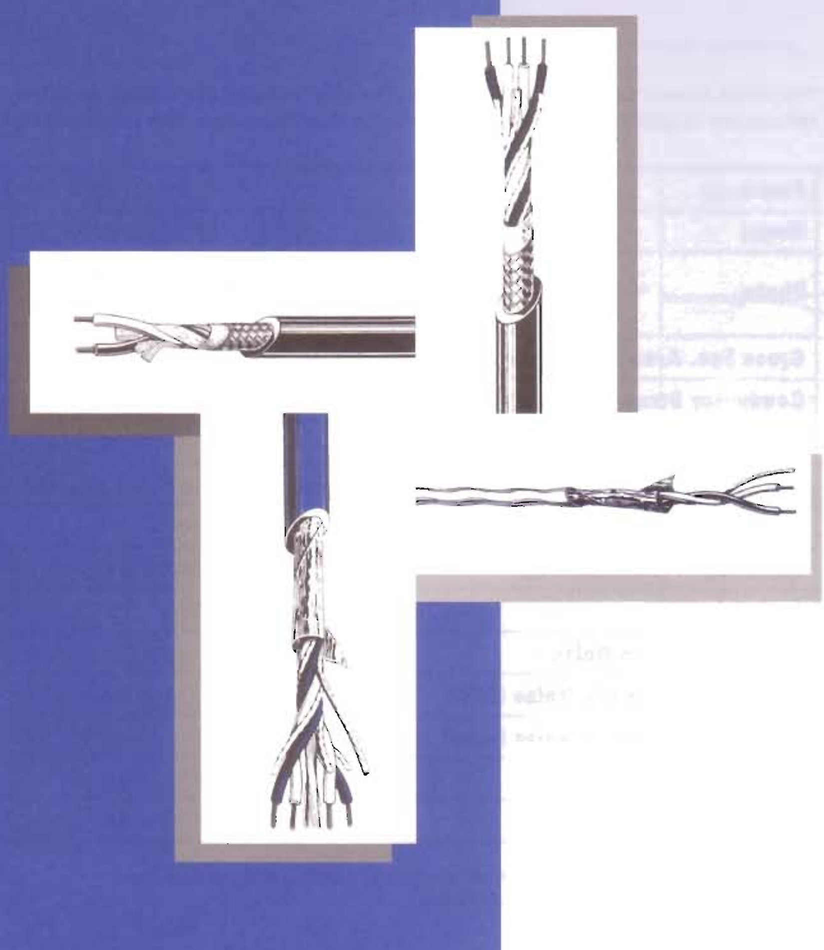
A TECHNICAL PAPER

Evaluating Microphone Cable Performance & Specifications



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Introduction

Generally, it is difficult for the typical purchaser of microphone cable to evaluate the many factors that affect the real-world performance of that cable. Often, manufacturers simply do not list sufficient specifications for comparison. The purpose of this document is to explain some of the most important specifications regarding microphone cable noise, frequency response and durability, and to provide a clear, straightforward comparison of some of the most common mic cables in the marketplace.

Microphone cables may carry line-level signals in the order of + 4 dBu (1.23 volts) to + 24 dBu (12.3 volts). However, when they are used to connect microphones to mixers or preamps, these cables often are required to convey very low level signals, signals in the nominal - 70 dBu range (0.3 millivolts). The lowest signal levels carried in the cable may be as low as -120 dBu (about 1 microvolt). Because such signals are subject to a large increase in level due to the high gain of microphone preamplifiers and subsequent amplifier stages, even the smallest noise signals entering the microphone cable can become a significant factor. Noise can "invade" the cable from external sources by means of electrostatic coupling or electromagnetic induction-sources that most engineers are aware of. However, given the high gains involved, so-called "microphonic" noise may also constitute a problem. Microphonic noise has nothing to do with a microphone; instead it is generated within the cable-caused by capacitance changes when the cable is subject to flexing, vibration, or dimensional changes due to changes in temperature. In effect, the cable becomes a crude microphone.

The longer the cable, the greater its susceptibility to potential sources of noise. Noise, however, is not the only pitfall with microphone cable. All cable has a characteristic impedance, due to inductive and capacitive coupling between the various conductors in the cable. This impedance, combined with the input and output circuits to which the cable is connected, can act as a filter which ultimately degrades the high frequency response of the audio system. With runs of 100 meters (328 feet), microphone cable quality is especially critical.

In professional applications, particularly with microphones or portable sound systems where cables are subject to continuous handling and flexing, durability is an important factor. While two cables may seem to deliver similar results when brand new, they may deteriorate at very different rates under actual field use conditions. The nature of insulation, shielding, conductor metallurgy, strain relief fibers, friction reducers, twisting pitch, and so forth all impact the practical life of a cable.

All tests used to prepare this document were performed under identical conditions, and the test setups are explained in sufficient detail that any competent engineer should be able to duplicate and verify the results presented here. In fact, we encourage you to do so with your favorite cables to discover more about their actual performance.

This chart shows the basic cable specifications for competitive cables, as listed in manufacturer's literature. Also indicated are references to additional tests, as presented in this document. Not all cables were subjected to all tests.

Brand		Canare			Columbia	
Model		L-4E6S	L-4E5AT	L-2E5AT	1323	2524
Photo						
Cross Sec. Area (mil. / mm)		310 / .20	279 / .18	465 / .30	496 / .32	822 / .53
Conductor Strand (Qty. / mil. / mm)		40 / 3.15 /.08	16 / 4.73 /.12	12 / 7.09 /.18	16 / 6.3 /.16	10 / 10.24 /.26
Number of Conductors		4	4	2	2	2
Configuration of conductors		Twisted quad	Twisted quad	Twisted pair	Twisted pair	Twisted pair
Insulation		PE	IPE	IPE	PE	PE
Shielding		Braided	AL-PET TP	AL-PET TP	SPIRAL	AL-PET TP
Jacket		PVC	PVC	PVC	PVC	PVC
TEST ITEMS*	**Electrostatic Noise**	Fig. 6	Fig. 1	Fig. 1	Fig. 11	Fig. 5
	Electromagnetic Noise (SCR)	Fig. 12	Fig. 13 & 14	Fig. 15 & 16	Fig. 21 & 22	Fig. 26
	Electromagnetic Noise (Hum)	Fig. 30	Fig. 31	Fig. 32	Fig. 35	Fig. 38
	Frequency Response	Fig. 42	Fig. 42	Fig. 42	N.T.	Fig. 45
	Flex Durability	Fig. 46	N.T.	N.T.	N.T.	N.T.

Figure numbers indicated in chart refer to test sections of book that show specific test results of individual cables.

Abreviation key:
PE: Polyethylene
IPC: Irradiated Polyethylene
PP: Polyethylene
AL-PET TP: aluminum polyester tape
PVC: Polyvinyl chloride

How Noise Invades Microphone Cables

Electrostatic Noise

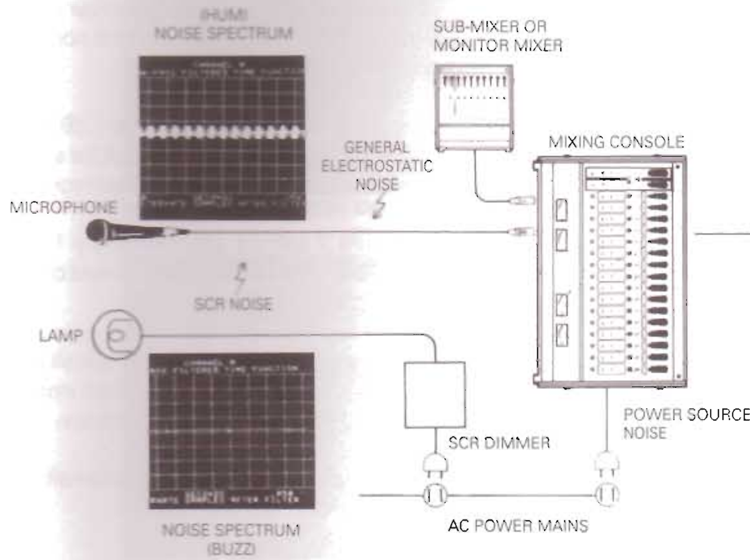
Electrostatic noise may be generated by sparks at the armatures of motors or generators, by gas-discharge lighting (neon, fluorescent), and other sources. Such noise can invade a microphone cable (or other sound system cables and components) by means of capacitive coupling. Electrostatic shielding such as a metallic braided jacket, a swerved (spiral wrapped) jacket or a foil tape jacket can reduce electrostatic noise, provided the shield offers a low-resistance path to ground.

Electromagnetic Noise

Electromagnetic noise may be generated by the coils in electric motors, the ballast in fluorescent lighting, the "chopping" of AC waveforms in Silicon-Controlled Rectifier (SCR) dimmers, the rheostat coils in large lighting dimmers, and so forth. Such noise can invade a sound system or cable by means of inductive coupling, and the typical electrostatic shield offers no protection at all here. Instead, solid conduit (iron or steel), or simply a lot of physical distance is required to minimize electromagnetic noise.

These noise sources and methods of coupling into a sound system are illustrated here.

NOTE: Ground loops represent another means by which noise enters the sound system. A "ground loop" is simply a duplicate path to ground from a given component in a sound system. Ground loops are not discussed in this document because they are more a function of how the sound system is wired rather than the nature of the cable itself.



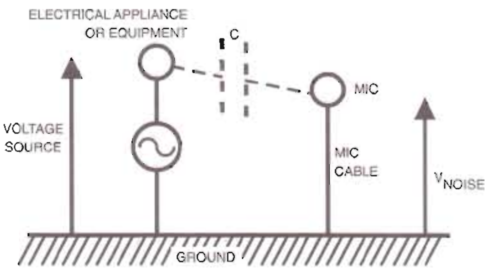
Pictorial representation of methods by which noise invades a sound system.

	Belden			Klotz	Mogami		West Penn	
	8412	8451	8762	13030	2534	2549	452	
								
	806 / .52	543 / .35	868 / .56	341 / .22	357 / .23	543 / .34	527 / .34	
	26 / 6.3 /.16	7 / 9.85 /.25	7 / 12.6 /.32	28 / 3.94 / .1	20/ 4.73 / .12	30 / 4.73 /.12	7 / 9.85 /.25	
	2	2	2	2	4	2	2	
	Twisted pair	Twisted pair	Twisted pair	Twisted pair	Twisted quad	Twisted pair	Twisted pair	
	Rubber	PP	PE	PVC	PE	PE	PP	
	Braided	AL-PET TP	AL-PET TP	SPIRAL	SPIRAL	SPIRAL	AL-PET TP	
	Rubber	PVC	PVC	PVC	PVC	PVC	PVC	
	Fig. 7	Fig. 3	Fig. 3	Fig. 10	Fig. 9	Fig. 8	Fig. 4	See Page 4
	Fig. 25	Fig. 19 & 20	Fig. 17 & 18	Fig. 23 & 24	Fig. 28	Fig. 29	Fig. 27	See Page 6
	Fig. 37	Fig. 34	Fig. 33	Fig. 36	Fig. 40	Fig. 41	Fig. 39	See Page 8
	Fig. 43	Fig. 43	Fig. 43	N.T.	Fig. 44	Fig. 44	Fig. 45	See Page 10
	Fig. 47	N.T.	N.T.	N.T.	Fig. 48	Fig. 49	N.T.	See Page 11

Testing For Electrostatic Noise

General Description

The circuit generating or carrying electrostatic noise acts as one plate of a capacitor. The microphone cable acts as the other plate of the capacitor. A portion of the noise source voltage will therefore be electrostatically (capacitively) coupled into the microphone cable. The nature of capacitive reactance is such that higher frequencies are more readily admitted into the mic cable. Moreover, the higher the impedance of the microphone circuit, the greater the induced noise voltage. (This is why low-Z mics are preferred.)

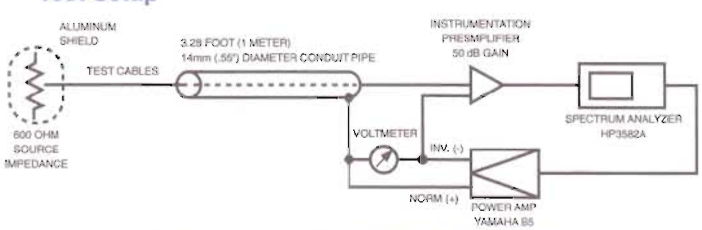


ELECTROSTATIC NOISE COUPLING
VIA MUTUAL CAPACITANCE

Wrapping the signal-carrying conductors of the mic cable with a grounded, electrically-conductive screen (shield) offers a low-resistance path to ground. This "electrostatic shielding" provides protection against the noise which would otherwise be induced by electrostatic coupling.

The effectiveness of the shield depends upon the percentage of coverage (how much "space' there is within the shield structure for noise voltages to leak into the signal carrying conductors).

Test Setup



Electrostatic Noise Immunity test setup

Measurement Conditions

1. +15 dBV of AC voltage is applied between the conduit pipe and the test cable, and noise induced in the cable was then measured. The conduit had an inner diameter of 14 mm (0.55 inch) and was 1 meter (3.28 feet) in length.

2. Cables subjected to this test included the following (listed alphabetically by manufacturer and model):
BELDEN 8412, 8451, 8762
CANARE L-4E6S, L-4E5AT, L-2E5AT
COLUMBIA 1323, 2524
KLOTZ 31030
MOGAMI Neglex 2534, Neglex 2549
WEST PENN 452

Test Results

1. Figures 1 through 5 are actual spectrum analyzer display photos that illustrate the test results for cables with shields of aluminum-mylar tape (foil), which should provide 100% coverage. The data indicates that there was less induced noise than the residual noise of the test equipment.

2. Figures 6 and 7 illustrate the test results for cables with braided shields.

3. Figures 8 through 11 illustrate the test results for cables with spiral wrapped shields.

4. The cable in Figure 5, despite its foil shield, admits approximately 2 dB of noise at 20 kHz. This suggests that the tape is too narrow to adequately cover the inner conductors (it may "split" at points to admit noise), or it may have pin-holes which admit noise.

5. The cable in Figure 6 admits approximately 1 dB of noise at 20 kHz, which is considered a good result for a braided shield (since no braid can offer 100% coverage.)

6. The cable in Figure 7 admits approximately 15 dB of noise at 20 kHz. This is the result of 85% shield coverage in that particular braid.

7. The cables in Figure 8 and 9, have high density spiral shields and show virtually the same noise immunity characteristics as that of the foil shield cables.

8. The cables in Figures 10 and 11 have low density spiral shields and admit a lot of induced noise.

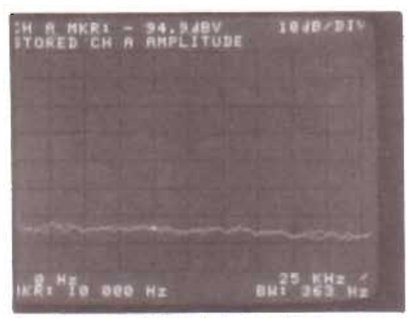


Figure 1 – Canare L-4E5AT & L-2E5AT Electrostatic Noise

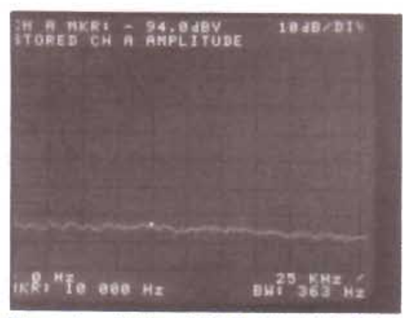


Figure 2 – Belden 8762 Electrostatic Noise

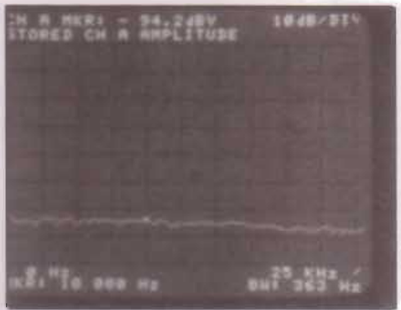


Figure 3 – Belden 8451 Electrostatic Noise

Figure 4 – West Penn 452 Electrostatic Noise

Figure 5 – Columbia 2524 Electrostatic Noise

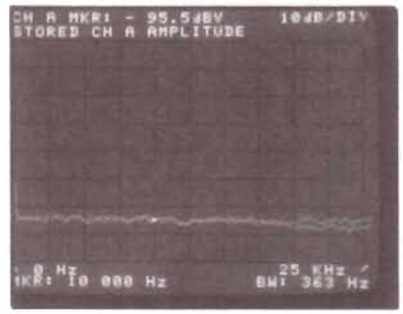


Figure 6 – Canare L-4E6S Electrostatic Noise

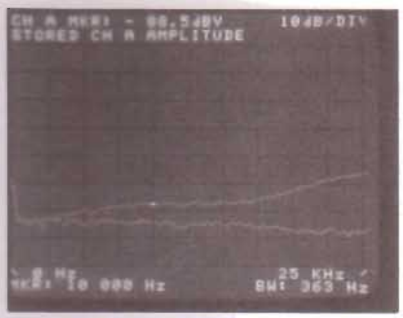


Figure 7 – Belden 8412 Electrostatic Noise

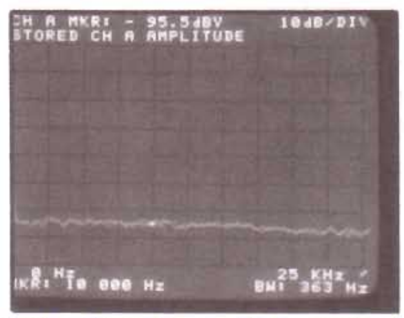


Figure 8 – Mogami Neglex 2549 Electrostatic Noise

Figure 9 – Mogami Neglex 2534 Electrostatic Noise

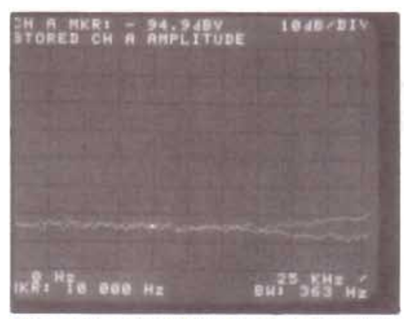


Figure 10 – Klotz 13030 Electrostatic Noise

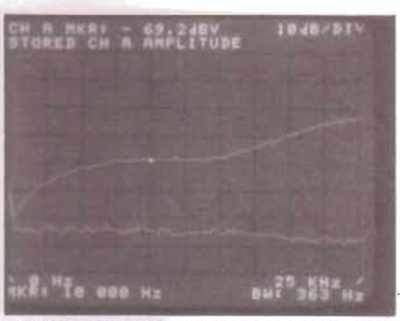
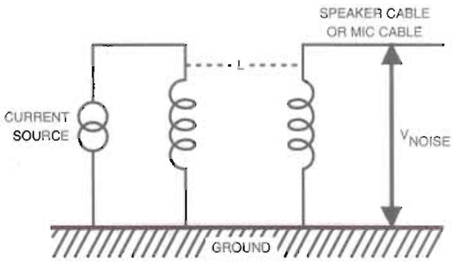


Figure 11 – Columbia 1323 Electrostatic Noise

Testing For Electromagnetic Noise (SCR Dimmer Buzz)

General Description

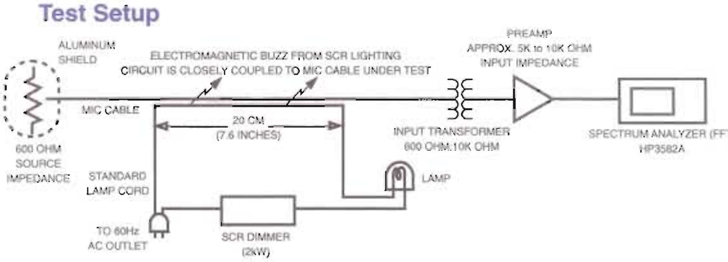
The magnetic fields generated by various sources cut across the conductors of a microphone (or other audio signal) cable. Since these fields alternately build and collapse, they induce a corresponding alternating noise voltage in the cable. The induced voltage becomes greater with a higher power line frequency, greater current flowing in the source, closer proximity of source to cable, or longer cable exposed to the noise source.



ELECTROMAGNETIC NOISE COUPLING
VIA MUTUAL INDUCTANCE

The AC power line waveform in most areas is 50 or 60 Hz, but this can become contaminated by a rich harmonic spectrum. The harmonics are generated by various sources, but most drastically, by the clipped waveforms emitted by SCR (Silicon Controlled Rectifier or Thyristor) dimmers. SCR dimmers are a major source of noise problems because they generate very high harmonics at some settings, and because these higher frequencies more readily couple into audio cables.

Test Setup



Electromagnetic SCR Noise Immunity test setup

Measurement Conditions

1. The test cables were 16.4 feet (5 meters) in length.
2. Each cable tested was placed so that a 7.6 inch (20 cm) segment of the cable was parallel and in very close proximity to one conductor of a lamp cord in the SCR dimmer circuit.
3. The test data was obtained by seeking the maximum induced noise near the mid-section of the test cable. This was obtained by sliding the test cable along the noise source (SCR dimmer circuit conductor).
4. Measurements were made in the 0 through 1 kHz range and in the 0 through 25 kHz range to best observe the induction of the rich harmonic spectrum from the SCR dimmer.
5. Cables subjected to this test included the following:
   BELDEN 8412, 8451, 8762
   CANARE L-4E6S, L-4E5AT, L-2E5AT
   COLUMBIA 1323, 2524
   KLOTZ 31030
   MOGAMI Neglex 2534, Neglex 2549
   WEST PENN 452

Test Results

1. All 2-conductor cables admitted nearly the same amount of electromagnetically induced noise.

2. CANARE L-4E6S (Figure 12) and L-4E5AT (Figure 13), which are fabricated using a 4-conductor configuration, exhibit 15 dB to 25 dB less SCR dimmer induced noise than that of the standard 2-conductor cables illustrated in Figures 15 through 27, and 29.

3. MOGAMI Neglex 2534 (Figure 28), which is fabricated with a 4-conductor configuration, exhibited 5 dB to 15 dB less induced noise than that of the standard 2-conductor cables illustrated in Figures 15 through 27 and 29.

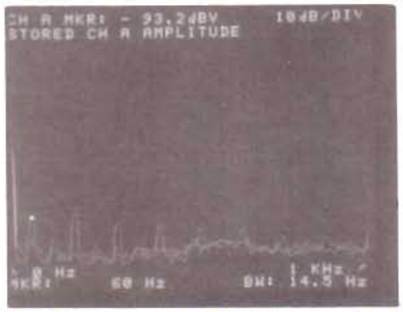


Figure 12 – Canare L-4E6S SCR Noise (0-1kHz)

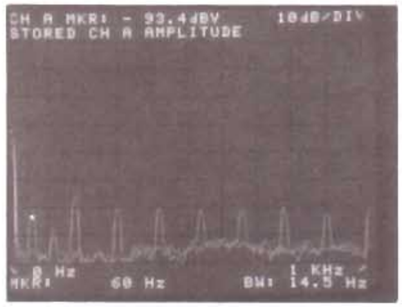


Figure 13 – Canare L-4E5AT SCR Noise (0-1kHz)

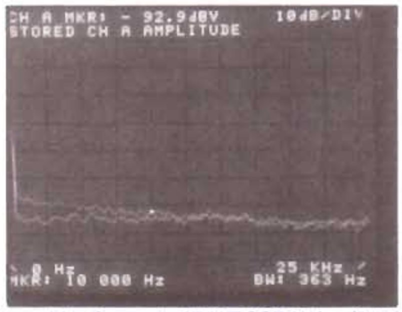


Figure 14 – Canare L-4E5AT SCR Noise (0-25kHz)

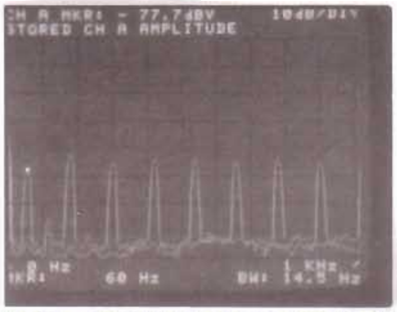


Figure 15 – Canare L-2E5AT SCR Noise (0–1kHz)

Figure 16 – Canare L-2E5AT SCR Noise (0–25kHz)

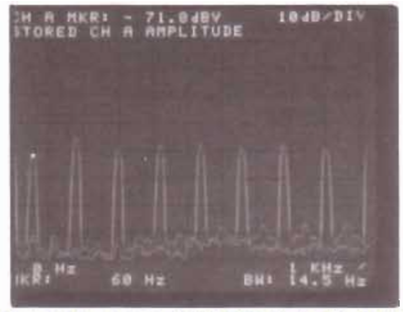


Figure 17 – Belden 8762 SCR Noise (0–1kHz)

Figure 18 – Belden 8762 SCR Noise (0–25kHz)

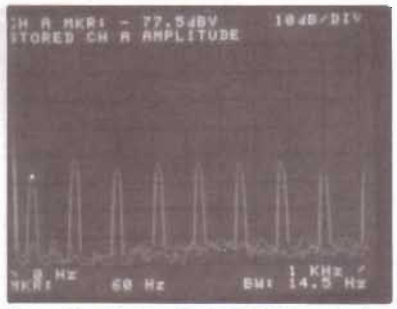


Figure 19 – Belden 8451 SCR Noise (0–1kHz)

Figure 20 – Belden 8451 SCR Noise (0–25kHz)

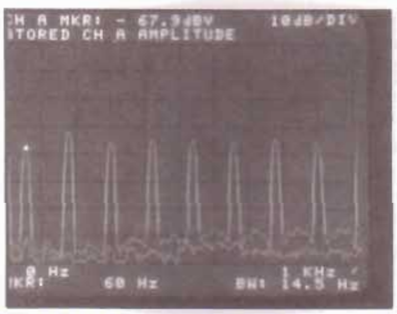


Figure 21 – Columbia 1323 SCR Noise (0–1kHz)

Figure 22 – Columbia 1323 SCR Noise (0–25kHz)

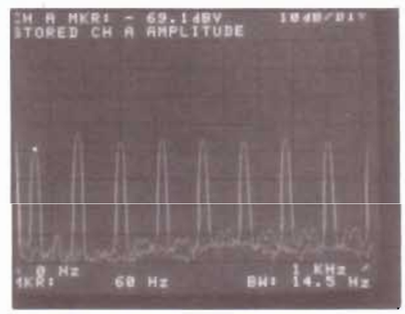


Figure 23 – Klotz 13030 SCR Noise (0–1kHz)

Figure 24 – Klotz 13030 SCR Noise (0–25kHz)

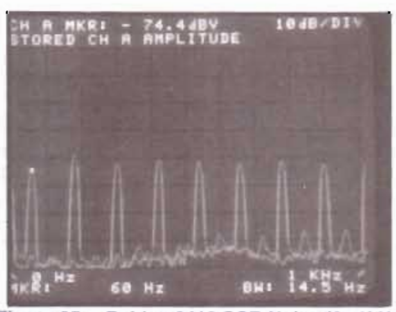


Figure 25 – Belden 8412 SCR Noise (0–1kHz)

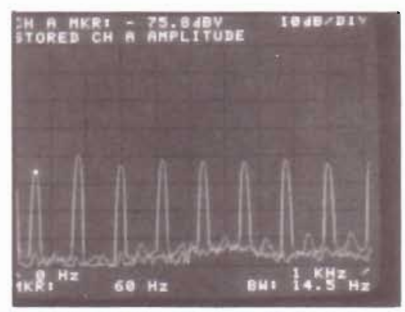


Figure 26 – Columbia 2524 SCR Noise (0–1kHz)

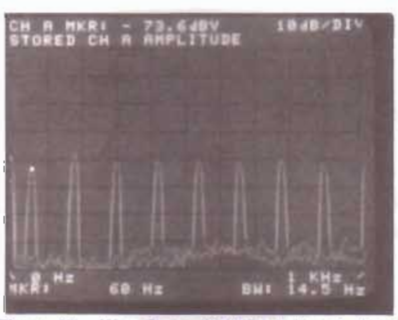


Figure 27 – West Penn 452 SCR Noise (0–1kHz)

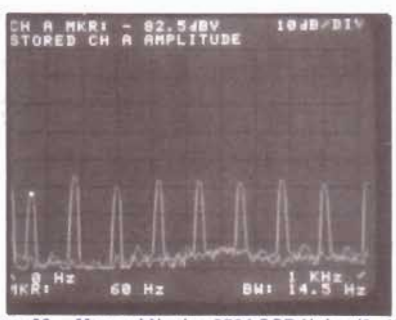


Figure 28 – Mogami Neglex 2534 SCR Noise (0–1kHz)

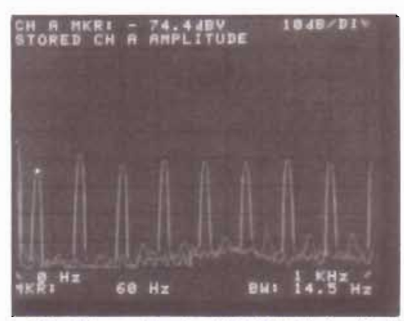


Figure 29 – Mogami Neglex 2549 SCR Noise (0–1kHz)

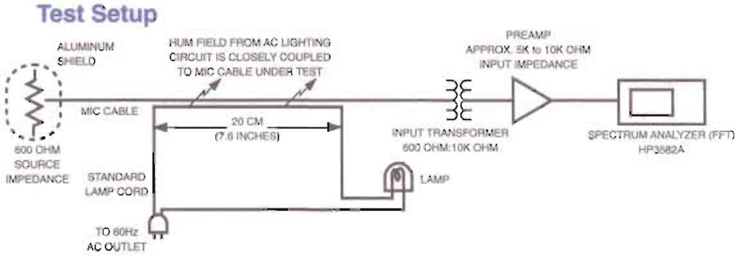
Testing For Electromagnetic Noise (General Power Line Hum)

General Description

As mentioned previously, magnetic fields are radiated from various sources, including power lines, motors, and power transformers. While SCR dimmers are a major factor contributing to higher order power line harmonics, they are not the only problem source of electromagnetic noise affecting sound systems. Saturated power transformer cores and reactive fluorescent lamp ballasts are two of the more common sources of power line harmonics. The noise caused by these sources includes not only 60 Hz hum, but also considerable energy at 120, 240 and 480 Hz. If the power lines are 3-phase, it is also possible to obtain harmonics at 180 Hz, 300 Hz, 360 Hz and so forth. Still, this is predominantly low frequency energy that is heard as "hum," rather than the higher order harmonic energy (as from SCRs) which is heard as "buzz."

These tests, while similar to the SCR dimmer noise source tests, focus on lower frequency hum energy.

Test Setup



Electromagnetic Hum Noise Immunity test setup

Measurement Conditions

1. The test cables were 16.4 feet (5 meters) in length.
2. Each cable tested was placed so that a 7.6 inch (20 cm) segment of the cable was parallel and in very close proximity to one conductor of a lamp cord in a simple AC lighting circuit.
3. The test data was obtained by seeking the maximum induced noise near the mid-section of the test cable. This was obtained by sliding the test cable along the noise source cable.
4. Measurements were made in the 0 through 500 Hz range.
5. Cables subjected to this test included the following:
   BELDEN 8412, 8451, 8762
   CANARE L-4E6S, L-4E5AT, L-2E5AT
   COLUMBIA 1323, 2524
   KLOTZ 31030
   MOGAMI Neglex 2534, Neglex 2549
   WEST PENN 452

Test Results

1. Cables which exhibited greater immunity to SCR noise in the previous tests also exhibited greater immunity to induced hum.
2. Peak voltages, except 60 Hz, come from harmonics of the AC power line frequency.

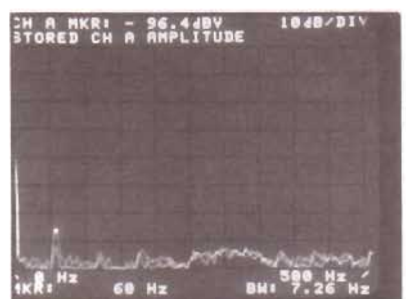


Figure 30 – Canare L-4E6S Hum Noise (0–500Hz)

Figure 31 – Canare L-4E5AT Hum Noise (0–500Hz)

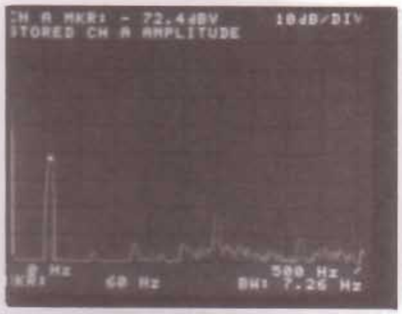


Figure 32 – Canare L-2E5AT Hum Noise (0–500Hz)

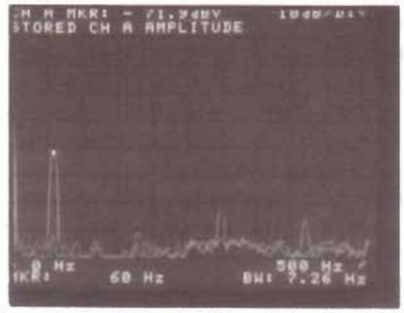


Figure 33 – Belden 8762 Hum Noise (0–500Hz)

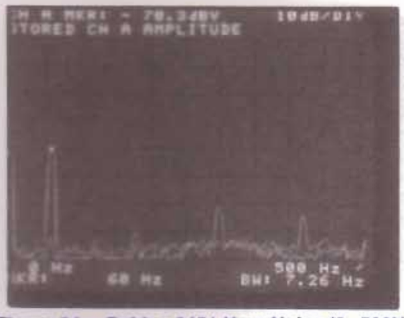


Figure 34 – Belden 8451 Hum Noise (0–500Hz)

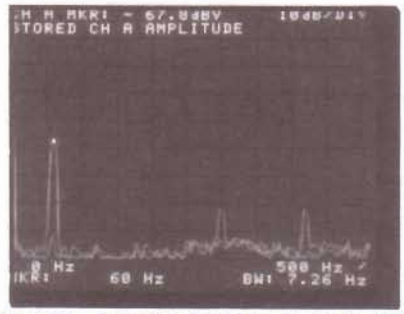


Figure 35 – Columbia 1323 Hum Noise (0–500Hz)

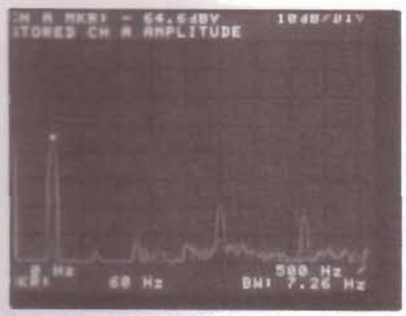


Figure 36 – Klotz 13030 Hum Noise (0–500Hz)

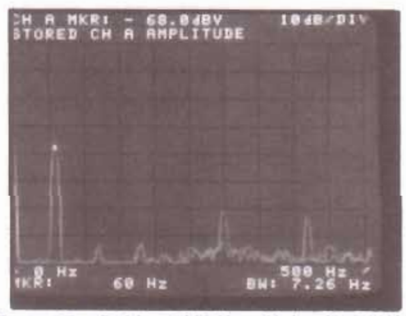


Figure 37 – Belden 8412 Hum Noise (0–500Hz)

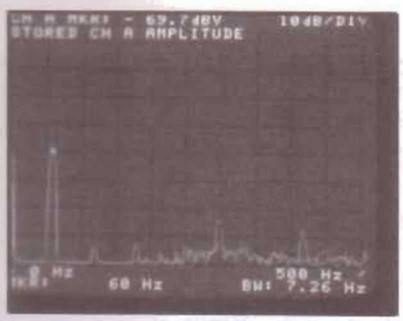


Figure 38 – Columbia 2524 Hum Noise (0–500Hz)

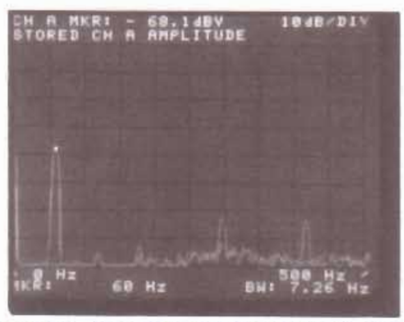


Figure 38 – West Penn 452 Hum Noise (0–500Hz)

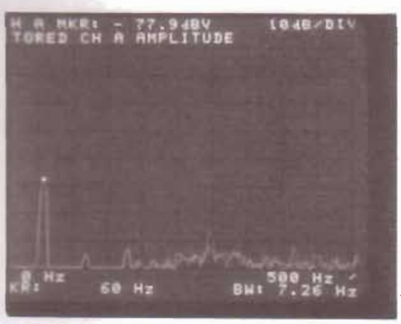


Figure 40 – Mogami Neglex 2534 Hum Noise (0–500Hz)

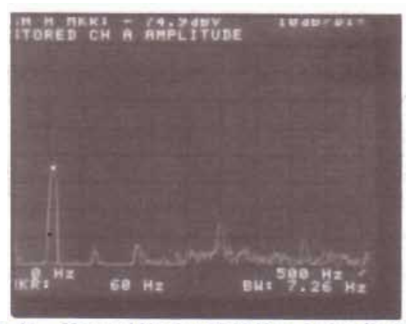


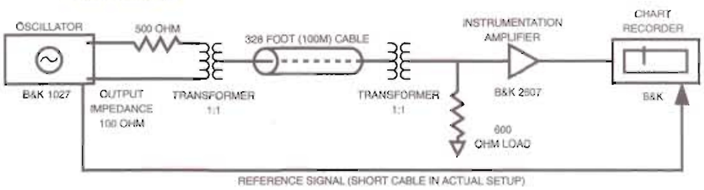
Figure 41 – Mogami Neglex 2549 Hum Noise (0–500Hz)

Testing For Frequency Response Degradation

General Description

While it may not make sense to measure the frequency response of an audio cable, cables most definitely affect the frequency response of the circuits in which they are used. The reactance of the cable serves as a filter which, depending on the source impedance, load impedance and cable length, can noticeably affect the high frequency (and phase) response of the audio system. These tests were devised to show how, in a typical line-level audio circuit, various microphone cables affect the frequency response. While the curves will differ in microphone circuits, due to the different impedances, the overall effects will be similar.

Test Setup



Frequency Response Degradation test setup

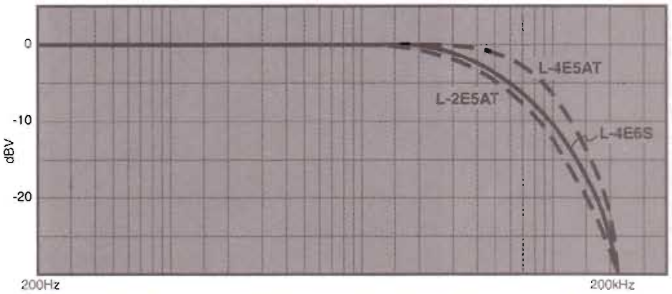


Figure 42 - Canare L-4E6S, L-4E5AT & L-2E5AT Frequency Response

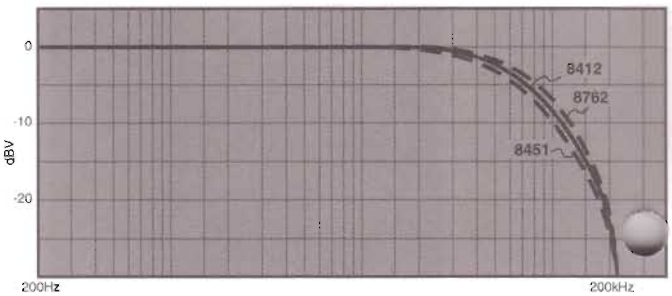


Figure 43 - Belden 8412, 8451 & 8762 Frequency Response

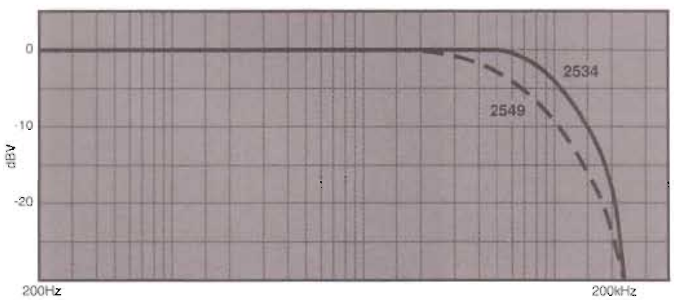


Figure 44 - Mogami Neglex 2534 & 2549 Frequency Response

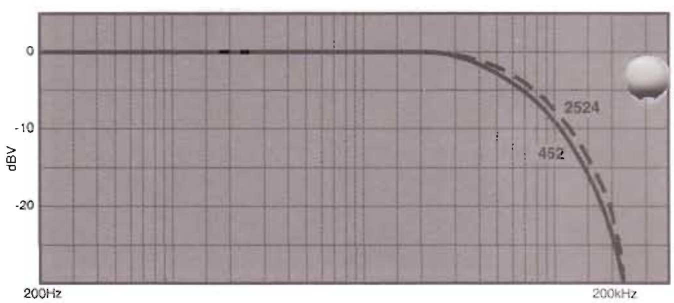


Figure 45 - West Penn 452 & Columbia 2524 Frequency Response

Measurement Conditions

1. The test cables were 328 feet (100 meters) in length.
2. Each cable tested was connected between two 1:1 transformers, with a 600 ohm source impedance from the test oscillator and a 600 ohm terminating load resistor across the input of the instrumentation preamplifier. This constituted a 600 ohm balanced (floating) circuit.
3. Nominal test signal level was 0 dBV (1 volt RMS).
4. Measurements were made in the 200 Hz through 200 kHz range (scale is 10X that shown on B&K chart paper).
5. Cables subjected to this test included the following:
   BELDEN 8412, 8451, 8762
   CANARE L-4E6S, L-4E5AT, L-2E5AT
   COLUMBIA 2524
   KLOTZ 31030
   MOGAMI Neglex 2534, Neglex 2549
   WEST PENN 452

Test Results

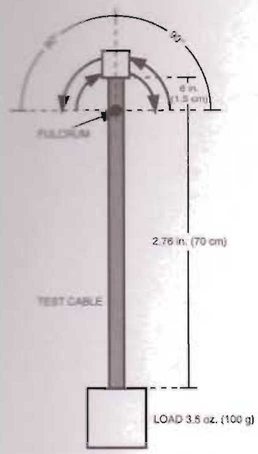
1. Cables insulated with polyethylene, which have very high dielectric constant, preserve good frequency response due to the lower capacitance between conductors.
2. Two-conductor cables maintain their response to a higher frequency than 4-conductor cables. This is due to the higher stray capacitance in the 4-conductor cables, which acts with the resistance in the circuit to form a low pass filer.
3. The Mogami 2549 cable shown in Figure 44 preserves excellent high frequency response because it has very thick polyethylene insulation.
4. Although the Belden 8412 cable shown in Figure 43 is a 2-conductor type, it exhibits the same high frequency roll-off as the 4-conductor cable due to the use of synthetic rubber insulation (which has a lower dielectric constant than polyethylene).

Testing For Durability By Means of Repetitive Flexing

General Description

If a microphone cable is used, it will be flexed. A cable should be capable of withstanding repeated flexing under heavy commercial use, and maintaining its mechanical integrity as well as its shielding effectiveness. The test results will show why some cables are preferable to others, even though laboratory "bench tests" of shielding effectiveness may not show a clear advantage. Only braided shield and spiral wrapped shield cables were tested. Foil tape shields are known to be intolerant of flexing, and such cables are primarily for use in fixed installations (i.e., within equipment racks or conduit).

Test Setup



Flex Durability test setup

Test Conditions

1. The test was performed in accordance with EIAJ (Electronic Industries Association of Japan) standard RC-7702 "Flex durability test of microphone cables."
2. As can be seen from the test setup diagram, the cable was fixed to a movable anchor, with a 0.6 inches (1.5 cm) length of cable between that anchor and a fulcrum. The remaining 27.6 inches (70 cm) of the cable was suspended beneath the fulcrum, with constant tension supplied by a 3.5 oz (100 g) weight.
3. The cable was bent at a 90 degree angle, left and right, for 50,000 cycles.
4. The flexing speed was 20 left/right bend cycles per minute.
5. After flexing, the cable's outer insulation was carefully removed in the area of the fulcrum so that the braid could be examined and photographed.
6. Cables subjected to this test included the following:
   BELDEN 8412
   CANARE L-4E6S
   MOGAMI Neglex 2534, Neglex 2549.

Test Results

1. Spiral wrapped shielding is much less tolerant to flexing than braided shielding, Both such cables tested (see Figures 48 and 49) were so badly deteriorated that all conductors in their shields were broken.
2. Not all braided shields are equivalent. Notice that most of the shield conductors were broken in the cable in Figure 47, whereas none of the shield conductors were broken in the cable in Figure 46.
3. These tests illustrate why, even though spiral wrapped cable appears to give better electrostatic noise immunity than braided cable in initial lab tests, it is likely to give worse results in actual field conditions.

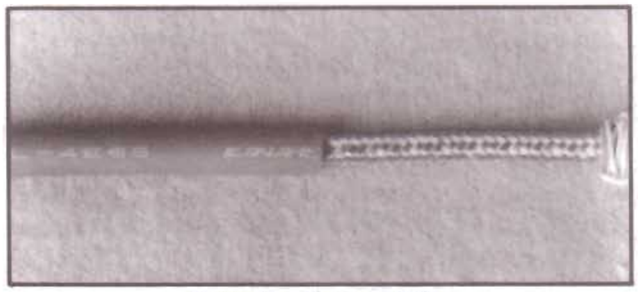


Figure 46 – Canare L-4E6S

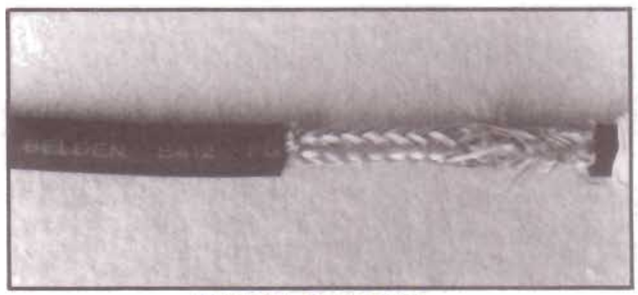


Figure 47 – Belden 8412

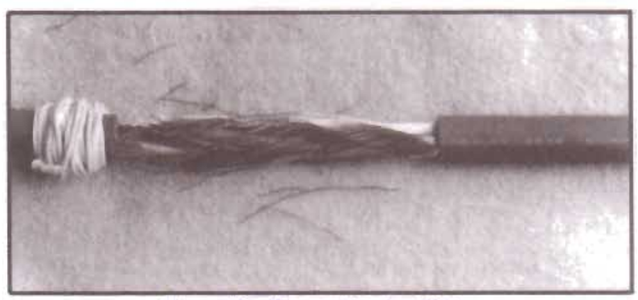


Figure 48 – Mogami Neglex 2534

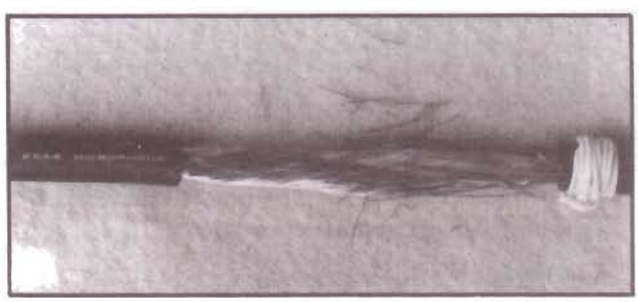


Figure 49 – Mogami Neglex 2549

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