communication difficult and will simply choose to leave. So, it is essential that facility managers or colleagues perform regular simple checks to ensure that the system is operating correctly.

Circumstance-based testing

Testing an induction loop system may become necessary for many reasons, including: damage to the loop cable, unwanted adjustments to the amplifier settings, amplifier malfunction or simply because a fault has been reported by a hard-of-hearing user.

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