FARADAY

SPEAKER
Application Guide

A guide for speaker placement and design for emergency voice evacuation applications

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1. Introduction

Fire Alarms Systems are crucial components of all types of buildings, office, manufacturing facilities, dormitory areas, etc. because they inform occupants if an emergency exists. Voice evacuation systems are a further enhancement of the building alarm system and are required by fire code in certain buildings. Voice evacuation systems provide the occupants of the building more information than any standard notification appliance (bell or chime), such as the nature and location of the potential incident as well as evacuation instructions. These instructions are considered the very lifeline of those occupants. Hence, a voice evacuation system must be able to provide clear and loud messages that an occupant can understand under the worst of conditions.

Voice paging communication systems have become a standard for all office and manufacturing facilities. These systems provide voice paging throughout a facility as well as background music by use of high fidelity speakers. Users of voice paging and background music systems require those systems to produce a higher quality sound than a standard voice evacuation system. Therefore, speakers and amplifiers designed for higher quality sound reproduction are used.

Traditionally, emergency voice evacuation systems and convenience paging and background music systems have been installed and used independently of one another due to code and practices. However, a change has been implemented. NFPA 72 (2002 Edition) provides statements allowing the voice evacuation system to provide both convenience paging and background music for a facility along with emergency evacuation indications. Stipulations in the standard require that the fire alarm system must supervise all speaker circuits when in an active or inactive state. Also, a priority has to be set for the voice evacuation activation over all other functions.

Speaker placement and voice system design are very complex due to the many environmental variables that affect the appropriate operation of a voice system. The proper design and installation is crucial for a system to operate properly. This Speaker Application Guide is a general guide for speaker placement and design for appropriate emergency voice evacuation communication, convenience paging, and background music applications.

This guide is divided into six sections:

1. Introduction
2. Codes and Standards
3. Speaker Information
4. Applications
5. Speaker Placement – Voice Evacuation
6. Speaker Placement – Convenience Paging and Background Music
7. Field Wiring Guidelines

This publication is designed to provide accurate information in regard to Speaker Application and Installation for emergency voice evacuation applications. However, Siemens Building Technologies, Inc. does not assume any responsibility for any decisions made or actions taken based upon the information provided herein. It is provided with the understanding that the publisher is not engaged in rendering engineering, design, architectural, legal or other professional services. If engineering, design, architectural, legal or other expert assistance is required, the services of a competent professional person should be sought.

2. Codes and Standards

NFPA 72 National Fire Alarm Code

UL 1480 Speakers for Fire Alarm, Emergency, and Commercial and Professional Use

ADA (AG) Americans With Disabilities Act

ANSI A117.1 Standard for Accessible and Usable Buildings and Facilities

IEC 60268-16 Speech Transition Index

ANSI S3.5-1969 Articulation Index

All notification appliances must be installed in accordance with the latest editions of national and local fire alarm codes and standards, with approval from the local authority having jurisdiction.

3. Speaker Information

3.1 Speaker Characteristics

The 295X, and 294X series loudspeakers provided by Faraday are highly efficient sound transducers specifically designed to meet the demanding requirements of emergency communication service. The speaker will dependably reproduce voice and alarm signals with maximum intelligibility at required sound pressure levels. The speaker is a compression driven sound transducer with a UL tested frequency response of 400-4,000 Hz. This combination provides a high ratio of sound pressure level per watt. The speakers utilize 70.7 Volt line matching transformers, or 25 Volt line matching transformers. The speakers can be semi-flush or surface mounted utilizing commercially available 4" square electrical boxes or UL Listed back-boxes listed below. The speaker temperature operating range is (0°C to 49°C).

The 295X speakers, ¼ to 2 watt, are a low cost low profile speaker designed for voice evacuation systems.
The 294X speakers, 1/16 to 4 watt, are high performance speakers designed for voice evacuation systems.

Faraday

Model	Description
295XBXX25V	¼, ½, 1, 2 Watt, 25 volt Surface or Semi-flush Mounted Speaker.
295XBXX70V	¼, ½, 1, 2 Watt, 70.7 volt Surface or Semi-flush Mounted Speaker.
294X	1/16, 1/8, ¼, ½, 1, 2, 4 Watt 25 volt or 70.7 volt Surface Mounted or Semi-flush Mounted Speaker

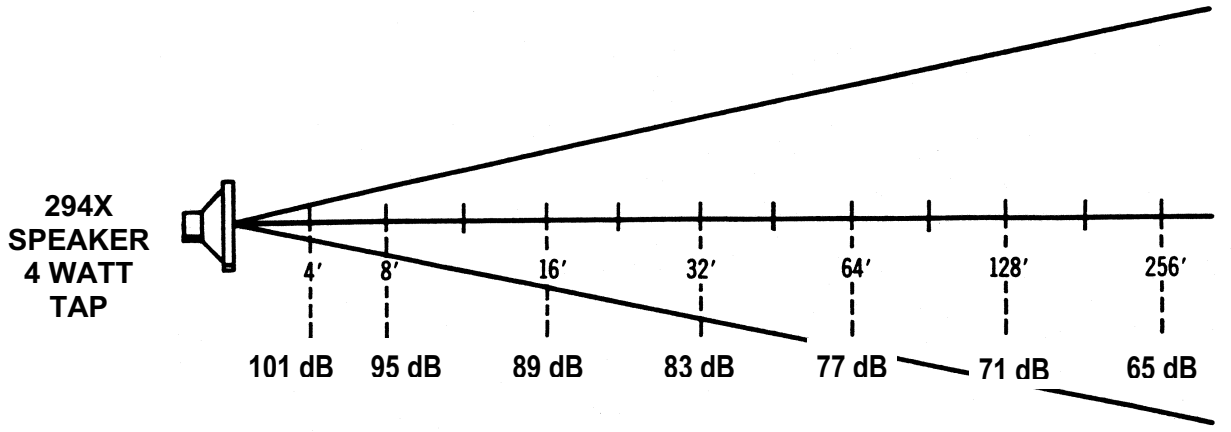
295X Series

	Distance/SPL*/dB				
TAPS	10 ft *(dB)*	20 ft *(dB)*	30 ft *(dB)*	40 ft *(dB)*	50 ft *(dB)*
¼ Watt	75	69	65	63	61
½ Watt	78	72	68	66	64
1 Watt	81	75	71	69	67
2 Watts	84	78	74	72	70

294X Series

	Distance/SPL*/dB				
TAPS	10 ft *(dB)*	20 ft *(dB)*	30 ft *(dB)*	40 ft *(dB)*	50 ft *(dB)*
1/16 Watt	75	69	65	63	61
1/8 Watt	78	72	68	66	64
¼ Watt	81	75	71	69	67
½ Watt	84	78	74	72	70
1 Watt	87	81	77	75	73
2 Watts	90	84	80	78	76
4 Watts	93	87	83	81	79

* Sound pressure level (U.L)



3.2 Sound Pressure Level (SPL)

Speakers are rated by measuring the sound pressure level (SPL) at a fixed distance in a special room. The sound pressure level is a measurement of how loud something is expressed in decibels (dB). It is measured using a Sound Pressure Level Meter, commonly referred to as a dB meter. For fire alarm applications the sound pressure level is expressed in dBA (decibels A-weighted). The A-weighted measurement has been adjusted to account for the way the human ear hears sound.

Sound Power is the total amount of work done by a speaker in producing sound in all directions. It is measured by measuring the Sound Pressure Level, in a reverberation room, at many points around the signal and then mathematically integrating these various readings. Underwriters Laboratories uses this average sound pressure measurement to determine the dBA rating of the speaker. In a typical installation the dBA reading is done directly in front of the speaker at 10 feet. These readings will be higher than the UL marked rating. The environment, area content and acoustics, and where you stand to take the measurement, all affect the dBA measured.

In a wide open area where sound does not reflect off any surface the sound pressure level decreases by 6 dB every time the distance is doubled. This 6 dB rule can be used when designing a system or analyzing the performance of the system. The formula to calculate the dB at specific distances is the inverse square law. 20log d2/d1 where d1 is the 10 foot measurement, d2 is the actual distance. An example: If you want the dB at 50 ft; 20log 50/10 subtracted from the 10 ft reading. The 294X AT 50 FT, tapped at the 4 watt setting is 79 dB, when using the UL listed dBA of 93 at 10 ft.

When there are multiple speakers in an area, the speakers combined SPL is greater than any one. Usually fire alarm designers ignore this effect so their designs are conservative.

For fire alarm systems the speakers must be louder than ambient noise. In the public operating mode the fire alarm system must produce a sound pressure level that is 5 dB above any ambient noise that lasts for 60 seconds, or 15 dB above the 24 hour average ambient, whichever is greater. If the area is used for sleeping the minimum SPL is 75 dBA. Consult NFPA 72 2002 Edition, Chapter 7 Notification Appliances for Fire Alarm Systems.

3.3 Impedance Matching

The 295X series, 294X series, S-HQ series speakers are matched to the constant voltage distribution line of a 70.7 volt or a 25 volt voice amplifier system. This simplifies the selecting of transformer taps to obtain the required sound pressure level from the speaker.

The Approximate Ambient Noise Level Chart lists possible noise sources and approximates noise levels in dB (Refer to figure 2).

Approximate Ambient Noise Levels Chart

Noise Source	Sound Level
Thunder	120 dB
Jet climbing, 600 feet overhead	110 dB
12 inch circular saw at 2 feet	100 dB
Busy street traffic or very noisy factory	90 dB
Machine shop average	85 dB
Shouted speech at 3 feet or printing press	80 dB
Factory average	75 dB
Very noisy restaurant or quiet assembly plant	70 dB
Conversation at 3 feet or department store	65 dB
Computer room	60 dB
Average office	55 dB
Normal restaurant	50 dB
Noisy residence	45 dB
Hospital room	40 dB
Average residence	35 dB

Figure 2

A general rule for audible signals for public mode is a sound level at least 15dB above ambient. Other options are available, consult NFPA 72 2002 Edition Chapter 7.

3.4 Speaker Phasing

Speaker phasing may become necessary if speakers are in the same area. The cancellation effect caused by out of phase speakers can cause a degraded tone quality, increased distortion and a loss of up to one-half of the volume. Speakers should not be situated facing each other. Alternate speakers on opposite walls.

Speaker phasing is accomplished by checking the polarity of the speaker terminals with respect to the movement of the speaker diaphragm. Connect the proper speaker terminals to produce the proper diaphragm movement.

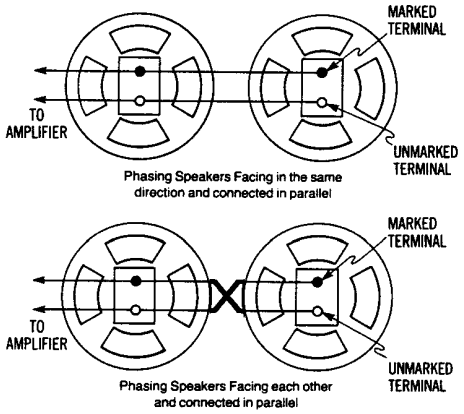


Figure 3

4. Speaker Application

4.1 Speaker Application Factors

These factors are:

1. Total wattage capability of the amplifier system.
2. Be sure to account for any required spare capacity future expansions.
3. Total system capability can be computed by totaling the wattage outputs of the individual speakers. A voice system of 40 watts of audio power can drive a speaker load of 40 watts. This can be 40 speakers tapped at 1 watt, 80 speakers tapped at ½ watt, 20 speakers tapped at 1 watt plus 40 speakers at ½ watt, or any mathematical combination of speaker tapped settings that are less than or equal to the 40 watts of power available from the power amplifier.

Speaker Wattage Tap	**Amplifier Wattage**				
watts	**30 watts**	**40 watts**	**50 watts**	**100 watts**	**180 watts**
1/16 W	480	640	800	1600	2880
1/8 W	240	320	400	800	1440
1/4 W	120	160	200	400	720
1/2 W	60	80	100	200	360
1 W	30	40	50	100	180
2 W	15	20	25	50	90
4 W	7	10	12	25	45

   This chart does not take into account line loss and spare capacity.

4. Ambient Noise Level is the next consideration. Refer to the approximate Ambient Noise Level Chart to determine what Ambient Noise Level is present for the area.
5. Intelligibility is affected by factors 6 & 7.
6. Area size must be considered, as the area gets larger more speakers must be utilized for proper coverage. A number of smaller devices strategically distributed provide an even and more effective sound level as compared to the placement of one or two large devices.
7. Area content and acoustics has a pronounced effect upon sound absorption and can attenuate the sound pressure level for a given speaker. Speakers located in areas that are carpeted, have heavy drapes or many obstructions should be capable of handling twice the wattage requirement to insure adequate coverage.
8. Locate speakers at all pull stations and in main corridors.
9. All occupied locations should be within 50 feet of a speaker at a minimum. For convenience paging and music see section 6.1.
10. Locate speakers in boiler rooms and mechanical rooms, locate speakers near or in bedrooms and bathrooms so if occupied the voice signal is clearly heard.
11. Allow at least 20 ft from speaker to any microphone or warden station and fire phone.
12. Set speaker tap to provide the required dB output.

4.2 Intelligibility

Voice Intelligibility is audible voice information that is distinguishable and understandable (NFPA 72, 2002 EDITION 3.3.208). It does not imply quality. For speech to be intelligible it must have adequate sound pressure level and clarity. The amplifier, the number of speakers, the sound power of the speakers, the voice information feed to the amplifier, and the acoustic environment all have an effect on the intelligibility of the system.

There are a number of methods to quantify the speech intelligibility of a voice system. Some are referenced in the annex of the fire alarm code NFPA 72.

Speech Transmission Index (STI): This method is covered in the International Electrotechnical Commission (IEC) standard 60268-16.

Articulation Index (AI): This method is covered in the American National Standards Institute publication ANSI S35-1969 (R 1986).

Phonetically Balanced Word Scores: This method is covered in the American National Standards Institute publication ANSI S3.2 (1989) and the International Organization for Standardization publication ISO/TR 4870.

Modified Rhyme Test: This method is also covered in the American National Standards Institute publication ANSI S3.2 (1989).

4.3 Where to Measure Pressure Levels and Intelligibility

At least one sound pressure level measurement and intelligibility measurement should be made in every zone. It is a rule of thumb that measurements should be taken on approximately a twenty (20) foot grid. Any room with a surface area that is less than 20 feet by 20 feet will require one measurement. Any room with a surface area that is larger than 20 feet by 20 feet, will require multiple measurements. Seams between two circuits within a single room should be measured using a 20 foot rule of thumb.

Measurements on the 20 foot grid should NOT be made near to or directly under a speaker. The measurement should be made in a position that the quality of the output would be judged to be inferior versus the quality at any other position on that grid (worst case scenario). If one measurement is being made in a zone, that measurement should NOT be made near to or directly under a loudspeaker. It should be made in a position that is considered to have the worst sonic quality within that room (worst case scenario).

Also, in cases where the loudspeakers coverage area differs from the zone (it is possible to cover only a portion of a zone with a loudspeaker coverage area while leaving other areas unprotected), measurements need to be taken in the all areas of the room, the unprotected area as well as the area that is protected. Remember, it is important to determine if an unprotected area exists and alter or add speakers that will protect that area properly.

4.4 When to Measure Pressure Levels and Intelligibility

Measurements for sound pressure levels (dBA) and speech intelligibility should be measured for each zone when a new structure using a voice evacuation system is newly constructed or an existing structure is renovated. A renovation should be defined as any changes of any wall, floor, or ceiling material including the removal or additions of walls or office partitions.

Measurements for sound pressure levels (dBA) and speech intelligibility should also be measured for each zone when an existing sound system is altered, noise-emitting equipment is installed, or the primary purpose of the structure/room/zone is changed (example: office changed to machine shop or new louder machinery like a copier is installed).

The measurements for sound pressure levels (dBA) and speech intelligibility should be measured for each zone when the existing sound system fails the audibility requirement of the code.

A zone should be measured when it is ready for occupancy. Materials used to construct walls, floors, and ceilings will affect the acoustical dynamics of that structure/room/zone. Other materials such as furnishings and partitions should also be in place during testing because these also affect the acoustical dynamics of the structure/room/zone. Also, any noise-emitting equipment should be installed and operating because of its affect upon the acoustical dynamics of the structure/room/zone.

An ANSI Type Two meter which measures on the A weighted scale and has a fast response would be an appropriate meter to measure the dB. For testing Voice Intelligibility see section 4.3 of this paper.

5. Speaker Placement Guidelines – Voice Evacuation

The following examples are for speaker placements in apartment buildings, schools, or other areas having similar characteristics. The speaker placement examples are general guides. Speaker placements in larger areas can be simplified by dividing the large area into smaller areas, then consider the speaker application factors for the smaller areas and follow the speaker placement guidelines. Refer to Figures 4, 5, and 6.

5.1 Typical Office Area Speaker Application

Ambient Noise Level	55db
Area Size	100 ft. x 100 ft. room
Area Content and Acoustics	Office furniture and carpet
Speaker Utilized	Four 295X tapped at 1 Watt or four 294X tapped at 1/4 Watt

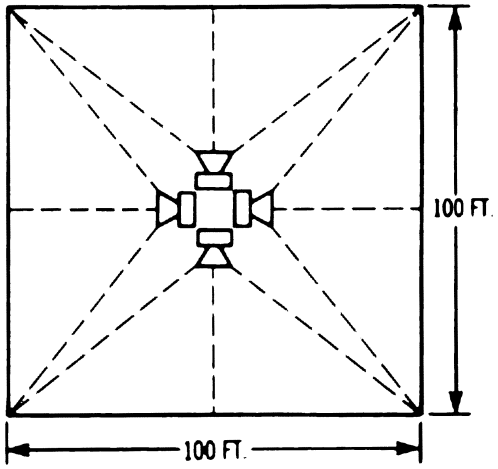
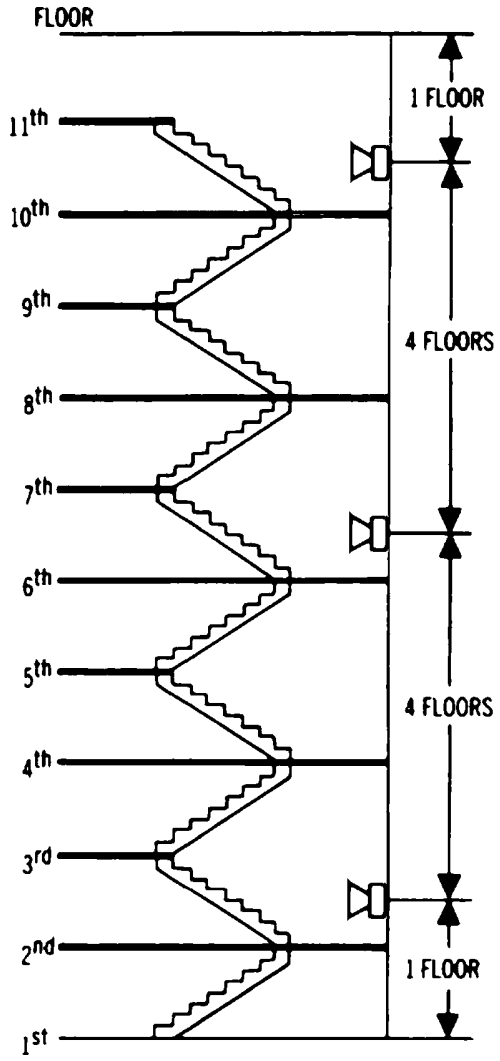


Figure 4

5.2 Typical Stairways Speaker Application

Ambient Noise Level	55db
Area Size	Stairway
Area Content and Acoustics	No furnishing, open area
Speaker Utilized.....	294X 1 Watt Tap



5.3 Typical Hallway Speaker Application

Ambient Noise Level	64db
Area Size	100 ft. long hallway
Area Content and Acoustics	Carpeted and no furnishing
Speaker Utilized.....	294X 1 Watt Tap

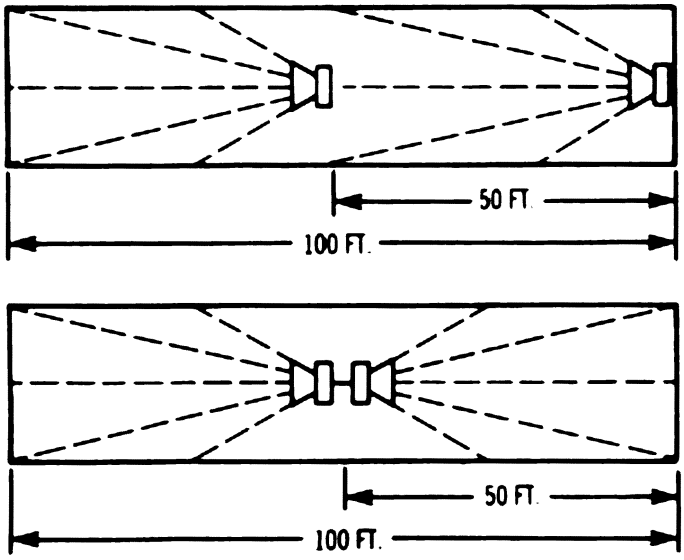


Figure 6

6. Speaker Placement Guidelines – Convenience Paging and Background Music Applications

1. Obtain the blueprints of the building.
2. Specify the level of coverage desired, where in the building are the speakers to be installed and for what purpose, voice or tone alarms.
3. If possible, visit the site noting all the Speaker Application Factors on the blueprints.
4. Install the speakers and perform a System Test, analyzing the sound coverage, changing taps as necessary to optimize sound coverage.

6.1 Speaker Locations And Volume

6.1.1 Ceiling Mounted Speakers

Ceiling mounted speakers that are used for convenience paging and background music, as well as emergency voice evacuation, should be located a distance from another speaker that is no more than twice the distance between the ceiling and the floor (height).

Remember, the output settings of the speaker (Watt taps) are set on the speaker.

6.1.2 Wall Mounted Speakers

Wall mounted speakers that are used for the convenience paging and background music, as well as emergency voice evacuation, should be located a distance from another speaker that is no more than 20 feet. And shall project a maximum distance of 30 feet.

Remember, the output settings of the speaker (Watt taps) are set on the speaker.

7. Field Wiring Guide

The installation of all wiring, cable, and equipment shall be in accordance with NFPA 70, National Electric Code.

Consult the voice systems specific speaker wiring circuits for types of wire useable on the voice system.

General Requirements:

Speaker Circuits for voice evacuation systems are normally classified as power limited circuits. Speaker circuits can be run with other power limited fire alarm wiring. For addressable systems special precautions maybe necessary to eliminate noise and possible interference with the addressable loop.

Typically #18 AWG will be adequate for speakers circuits. Heavier wire would have less voltage loss and allow for higher loads or greater distances.

This table illustrates typical wire lengths for specific wire gauges for speaker loads based on power, and assuming a 20% line loss due to voltage drop is acceptable.

Maximum Wire Length in Feet Based on a 20% Voltage Drop

Total wire length for all wires, two wires class B, four wires class A.

	25 Volt				70 Volt			
Power Watts	**18 AWG 8.08 ohms 1000'**	**16 AWG 5.08 ohms 1000'**	**14 AWG 3.19 ohms 1000'**	**12 AWG 2.01 ohms 1000'**	**18 AWG 8.08 ohms 1000'**	**16 AWG 5.08 ohms 1000'**	**14 AWG 3.19 ohms 1000'**	**12 AWG 2.01 ohms 1000'**
5	3094	4921	7837	12438	24257	38583	61442	97512
10	1547	2461	3918	6219	12129	19291	30721	48756
15	1031	1640	2612	4146	8086	12861	20481	32504
20	774	1230	1959	3109	6064	9646	15361	24378
25	619	984	1567	2488	4851	7717	12288	19502
30	516	820	1306	2073	4043	6430	10240	16252
35	442	703	1120	1777	3465	5512	8777	13930
40	387	615	980	1555	3032	4823	7680	12189
45	344	547	871	1382	2695	4287	6827	10835
50	309	492	784	1244	2426	3858	6144	9751
55	281	447	712	1131	2205	3508	5586	8865
60	258	410	653	1036	2021	3215	5120	8126
65	238	379	603	957	1866	2968	4726	7501
70	221	352	560	888	1733	2756	4389	6965
75	206	328	522	829	1617	2572	4096	6501
80	193	308	490	777	1516	2411	3840	6095
85	182	289	461	732	1427	2270	3614	5736
90	172	273	435	691	1348	2143	3413	5417
95	163	259	412	655	1277	2031	3234	5132
100	155	246	392	622	1213	1929	3072	4876

Notes: For each speaker zone, select total power.

Calculations are based on assuming that all speakers are lumped at the end, worst case condition.

Wire resistance is based on solid copper at 75 degree C. (167 degrees F.).

Calculation is based on a 20% voltage drop if allowable. UL states when the operating voltage is reduced to 80% the dB cannot be reduced greater than 3dB. For a 10% voltage drop divide the maximum wire length in half.

These calculations are guide lines for signal wire loss. Consult your voice evacuation panel, and your local authority having jurisdiction, for specifics to your application.

Notice:

The use of other than Siemens Building Technologies, Faraday detectors, bases, accessories and appliances with Faraday control equipment will be considered a misapplication of Faraday equipment and as such will void all warranties either expressed or implied with regard to loss, damage, liabilities and/or service problems.

For system information, custom equipment, components and quotations for non-standard equipment used in conjunction with Faraday systems and components not listed, contact Siemens Building Technologies, Faraday, 8 Fernwood Road, Florham Park, New Jersey 07932.

This Price List supersedes all previous price lists.
Prices subject to change without notice.

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