



Designing Induction Loops

AMPETRONIC

Listen to the difference

Email support@ampetronic.co
Phone +44 (0) 1636 610062
Web www.ampetronic.co

Ampetronic Limited

DOCUMENT UP60001-13

Legal Disclaimer

The information contained within this document is solely advisory, and should not be substituted for legal, financial or other professional advice. Any and all decisions and actions must be done through the advice and counsel of a qualified engineer or other professional. We cannot be held responsible for actions you may take without proper advice. You should not rely on this information as absolute.

You are responsible for understanding the information. You should not rely on this information as absolute. If you do act upon the suggestions contained in this document, you are responsible for yourself and your actions. If you rely on the information on these pages, you are responsible for ensuring by independent verification its accuracy or completeness.

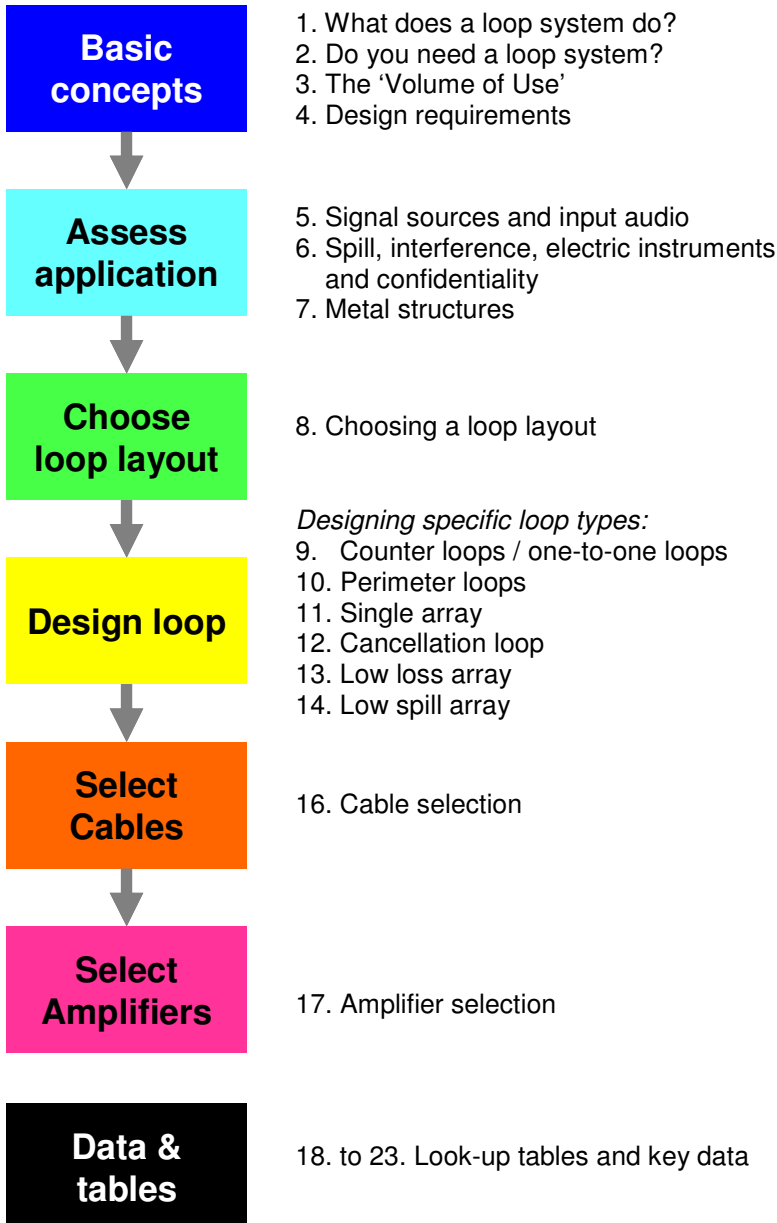
Ampetronic Limited makes no warranties, either expressed or implied, of merchantability or fitness for a particular purpose. This document is published solely on an "as is" basis. The entire risk as to its quality, performance, or applicability is with you. If you rely on the information on these pages, you are responsible for ensuring by independent verification its accuracy or completeness.

Should the information in this document prove to be false, misleading, or in contravention to law, statute, or regulation, you, and not Ampetronic Limited, assume all risks. Ampetronic Limited will not be liable for direct, indirect (including, but not limited to any loss of business or anticipatory profits), incidental, or consequential damages resulting from your reliance on the information contained herein, even if the information was false, misleading, or in contravention to law, statute, or regulation, and even if Ampetronic Limited has been advised of the possibility of such.

The information contained in these pages does not constitute legal advice. No claims, promises or guarantees about the accuracy, completeness, or adequacy of the information contained in these pages are made. As legal advice must be tailored to the specific circumstances of each case, and laws are constantly changing, nothing provided herein should be used as a substitute for the advice of competent counsel. You are encouraged to show this document to your legal advisor so that s/he can make adjustments to the document, as necessary, before implementing it or using it.

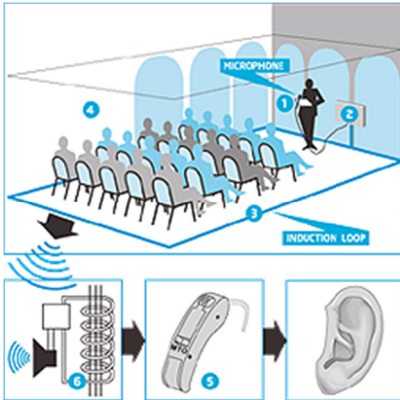
Designing a loop system

This booklet will take you through the process of designing an induction loop system, following these 6 stages:



1 What does a loop system do?

Loop systems take an audio signal and transmit it as a magnetic field into a space where hearing aids can receive the signal and convert it back to high quality audio. The simplest form of loop is a perimeter loop, shown in this diagram to illustrate how a loop system works:



Audio Inputs **1**, either from an existing audio source such as a P.A. system or from dedicated microphone inputs feed an audio signal into an Induction Loop Amplifier **2**. The amplifier drives a current into a Loop **3** or series of loops. As the current flows through the cable it creates a Magnetic Field **4** in the required area – careful loop and amplifier design ensures that the vertical component of the field is even and free of weak or dead zones wherever the user might be. Inside most Hearing Aids **5**, a small coil known as a Telecoil **6** picks up the magnetic field signal, which is amplified into a high quality audio signal delivered directly to the ear of the hearing aid user.

2 Do you need a loop system?

Loop systems are the most effective and least discriminatory form of assistive listening. An effective assistive listening system will dramatically improve the separation of signal (e.g. speech) from background noise for a hearing aid user. For a system to be useful and effective the following must be true:

- **There is reverberation or background noise**

In most situations there is sufficient background to affect the hearing aid user. Occasionally a loop will not be necessary e.g. in small closed interview rooms with low reverberation.

- **There is access to the required audio input**

To improve signal to noise separation, the system must amplify the signal not the background noise! Therefore the loop system needs an input from an existing audio system, or from dedicated microphones that are designed to pick up the required signal and *not* the background noise. An omni-directional microphone on the ceiling of a meeting room will amplify everything and yield little or no benefit!

3 The ‘Volume of Use’

The loop must create the right magnetic field strength and frequency response in the volume that the users’ hearing aids will be located in use. We call this the **volume of use**, and it is important to determine what this needs to be by asking the following questions:

- **What is the range of heights?**

The following table gives typical values for the height of a hearing aid above floor level. The height of the hearing aid is often referred to as the **listening plane**.

	<i>Adults</i>	<i>Children</i>
<i>Normally standing</i>	1.4 to 1.7m (4’7” to 5’7”)	1.2 to 1.5m (3’11” to 5’11”)
<i>Normally seated / wheelchair user</i>	1.2 to 1.4m (3’11” to 4’7”)	0.9 to 1.2m (2’11” to 3’11”)

- **Are users on fixed seating, or can their positions move?**

If users or seating can move, the field must be of consistent strength across all the potential areas of movement to avoid disturbing changes in volume and frequency response. No ‘nulls’, low spots or peaks can be allowed in this volume.

If users are in fixed seating their location is well known then more variation may be acceptable as long as the areas of use (i.e. over the seating areas) are consistent. For example it may be acceptable to have dips in the signal level in the gaps between fixed seating areas or rows.

- **Where is the system actually required to be used?**

Not all areas in a room actually need coverage from a loop system. The loop is only required to meet requirements in the areas where listening is required. It is important to consider which areas are necessary and which are not. For example in many churches or theatres there are large areas that are *not* used except to pass through on entry or exit. Do these areas need coverage?

4 Design requirements

The loop system must meet performance requirements in the defined **volume of use** (see section 3). Requirements are set by the international standard for loop systems IEC60118-4. Meeting these requirements is usually essential to ensure that the system provides a benefit. There are 3 key requirements:

- **Field strength = 400mA/m \pm 3dB**

Magnetic field strength must be 400mA/m \pm 3dB across the volume of use. This is the reading with 125ms RMS measurement with a 1kHz sine wave applied to the system.

The variation over the loop is affected by height, presence of metal structures, relative position within the loop area etc.

- **Frequency response = \pm 3dB from 100Hz to 5kHz ref. 1kHz**

The total variation in signal across the frequency band 100Hz to 5kHz must be within 3dB of the strength at 1kHz at any point within the volume of use. The frequencies between 2 and 5kHz are vital for intelligibility - good response at these frequencies is essential.

Poor quality systems, wrongly specified amplifiers and metal structures are the main causes of poor frequency response.

- **Background noise = $<$ -32dB ref. 400mA/m**

With all inputs to the loop system turned off, magnetic noise (measured with an A-weight filter) should be $<$ -32dB or better relative to 400mA/m. High quality systems should aim for $<$ -47dB. In exceptional circumstances where use periods are short and for speech only, up to -22dB may be acceptable.

Noise is often a characteristic of the environment rather than the loop system, so background noise can and should be measured before a system is designed or installed and with all lighting and audio visual systems in operation.

Don't cut corners!

While loop systems exist that do not properly meet these requirements, such systems often do not help the hearing aid user and therefore may not fulfil legislative requirements for disability access. To ensure that a loop system provides a genuine benefit to the hard-of-hearing, it must comply with the requirements of IEC60118-4.

5 Signal sources and input audio

The loop system requires an audio input or multiple inputs. To ensure good intelligibility as required for a useful system, the signal fed into the loop must be very clear, and without background noise, reverberation or similar. You must decide what the input needs to be:

Type of audio signal / input

Typical input requirements

Existing audio system

Often the best input choice is from an existing audio system.

Check that the input signal is from suitable sources, i.e. designed to pick up intended speech / signal and eliminate background noise.

Fixed talker

E.g. a ticket counter where the speech source is from one place.

Requires a directional microphone to pick up the speech only.

Moving talker

E.g. classroom, conference hall.

Typically requires a radio microphone or dedicated mobile microphone.

Multiple talkers, fixed locations

E.g. 'Round table' meeting room

Conference microphone system with directional boundary microphones on the table. Auto-mixing may provide additional improvement in signal to noise separation.

Multiple conversations in one space, moving

E.g. social event

This scenario does not benefit from an assistive listening system unless a means can be found to take audio from only the single source required to feed the loop. The hearing aid microphone is usually the best solution.

Electrical instruments or dynamic microphones

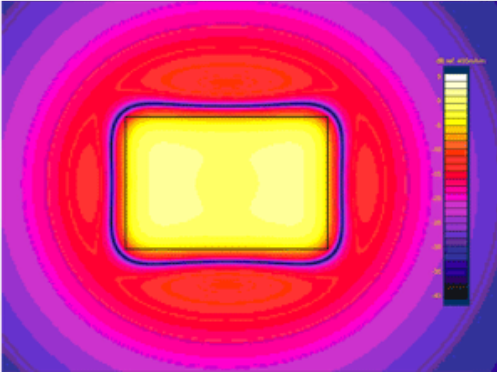
E.g. Live music on a performance stage

Magnetic pickup devices such as electric guitars and low quality dynamic microphones can pick-up the loop signal and potentially cause feedback. In addition to appropriate loop design to attenuate the magnetic field, signal processing techniques may be needed to prevent feedback.

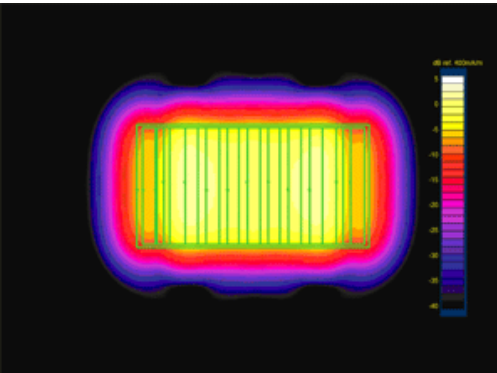
Check what input sources are going to be used and compare to the amplifier inputs (see section 19). If input levels or formats are not compatible with the amplifier inputs, consider using input adaptors (ATT or MAT series) or pre-amplifiers (MP series). Details available at www.ampetronic.co.

6 Spill, interference and confidentiality

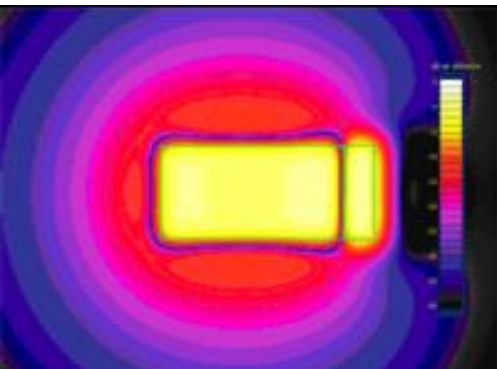
Views of the magnetic field from above a rectangular loop system:



Perimeter loops spill signal outside the loop (black is 'silent')



Low spill arrays contain signal to within 1.5m of the loop (black is 'silent')



Cancellation loop can limit signal spill in a single direction (black is 'silent')

Loop systems radiate a magnetic field beyond the perimeter of the loop itself. Simple perimeter loops will radiate a field sufficient to be detected by a hearing aid up to 4 times the loop width away from the side of the loop and above and below the loop!

Spill control is also vital to prevent the magnetic field generated by the loop from causing interference to electric guitars, low quality dynamic microphones and some other electrical equipment, or vice-versa.

If your venue includes a performance stage or is used for live music, spill control will be required to isolate an area by using either a cancellation loop or Low Spill design. We need to ask:

- **Is there another loop system to the side, above or below the proposed loop area within 4x the width of the largest loop?**
- **Is there a need to restrict the spill of the loop for confidentiality?**
- **Is there an area or stage within or close to the looped area where electric instruments are used?**

If either answer is yes, spill control will be required and a simple perimeter loop *will not be sufficient*.

Spill control is usually achieved through **low spill phased arrays** which use a series of smaller loops to dramatically reduce the spill from the loop. With a good low-spill system, spill can be reduced to 1.5m from the loop edge and 3.5m above and below the loop plane. See sections 13 and 14.

7 Metal structures

- **Metal structures can profoundly affect loop performance**
- **Metal structures are found in nearly all modern buildings**
- **Effects of metal can usually be overcome, but cannot be ignored!**

The magnetic field generated by an induction loop system induces a current in any closed path of a metal structure near to the induction loop with two effects, reduced signal and frequency dependant loss:

Reduced signal

Induced currents take energy from the loop and weaken the magnetic field. Loss increases with distance from the loop cable so the field often becomes highly variable and fails to meet basic requirements. Simply providing more power will not help, the variability remains.

In the presence of metal reducing the maximum loop width reduces the variation experienced in the loop. Section 17 shows maximum allowable loop widths for different scenarios. To cover large areas an array is required to eliminate high variability. In all cases a loop system requires substantially more power in the presence of metal.

Frequency dependent loss



Loss due to metal is greater at higher frequencies. Without compensation the signal will sound muffled, providing poor intelligibility and not meeting standards. Most Ampetronic amplifiers have a Metal Loss Corrector (MLC) which pivots frequency response around 1kHz, up to 3dB per octave correction to obtain flat frequency response in the presence of metal.

Losses are very dependent on the type and thickness of metal and its position in relation to the loop. We can make estimates based on our experience as shown in section 17, however the best way to predict loss is a full SITE SURVEY. Contact Ampetronic support if you would like assistance or advice on conducting a site survey.

What is a Metal Structure?

Floor loops will be affected by:

- Mesh reinforced concrete
- Concrete slab on steel deck
- Metal system floor
- Steel frame construction

Ceiling loops will be affected by:

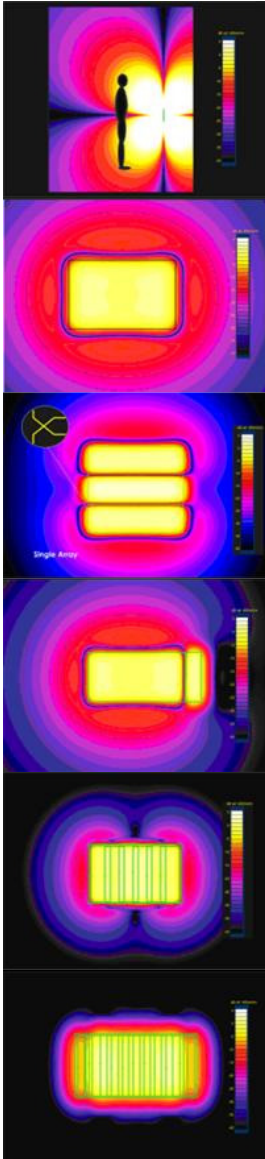
- Suspended ceiling grid
- Mesh suspended ceiling tiles
- Mesh or metal sheet reinforcement for slab above
- Steel frame construction

Heating pipes, metal windows, furniture, electrically isolated reinforcing bars and vertical girders etc. will not typically have any effect on loop systems.

8 Choosing a loop layout

There are 6 basic types of loop layout for an audio induction loop system, detailed in the following sections.

Field Pattern



Loop type and applications

Counter loop / one-to-one systems (section 9)

For counters, reception desks, ticket counters and other one-to-one communications.

- Simple loop coil, usually vertically mounted

Perimeter loop (section 10)

For rooms up to 20-25m wide with *no metal present*, or rooms 2-5m wide with metal present. Usually only possible for smaller rooms in modern buildings.

- Simple loop of wire around room / area perimeter.

Single array (section 11)

Rooms where a perimeter loop is not possible, usually due to metal losses. Only suitable for fixed seating applications.

- Single loop laid as individual consecutive segments

Cancellation loop (section 12)

For controlling spill in one direction only, for back to back rooms or performance stages to prevent interference.

- Single loop with carefully designed 'figure of 8'

Low loss phased array (section 13)

For areas where a perimeter loop is not possible. Any area >20-25m wide, or rooms with metal loss. Provides limited spill control.

- Two loop patterns overlaid, 90 degree phase shift

Low spill phased array (section 14)

For true control of loop spill to 1.5m from loop edge, 3.5m above and below. For confidentiality and for adjacent loop systems. Excellent for metal loss.

- Two loop patterns overlaid, 90 degree phase shift

9 Counter loop / one-to-one systems

9.1 Loop design

There are two types of loop that can be used for this kind of application:

(1) Small floor or ceiling mounted loop

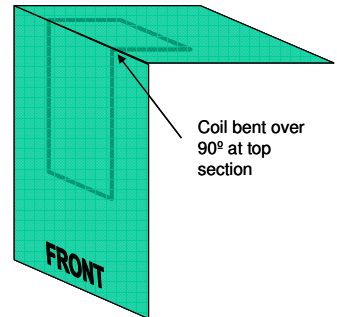
Typically 1.5 x 1.5m square loop coil (4 turns) of 1.0mm cable, mounted in the floor or between 2.5 and 3.0m above floor level in a ceiling void. Provides excellent performance. Avoid if floor is metal or heavily reinforced concrete, or if ceiling void is a suspended steel frame.

(2) Loop pad / preformed loop coil

The coil must be placed near to the listener, ideally 20- 50cm from the listeners position.

Preformed multi-turn loop approximately 350mm square (supplied with CLD1 as standard). Mount on VERTICAL surface as high as possible below desk / counter height. Horizontal gives poor performance!!!

Loop coil can be bent at top to put top cable under top surface of desk (see picture). If the front panel is made of metal and the top is wood, this arrangement is required. If both counter top and front are metal, a counter loop may not work at all – test performance before install.



9.2 Current calculation

The following amplifiers will all provide the required power and current:

CLD1	Compact, 1 mic + 1 mic / line unbalanced inputs. External 'wall cube' power supply or 12V DC input.
CLD1AC	As CLD1 with internal power supply.
CLS1	Wall mountable tamper resistant perimeter/small area driver.
HLS-2B	Industrial specification unit design for elevators (lifts). <i>REQUIRES SPECIAL LOOP SOLUTIONS, SEE DATASHEET ON www.ampetronic.co</i>
HLS02	Open unit for integration into other enclosures or for OEM use.
DLS	Compact system designed for office or home use

More detailed information on counter loops is available from Ampetronic.

10 Perimeter loops

10.1 Perimeter loop design

A perimeter loop consists of a cable laid around the perimeter of the area to be used. There are several considerations in designing a perimeter loop:

(1) Metal structures

The maximum width of a perimeter loop is restricted by the presence of metal structures. The maximum width recommended is shown in the table in section 17. If your room exceeds the maximum recommended width you should consider a low loss array, or contact Ampetronic for advice.

These figures are very approximate! Without a detailed site survey it is advisable to leave a 'safety margin' when calculating the power required. Metal losses are often a very significant factor in specifying a loop system, and are not always predictable.

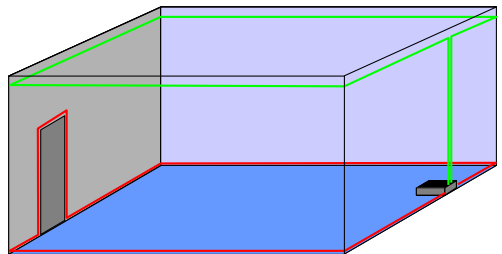
(2) Loop spill

Perimeter loops will spill audibly up to 4x the loop width to the side, above and below. If this is not acceptable then use a low loss or low spill array depending on the level of control required.

(3) Loop location

The loop location must be determined based on the nature of the building. The loop can be installed:

- **above** the user (around a wall or in the ceiling)
- **below** the user (on the floor or in a basement)
- **never** install a loop at head height!!!



See the detailed notes in section 15 for further guidance.

Loop displacement – the distance between the loop height and the listening (hearing aid) height – typically between 8 and 25% of the loop width for normal perimeter loops, or up to 50% for smaller room systems.

*Example – 10x15m room. Room **width** is the smaller dimension = 10m. Listening height is 1.2m. Loop displacement typically 8 to 25% of the room width, 0.8 to 2.5m. Loop should be mounted between 0.8 and 2.5m from head height (1.2m) either above or below floor level - from 0.4 to 1.3m below the floor or from 2.0 to 3.7m above.*

10.2 Perimeter loop current

Calculate current as follows:

(1) Calculate base current

Determine the **loop width**. Loop width is the shortest side of a rectangular loop, or the average width for an irregular loop shape.

Determine the **aspect ratio**. Aspect ratio is the loop width divided by the loop length, and is always less than or equal to 1.0.

Use graph 1 (section 0) to find **base current** for the aspect ratio and loop width of your loop.

(2) Adjust for displacement

Determine “% Displacement”

“% Displacement” is the distance from loop to listener, expressed as a percentage of loop width. It is calculated using the following formula:

$$\% \text{ Displacement} = \frac{\text{Loop Height} - \text{Listening Height}}{\text{Loop Width}} \times 100$$

The resulting % Displacement will typically be between 8% and 50%. This percentage is converted into a current multiplier using Graph 2 (Section 21).

(3) Adjust for metal

The **metal adjustment factor** is shown in the table in section 17. The factor assumes that the loop width does not exceed the maximum recommended widths shown in the same table.

(4) Adjust and leave headroom if possible

$$\text{Required Current} = \text{Base Current} \times \text{Loop displacement adjustment} \times \text{Metal adjustment factor}$$

You have now identified the current required. It is good practice to leave some safety margin when choosing an amplifier, especially if there are metal structures present, unless you have conducted a full site survey in advance.

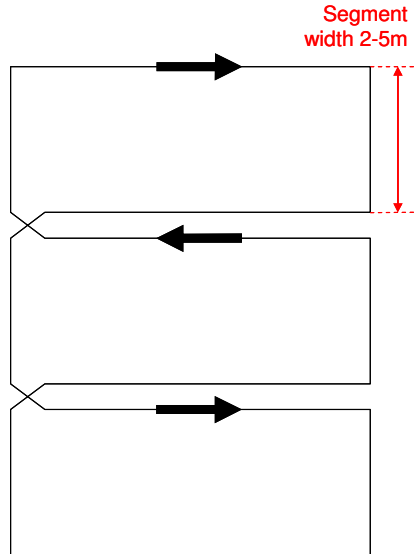
Now go to section 15 to select a cable.

11 Single arrays

11.1 Single array design

A single array is a series of loops or 'segments' laid from the same single loop cable. Single arrays must follow a few basic rules:

- Loop segments must all be the same width
- In the presence of metal, each segment width should be 2 – 5m depending on degree of loss – see table in section 17.
- Loop segments must be laid as 'figure-8s' so each one has current flowing in the *opposite directions* to the adjacent loops (see diagram)



Between loop segments there will be a null – a zone with no field strength. This is only acceptable if it is known that the users will not pass through this area during use. Typically a single array can only be used with fixed seating arrangements.

11.2 Single array current

Determining current, cable and amplifier for a single array is similar to perimeter loop design in section 10.2.

Follow section 10.2 and use the width of *one* loop segment instead of the whole loop area for current calculation. When current is calculated, *reduce* the calculated current by 2.5dB, equivalent to reducing the current required by 25%. (Single arrays require a little less current as each segment adds some field strength to the areas within adjoining segments).

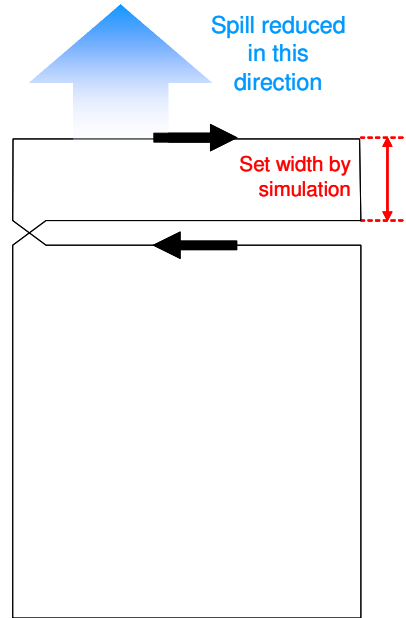
Continue to determine cables and amplifiers following the process in 10.2.

12 Cancellation loops

12.1 Cancellation loop design

A cancellation loop is a special version of a single array, being a normal perimeter loop with an additional coil laid as a 'figure-8' at one end. Designed correctly the cancellation loop will dramatically reduce loop spill in *one direction only* which can be very useful for back to back rooms.

The width of the end coil is critical and can only be achieved by trial and error or by simulation. Ampetronic will help you to design a cancellation loop if required.

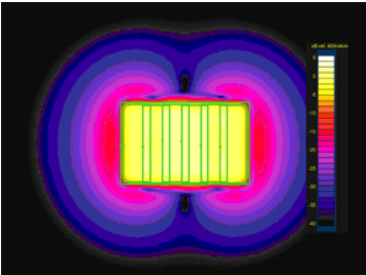


12.2 Cancellation loop current

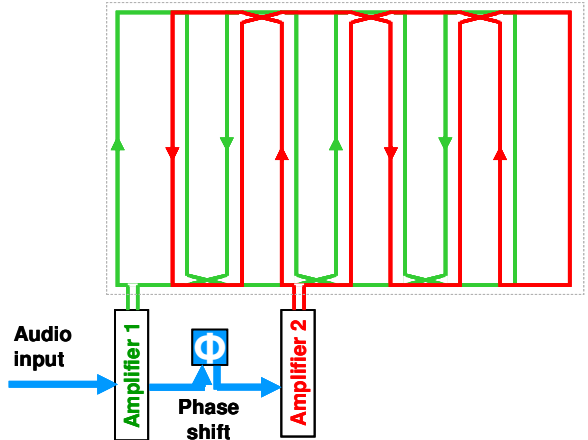
Current requirement is calculated in the same way as for a perimeter loop in section 10.2. The calculation is made using the dimensions of the larger loop area, with the width being the shorter of the two dimensions.

13 Low loss arrays (basic spill control)

Low loss arrays will give a very flat and even field across a large area, or an area with metal losses such as a reinforced concrete floor.



Typical low-loss array field pattern



Low loss arrays consist of two multi-segment loops driven by two amplifiers. The amplifiers are connected by a phase shifter that makes them 90 degrees out of phase with each other.

Each array is made from segments of equal size, separated by a gap. The second array is offset from the position of the first.

13.1 Low loss array design

Here we set out a procedure to design low-loss arrays for rectangular rooms. To design the array, all you need to know are room length and the preferred width of loop segment in the array. *Please remember that Ampetronic can do this design work for you if this is too involved for you!*

Room length: The longest side of the rectangular or near-rectangular room. Leave some room for installation, typically a gap of 100-200mm around the edge of a room.

Preferred segment width: An array can be made of loop segments down to just under 2m wide and as wide as 5m. The more metal loss in the installation the smaller the width should be – consult the table in section 17 to see *maximum* widths. The choice of preferred width may also be affected by installation considerations, for example the location of fixed seating rows.

If your area or room is approximately rectangular you can still calculate the array by this procedure, and then adjust the shapes of individual loop segments to fit the room. If the room is very irregular then you should ask Ampetronic for assistance.

Design loop – Low loss (2)

Calculations

L = Room Length (longest side of the room) leaving gap around edge of room if necessary e.g. 100-200mm gap

W_P = Preferred segment width

X = L / W_P

Compare X to α in the table on the right and find the closest match. For this value of α , write down α , **N₁** and **N₂** from the table.

Calculate or write down the following 5 numbers:

Number of segments in array 1 **N₁ = From table**

Number of segments in array 2 **N₂ = From table**

Actual segment width **W_A = L / α**

Segment pitch **P = 1.6 x W_A**

Second array offset **S = P / 2**

Values can be adjusted by +/-0.1m or more to fit the specific installation.

α	N₁	N₂
2.6	2	1
3.4	2	2
4.2	3	2
5	3	3
5.8	4	3
6.6	4	4
7.4	5	4
8.2	5	5
9	6	5
9.8	6	6
10.6	7	6
11.4	7	7
12.2	8	7
13	8	8
13.8	9	8
14.6	9	9
15.4	10	9
16.2	10	10
17	11	10
17.8	11	11
18.6	12	11
19.4	12	12
20.2	13	12
20.2	13	12

Example

Room 18 x 15 m

Reinforced concrete floor

Room length **L** = **18 m**

Preferred loop width **W_P** = **3.0 m**

$X = L / W_P$ **X** = **6.0 m**

Closest α from table **α** = **5.8**

Array 1 segments **N₁** = **4**

Array 2 segments **N₂** = **3**

Actual segment width **W_A = 18 / 5.8** = **3.1 m**

Segment pitch **P = 1.6 * 3.1** = **5.0 m**

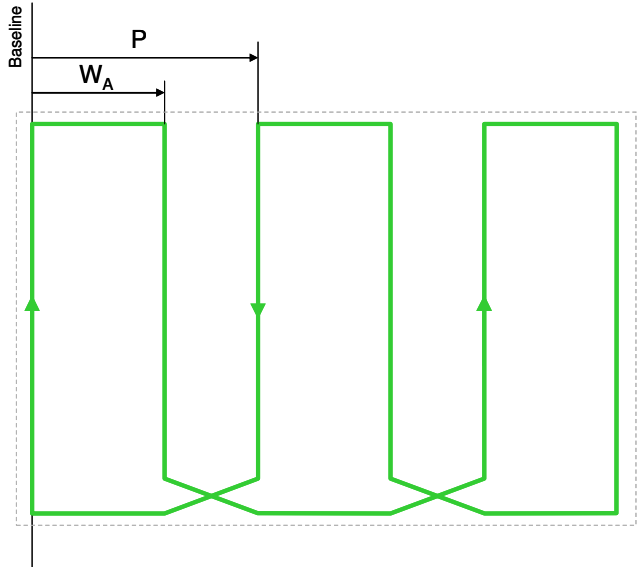
Second array offset **S = 5.0 / 2** = **2.5 m**

First array layout

Choose a **baseline** along one of the short ends of the area to be covered (it is easiest to make this nearest to the amplifier location). Measure and mark out the shape of the first array as shown. (Shown in green in the example diagram).

The first array has N_1 loops, each of them W_A wide, at an interval of P .

The direction of the current in each segment should alternate, so each segment runs in the opposite direction from the previous one. Take care when laying the cable or tape that the directions alternate or the array will not work!

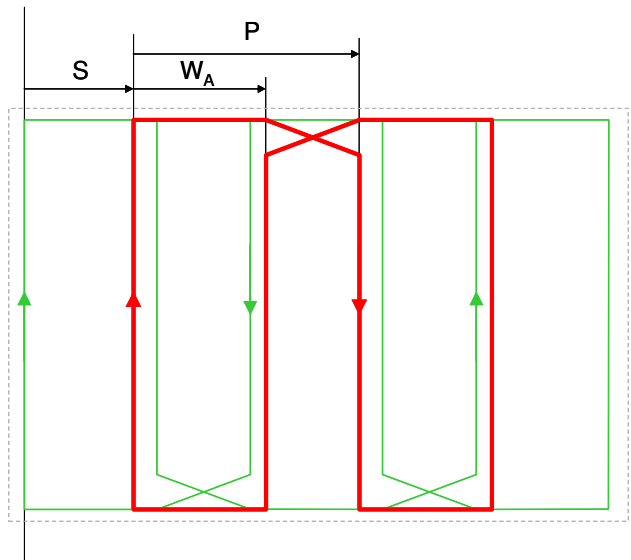


Second array layout

Measure and mark out the second array over the top of the first array (shown in red in the example diagram).

The baseline for the second array is offset by S as shown in the diagram.

The array is very similar to the first array, with N_2 loops, each of them W_A wide, at an interval of P .



13.2 Low loss array current

Array currents are calculated with a simple process as follows. This is only valid if the loop displacement (distance between the listening plane and the loop plane) is approximately 1.2m or less. If displacement is much greater than 1.2m, contact Ampetronic for assistance.

(1) Determine array current

Determine the **loop width**, the width of a segment - recommended segment width is found from the table in section 17.

Determine the **loop displacement** which is the vertical distance from the listening plane to the loop plane in metres.

Array current is determined from the graph in section 1.

(2) Adjust for metal

Check the metal adjustment factor in the table in section 17.

(3) Adjust and leave headroom if possible

Adjust the current required with the following formula.

$$\text{Required Current} = \text{Base Current} \times \text{Metal adjustment factor}$$

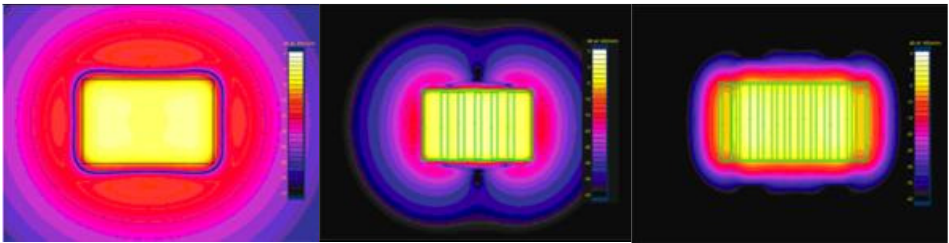
You have now identified the current required. It is good practice to leave some safety margin when choosing an amplifier, especially if there are metal structures present, unless you have conducted a full site survey in advance.

Now go to section 15 to select a cable.

14 Low spill phased arrays

Ampetronic specialise in 'low spill' systems. True low spill arrays* require much more careful precision design than the low-loss arrays shown above. With simulation and experience it is possible to restrict spill to within 1.5m of the loop edge, and 3.5m above and below.

How do the different types of loop compare? These three plots show a similar size loop system in three configurations. Black is inaudible, effectively silent. Yellow areas are full field strength (400mA/m). The plots are a view from above and show how far the signal will typically spill.



Perimeter loop

Spill up to 4x loop width

Low-loss array

Spill to 1x loop width

Ultra-low spill array

Spill as low as 1.5m from loop edge

Ultra-low spill requires analytical design tools and a great deal of experience to get right. If you require very good spill control for adjacent rooms or confidentiality, Ampetronic can design this for you. You must provide dimensioned drawings and some basic information about the installation and Ampetronic will return a fully marked up set of drawings and comprehensive notes for a nominal design charge.

**Note – most other induction loop companies will refer to 'low spill' as a single array or a low-loss array as shown in this document in sections 11 and 13. This level of spill control is certainly better than a perimeter loop, but is not sufficient for adjacent rooms or any level of confidentiality. True low spill requires a different design approach.*


15 Cable selection and installation

Choose a cable once your loop layout has been designed using the notes below and the selection table in section 18.

Cable options

There are three cable options, in order of increasing cost:

Tri-rated copper cable	Suitable for running along skirting boards, inside conduit, ceiling cavities or behind cosmetic features. Gauges typically used: 0.5, 0.75, 1.0, 2.5, 4.0mm ² .
Copper foil tape FC1.8	Very flat tape designed for running underneath floor coverings e.g. carpet. Very low impedance is ideal for long cable runs and gets more from the amplifier.
Direct burial cable (DBC)	Specialist cable resistant to degradation from concrete, suitable for direct burial in screed, underground and outside use.



The length limit of the available amplifiers

Determine the total length of cable that needs to be driven by one amplifier in your system. For an array system use the longest of the two array cable lengths. Compare length required against the maximum lengths that can be driven by each amplifier in the tables in section 18.

Maximum cable lengths assume that the amplifier is running close to maximum current. If you are using the amplifier at a current well below it's maximum then the amplifier will be able to drive longer cable runs. Contact Ampetronic for a more accurate calculation of amplifier capability if this is the case for your application.

If no amplifier can drive the cable length you require, contact Ampetronic support (support@ampetronic.co) and we can help you to find a suitable solution.

Installation practicalities

Have you considered the practical issues of installing cable? If it is not obvious where the cable can go you should either contact Ampetronic support for advice or start with these essential notes:

- The approximate position of the loop cables will depend on the type of loop system that you are installing – make sure you understand what loop layout you would like first.
- Loops can be positioned either below or above the listening plane (the height of the hearing aid). The loop must not be fitted at the same height as the hearing aid as this causes massive fluctuations in signal loudness across the width of the area.
- Loops can be placed in basements, at floor level, around the wall at high level or in ceiling cavities, or even in the room above. 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 architraves and coving, or architectural features such as galleries
- Cables can be placed behind wooden panelling, or under carpets etc. Flat copper tape is available (FC1.8) for discrete placement under floor coverings or similar.
- Cables can be buried in concrete screed, or buried in the ground outside or under the building – use DBC Cable for Direct Burial for these applications as standard cable will degrade.
- Array dimensions for low spill systems can be very critical – tolerances of 50mm can be required. Ensure that you understand how important the tolerance is for your system before installing.
- Cables are sometimes damaged by from carpet fitters (using knives), from contractors drilling or cutting using slot saws etc. Make sure that the cables are clearly marked, for example using Ampetronic printed warning tape (PWT).
- Consider any environmental factors such as water, damp, heat or abrasion that could damage the loop when installed.
- Ordinary wire can be fastened with cable clips, secured with a hot melt glue or other adhesive such as sealant from a mastic gun. In all cases, public safety (avoidance of trip hazard) and long term reliability need to be carefully considered.
- Flat copper tape can be secured with printed warning tape (PWT) or under plastic extrusion (EXT) both available from Ampetronic.
- Unsealed concrete contains alkalis which can attack flat copper wiring if there is any moisture present. When installing copper tape on top of concrete, the surface should be sealed by painting the concrete with a suitable sealant prior to installation. Alternatively use DBC, cable for direct burial which is resistant.
- Suspended metal ceilings will cause metal loss if the loop is installed in the ceiling void – minimise loss by tying cables up well above the main metal framework by 100mm or more
- Keep loop cables at least 600mm from any parallel telephone, mains or control cables to meet current wiring standards (UK)
- Installing over steps? Check our suggested methods on www.ampetronic.co
- Lifts or other all metal constructions need special techniques, for example insulated lift bars which can be specially manufactured to fit inside a lift car.

16 Amplifier selection

You should now know:

- The required current for your loop
- Which amplifiers can drive the required type and length of cable

From the shortlist of amplifiers already selected, choose an amplifier (or amplifiers) that can deliver the required current using the table in section 19.

If current is too high for the amplifiers available, contact Ampetronic support (support@ampetronic.co) - there are solutions for much higher current and power loop systems if required.

Finally check other specifications for the amplifier to ensure that the product is a good fit for your application. Don't forget to consider:

- Available inputs (and potential need for adaptors / preamplifiers)
- Mounting requirements
- Size and weight
- Recommended environments for use
- Power requirements
- Ventilation / environmental requirements

Full datasheets are available for all products at our website www.ampetronic.co or by contacting us at support@ampetronic.co

17 Metal Adjustment Table

Type	Metal structure	Loop widths (m)		Metal loss adjustment multiplier (dB in brackets) for loop or segment width =							
		MINIMUM	MAXIMUM	2.0m	2.5m	3.0m	3.5m	4.0m	5.0m	>5.0m	
1	Old buildings with stone and brickwork only. Heating pipes Isolated re-bars only	2	22	x 1.0 (0dB)	x 1.0 (0dB)	x 1.0 (0dB)	x 1.0 (0dB)	x 1.0 (0dB)	x 1.0 (0dB)	x 1.0 (0dB)	x 1.0 (0dB)
2	Moderate mesh reinforcement (e.g. A142 or <3kg/m ²)	2	5	x 1.4 (+3dB)	x 1.6 (+4dB)	x 1.9 (+5.5dB)	x 2.1 (+6.5dB)	x 2.3 (+7.2dB)	x 2.8 (+8.9dB)	With metal structures present, loops wider than 5m are highly unlikely to meet IEC60118-4 requirements for variations across the loop. An array or other solution is required.	
3	Heavy mesh reinforcement (e.g. A393 or >3kg/m ²)	2	3.5	x 1.6 (+4dB)	x 2.1 (+6.5dB)	x 2.7 (+8.5dB)	x 3.2 (+10dB)	n/a	n/a		
4	Steel deck floor (floor level loop)	2	3	x 2.0 (+6dB)	x 2.6 (+8.2dB)	x 3.2 (+10dB)	n/a	n/a	n/a		
5	Metal system floor (floor level loop)	2	3	x 2.4 (+7.5dB)	x 3.6 (+11dB)	x 5.6 (+14dB)	n/a	n/a	n/a		
6	Suspended ceiling tiles with metal grid	2	5	x 1.4 (+3dB)	x 1.6 (+4dB)	x 1.9 (+5.5dB)	x 2.1 (+6.5dB)	x 2.3 (+7.2dB)	x 2.8 (+8.9dB)		
7	Metal cage /solid metal floor, e.g. lifts, cruise ships	2	?	> x 3.0 (> +10dB)	Requires site survey. Contact Ampetronic for advice.						

These figures are based on experience and are typical. However, metal structures can have very variable impact on a loop system therefore reality may be better or worse than the table suggests. To ensure success a site survey is recommended. Contact Ampetronic for advice on site surveys.

18 Maximum and minimum cable lengths

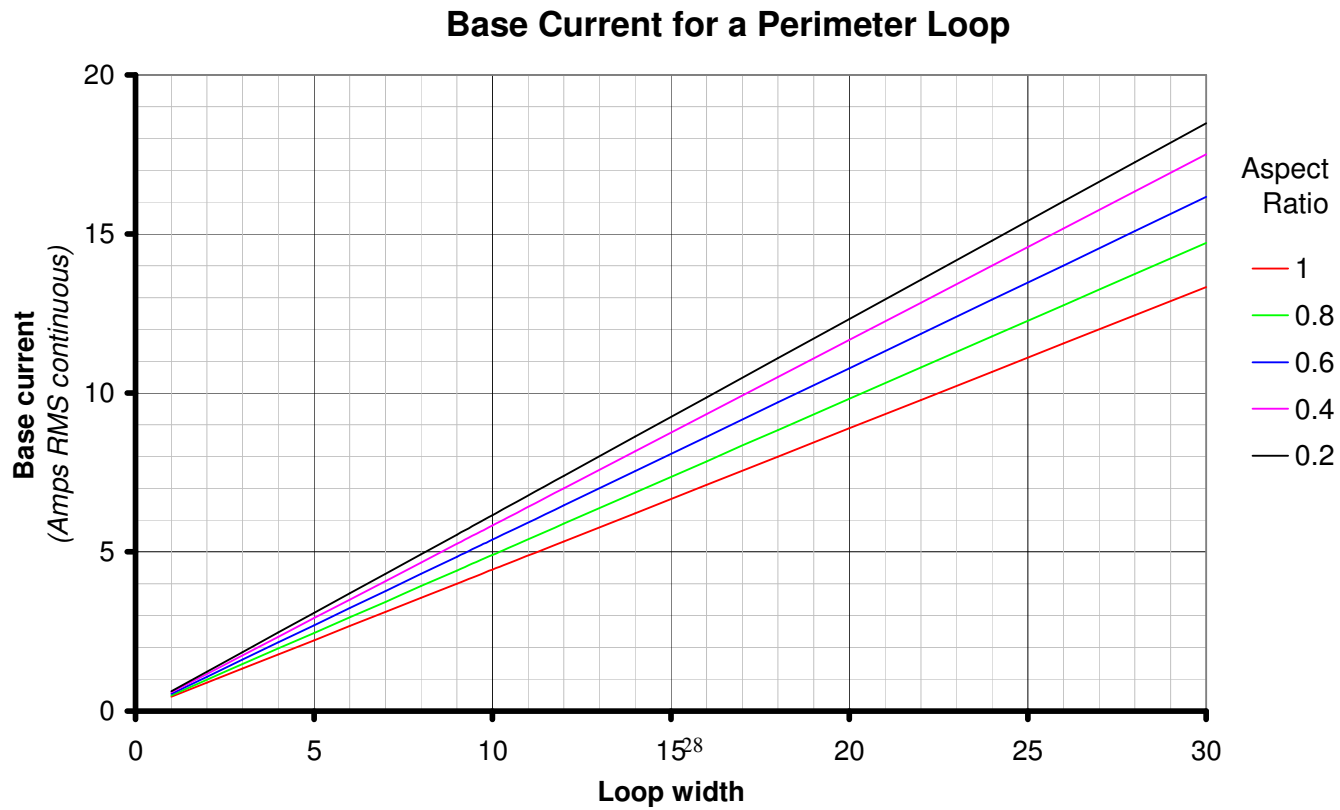
Amplifier		Minimum and maximum cable lengths (m)							Minimum and maximum cable lengths (feet)			
		Copper Tape (FB1.8)		Wire gauge				American AWG				
				0.5mm ²	1.0mm ²	1.5mm ²	2.5mm ²	4.0mm ²	22 (7x30)	18 (16x30)	14 (41x30)	10 (65x28)
CLD1 HLS02	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	50m	165'	33m	50m	60m	69m	71m	83'	149'	219'	237'
ILD100	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	58m	191'	22m	33m	39m	45m	47m	55'	98'	144'	156'
CLS1	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	146m	479'	55m	83m	98m	113m	130m	137'	246'	361'	433'
ILD 122	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	161m	529'	61m	92m	109m	125m	130m	152'	273'	400'	433'
ILD300 CLS2	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	106m	349'	40m	60m	71m	82m	85m	99'	178'	262'	283'
MLD5 - per output	min	52m	171'	15m	29m	44m	73m	116m	34'	78'	199'	501'
	max	136m	447'	51m	77m	91m	105m	109m	127'	229'	336'	363'
ILD500	min	31m	102'	9m	17m	26m	44m	70m	20'	47'	119'	300'
	max	177m	581'	66m	100m	119m	137m	143m	166'	298'	437'	473'
MLD7	min	52m	171'	15m	29m	44m	73m	116m	34'	78'	199'	501'
	max	177m	581'	66m	100m	119m	179m	143m	166'	389'	437'	617'
ILD 1000G MLD9 - per output	min	52m	171'	15m	29m	44m	73m	116m	34'	78'	199'	501'
	max	230m	755'	87m	131m	155m	179m	186m	216'	389'	570'	617'
D7	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	124m	407'	34m	69m	103m	172m	261m	80'	184'	470'	865'
D10	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	122m	401'	34m	68m	102m	170m	182m	79'	181'	465'	606'
D14	min	21m	69'	6m	12m	17m	29m	46m	14'	31'	79'	200'
	max	128m	420'	36m	71m	107m	125m	130m	83'	190'	400'	433'

Note: Maximum lengths are at FULL CURRENT – if reduced current is used, longer cable length may be used contact Ampetronic for assistance. Lengths assume a maximum power bandwidth of 1.6kHz suitable for good quality normal use. Values must be calculated if other corner frequencies are required.

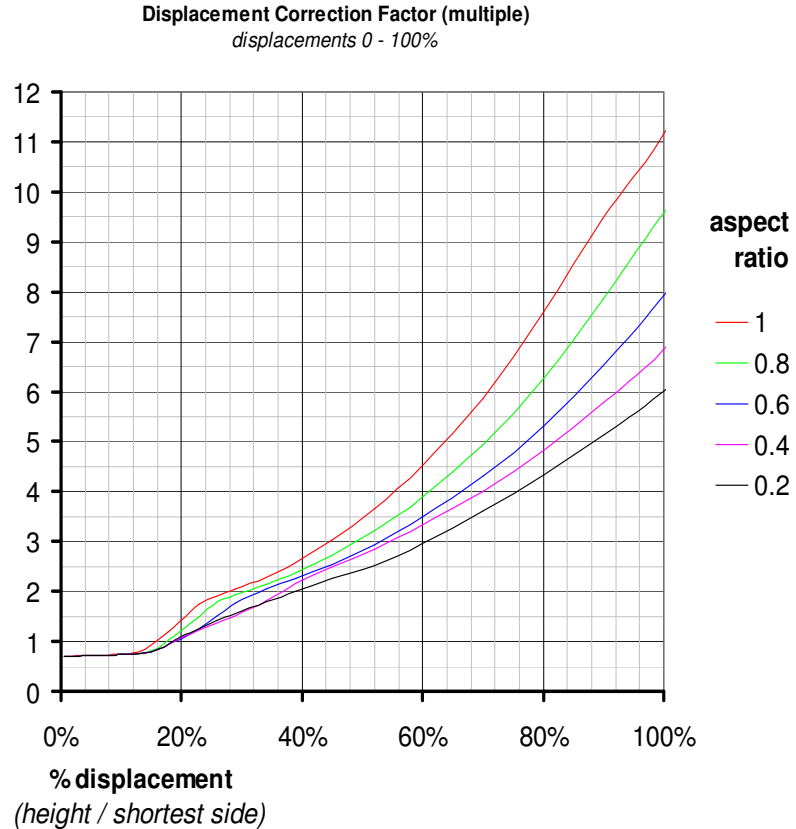
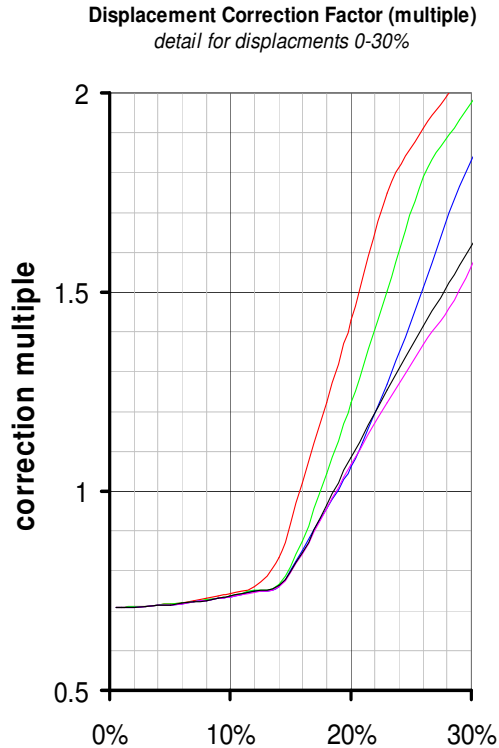
19 Amplifier data

Amplifier	Current max RMS	Voltage max RMS	Inputs		Size	Suitable for MultiLoops?	Mounting		Comments
			Balanced	Unbalanced			Rack mount	Panel mount	
HLS02	2.1A	3.2V	2 inputs (terminals) line – low z speaker Line – 100V line		107 x 160 x 45mm	✗		✓	For integration into existing closures e.g. help points
CLD1	2.4A	3.2V		2 inputs Mic/line 3.5mm jack Mic – 3.5mm jack	128 x 74 x 35mm (no power jack)	✗		✓	Compact counter loop. Accepts 12V DC power supply or uses external power pack.
ILD100	3.4A	3.0V		3 inputs Line – 2 RCA phono 2 x mic – 3.5mm jack	124 x 216 x 44mm	✗		✓	'TV room' amplifier, with VOX priority switching on microphone inputs
CLS1	3.5A	6.4V	Mic/line – 3 inputs – 3.5mm speaker jack		200 x 200 x 44mm	✗	✗	✓	Suitable for wall mounted perimeter loop solutions
ILD122	3.5A	7.1V	2 inputs line – 6.3mm jack mic – XLR		½ width 19" rack (1U)	✗	✓ tray required	✓ requires bracket	Pro-audio amplifier
CLS2	6.9A	6.4V	Mic/line – 3 inputs – 6.3mm speaker jack		200 x 200 x 44mm	✗	✗	✓	Suitable for wall mounted perimeter loop solutions
ILD300	4.9A	6.4V	2 inputs line – 6.3mm jack mic – XLR		½ width 19" rack (1U)	✗	✓ tray required	✓ requires bracket	Pro-audio amplifier
ILD500	6.4A	14.1V	2 inputs line – 6.3mm jack mic – XLR		19" rack (1U)	✗	✓ brackets included	✓ requires bracket	Pro-audio amplifier
ILD1000G	9.2A	32V	3 inputs line – 6.3mm jack mic – XLR		19" rack (1U)	✗	✓ brackets included		Pro-audio amplifier
MLD5	2 x 4.9A	2 x 10.2V	2 inputs mic/line - XLR		19" rack (1U)	✓	✓ brackets included	✓ requires bracket	Pro-audio amplifier
MLD7	2 x 6.4A	2 x 17V	2 inputs mic/line – XLR		19" rack (1U)	✓	✓ brackets included	✓ requires bracket	Pro-audio amplifier
MLD9	2 x 9.2A	2 x 32V	2 inputs mic/line - XLR		19" rack (1U)	✓	✓ brackets included	✓ requires bracket	Pro-audio amplifier
D7-2	7A	2 x 34V			19" rack (1U)	✓	✓ brackets included	✓ requires bracket	
D10-1	10A	1 x 34V	2 inputs mic/line – XL2 input 2 - AES		19" rack (1U)	✗	✓ brackets included	✓ requires bracket	Dante™ available as input 2 RJ45 socket
D10-2		2 x 34V			19" rack (1U)	✓			
D14-2	14A	2 x 34V			½ width 19" rack (1U)	✓	✓ brackets included	✓ requires bracket	

Base Current for a Perimeter Loop



20 Displacement Correction for Perimeter Loop



21 Current for an Array

