

Lady Fidelity
&
**Academia vs. Esoterica,
Audio Research & Experiments**



"The search for truth is more precious than its possession."
Albert Einstein

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&

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Dedicated to:

Dr. Robert Meyers,
[1951- 2000]

Erick Alexander,

Richard Diamond ,

and to my grandfathers

Reuben Walter Larsson - Swedish black smith - mechanic &
Alvey Clark McCullough - Irish horticulturist – roses.

With special thanks to the following:

Kimber Kable, Sound-Tube, Talon Audio,

and Mayor Glenn Willey of Plain City, Utah.



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Prologue

Over the previous twelve years we have compiled and developed many interesting ideas for testing and improving the Fidelity of the audio components in use today.

As part-time consultants, one of our first audio assignments was to design new Speaker-cables and Inter-connects. Fortunately we would soon discover that our 'great' improvements were hidden, lost, un-noticeable and even failed to work at all in some audio systems !

These early 'failures' and hindrances to our 'new' designed cables and inter-connects greatly enhanced our knowledge and understanding of the problems plaguing the Audio world.

Our Book:

Lady Fidelity & Academia vs. Esoterica, Audio Research & Experiments

is intended for the Audio hobbyist to encourage exploration of many of the controversial topics of today's Audio. Lady Fidelity is also written to encourage audio manufactures to explore and try different approaches to their audio designing and testing.

Academia - Esoterica

Also, far too much confusion and useless debating exists in the Audio world. There is little progress in developing new testing procedures, which are needed to more fully understand why we hear and perceive audio-differences in audio equipment and accessories.

Our book, written to share our unique approach to the various audio topics, is a compilation of some of our findings, experiments and tests.

And like most other advances in 'science'; they are *esoteric* in nature.

Esoteric:

- a.) designed for or understood by the specially initiated alone...
- b.) or relating to knowledge that is known by...a small group
- c.) restricted, private or confidential knowledge...

[Webster's Dictionary Ninth 1983 edition p.424]

Looking back on history you will notice all science was esoteric at some time, even the notion of a round world vs. being a flat one, was esoteric!

Academia per-se:

1. very learned, but void of experience in practical matters;
2. conforming to the traditions of a field of study.

[Webster's Dictionary Ninth 1983 edition p.48]

Stuck in the **Academic** paradigms of the institutions of 'higher learning' generally prevents advances in some areas of knowledge, particularly in the **Audio** industry. Some expert, hard core Electrical Engineers hold a disdain for audio research with little understanding of the field themselves. Their experience is severely limited in understanding the FIDELITY of an audio signal. Fidelity, audio-fidelity, is not a prerequisite for good digital or analog signals, for how these signals sound is of no concern.

Whereas in the audio world its whole endeavor is concerned about the *Fidelity* of a audio signal. Unfortunately the audio-world itself has slightly more awareness of the concepts of producing better Fidelity themselves. So the esoteric advances are the only avenue we see that will reduce our ignorance and lead us to learn and understand that which we have yet to truly comprehend. For more often or not new ideas come from private individuals 'experimenting' in the garage or a small workshop.

Academia has its rightful place as the keepers of the foundations of 'proven' principles and laws, but has very little to offer unless it applies itself to explore the undefined and not 'measurable', in order to further comprehend the unknown.

In our discussion of Esoterica, esoteric knowledge is found mostly in part time researchers or some audio manufactures looking for a new Audio 'affects'.

Sadly though, when a new-change or some new-idea is 'found' it is usually over played as a *great new concept*, which is then used to sell over-priced-cables, speaker systems or audio equipment.

But wisely applied, esoteric knowledge builds upon and readily accepts that which is proven or accepted. But at the same time has the ability and 'freedom' to question and apply the 'accepted' principles and physical 'laws' in unique ways.

Failing to solve a problem [or make better sounding cables] lends to a greater appreciation of the principles of 'Lady Fidelity' once an answer is 'found'. This willingness to pursue 'odd' or different avenues of looking at a concern or problem with questioning repose often leads to interesting answers.

For example let us mention two instances of esoteric research...

The Wright Brothers failure after failure of trying to get their aircraft off the ground consumed many hours of valuable time. Using faulty information from the 'academia' of their day, which had incorrectly 'developed' the wrong lift factor; drove the Wright Brothers to head home to their bike shop.

There at their Bike-Shop, the Wright Brothers had to figure out how to set up and perform extensive airflow tests in order to discover the correct lift-factor.

After determining the correct lift-factor they achieved their goal[s].

- - -
Iomega Inc., Roy, Utah 1980: was born of the ashes of the Blue-Gill-Project [as far as I can recall ?]. The lead project manager and several technical team members left IBM to achieve the impossible.

The goal was to shrink down the 14 inch platters of the day to a 5 inch disk with about 70 times more memory; 140 k-Bits to 10 M-bits.

The 'experts', large frame users, media manufactures and 'academicians' of the 1980's thought the project was doomed to failure. Problems of 'bit-size', head-dimensions and the media's magnetic properties and physical limitations had to be addressed. After 3 years of testing, many 'esoteric' experiments & 17 patents; the 10 Mega-bits 'hard'-drive was born: the **Alpha 10**. [Iomega Inc. 1980's]



WARNINIG: we show how to do some home testing on power cords, interconnects, speakers etc.; **You** agree to take **all responsibility** for any and all damage or losses if you make any mistakes !!!

**We do not assume any responsibility or liability
for your mistakes.**

Introduction

Fidelity and Intelligibility

Decades ago the Bell Telephone Company did their famous research to figure out what frequency range was necessary to have good *intelligibility*. The range of 300 Hz to 3 kHz became their spectrum of required frequencies, in order to have highly intelligible phone communications.

In comparison to telephone-work, the frequency spectrum for Good Audio Fidelity, we currently accept the frequency range of 20 Hz to 20 kHz. The difference in being able to clearly hear a conversation is a 'minimal' level of transmission and reproduction as compared to what is required for high Fidelity in high end Audio signals.

Fidelity requires higher levels of technical acuity, accuracy and details in manufacturing in order to reproduce the complex audio signals of 'music'.

So it is our endeavor to 'reveal' and share our 'esoteric' thoughts and works to help the audio-world in the interesting pursuit of creating systems of greater Fidelity. In so doing we offer and provide some interesting experiments to allow audiophiles the opportunity to test-out some of our 'esoteric' thoughts and ideas.

Even though our test equipment that we use is expensive, the home hobbyist can perform most of these tests on their own systems to discover and explore for themselves several 'Esoteric' principles of Fidelity.

Curtis Larson
Ros-Veta Audio
Esoteric Engineering



R.W.L. Vasteras Varja A.C.M.
[A Swedish sword, some made of three separate strips of iron.]

Chapter 1

Crossovers

One of the major reasons for our cable's failures - to provide better 'sound' - was due to the circuits used in most speakers systems:
the traditional 'Crossover'.

It was found that theses Crossover-circuits attenuated and smeared much of the available improvements in our 'new' cable designs.

After many month of testing various 'academic' crossover circuits and designs, ranging from simple designs having a few components, to crossover circuits that have evolved into pounds of reactive components sealed in plastics; we found that these circuits hindered our efforts to reveal the improvements in our 'new' cable systems.

We contacted Talon Audio [Mike Farnsworth] to see if we could do on site research to learn how speakers and crossovers were currently being designed for their High-end speakers.

Mr. Farnsworth was gracious in letting us analyze their designs at the time.

After several months at Talon Audio, we returned to our own shop to do more research on cable designing and speaker inter-face circuits. Erick Alexander made circuits without any capacitors; this idea had us turn our attention to the major components of crossovers circuits:

Inductors and Capacitors.

Even though great advancements have been made in the manufacture of these two major components, we found that these improvements have done little in providing better Fidelity. In some cases these advanced design changes in these components have only added to the CROSSOVER dilemma.

Crossover circuits are 'filters' and they
filter and change the signals passing through them.

FILTERS

Some filters are used to 'filter' out the AC frequency component of 60 Hz, 400 Hz, etc. of rectifier circuits and suppress noise transients in the rectified DC voltage. Many filter circuits are designed to separate different frequencies of voltage from one another.

But, most unfortunately, these same ‘filter-circuits’ are also used to filter, or more accurately, separate the 'Lows', 'Mids' and 'High's from each other in audio speaker systems. This was a logical step at the time [1930's], but as we shall demonstrate has ended up being a big mistake in the pursuit of Fidelity.

As is accepted in the design of filter circuits the design processes do not necessarily consider how the 'filtered' signal will 'sound'.
[Intelligibility vs. Fidelity - p.10]

That is, one of the major tests for Crossover circuits is the *flatness* response. Frequency response is only part of the acoustical ‘picture’. A necessary and crucial companion is the Phase response of the Audio signal.

To discern how a signal will 'sound' once it is 'filtered' is the heart of our problem of the modern Audio systems.

The FIDELITY of the 'filtered' signal is a highly miss-understood topic. So then, let us turn our attention to the ‘filtering’ of these complex waveforms, considering how to best 'convey' and reproduce these complex Audio signals.

Phase

Fidelity, for our discussion, is:

- the accuracy of the details, or the accuracy of reproduction of the original complex Audio signal.

[Webster's Dictionary Ninth 1983 edition p. 460]

Unlike the use of these circuits in AC to DC filtering, where the phase is totally 'lost' or is relatively ignored; in the complex audio signal, the – PHASE – of the signals that make up the complex Audio signals is very significant.

Quote on PHASE [Academia]

“It is not important in amplifying and reproducing sound since the ear is not able to detect relative phase angles of the components of a sound wave.”

McGraw-Hill

Electrical and Electronic Engineering Series

Electronic and Radio Engineering

Fourth Edition 1955; pages: 256-257

part: 8-2 Distortion in Amplifiers; paragraph. C

Phase has several electronic meanings or situations.

One situation is the time-spacing-relationship of the frequencies in respect to each other, the second situation is the relationship of the individual frequency's voltage in respect to its associated current, being in phase [maximum-power], phase shifted or totally out of phase [minimum power].

Phase has other meanings and uses; but we will limit our discussion of phase to the two meanings that have been described.

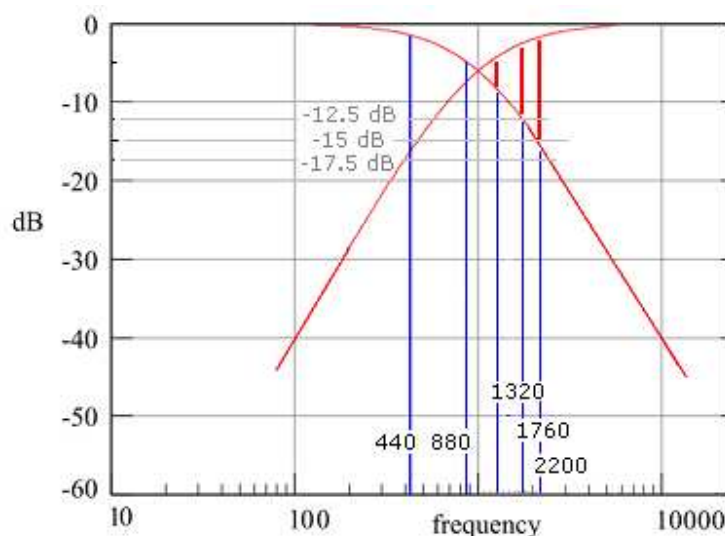
Also, let us remember that Phase-distortion is not the same as Phase-shifting.

Phase distortion can be understood when referenced to time delay.

A Phase shift caused by a Time-delay that is the same for all frequencies of a signal is not Phase-distortion. Whereas, frequencies of a signal that experience a unique phase shift due to different time-delays is Phase Distortion.

When 'filtering' the complex waveforms of Audio signals we must be aware of amplitude and frequency of a signal, but an equal consideration must be given to the 'phase' of the signals making up the complex Audio signals, for 'phase' [phase-angle] is a major factor. [Power = $V * \cos I$]

We all understand that two tones reproduced from two speaker playing two different tones, say 500 Hz and 700 Hz, the listener [as usually accepted] can not detect the phase relationship of these two tones or frequencies. But in a complex waveform the listener can 'hear' or more accurately sense the effects of 'phase shift' of the complex audio signal due to crossovers.



HOW ?

To start with, let us analyze human voices, the piano {27.5 Hz – 4188 kHz} and the violin {Violin ~16 Hz – 4 kHz}. One of the hardest instruments to reproduce accurately is the Violin. So in particular, let us examine the 'A' note of a violin and its component frequencies.

The concert A-note has frequencies components of: 440 Hz, 880 Hz, 1320 Hz, 1760 Hz, 2200 Hz and many upper partials.

[Non-harmonic components and other frequency elements].

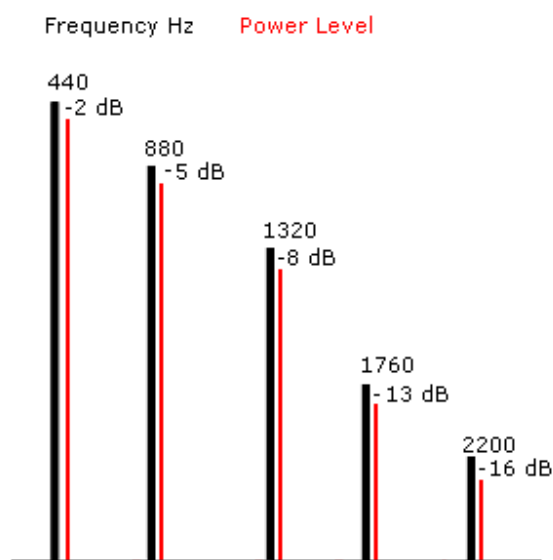
If you will notice' that when we use a crossover point of 1,000 Hz; the A-note has four of the major component frequencies [880, 1320, 1760 and 2200 Hz] in the 'crossover' region. These four frequency components are individually -time shifted- from their time-position in respect to their original-companion frequencies. This 'misalignment-in-time' is one of the main problems in reproducing an accurate Timbre, especially in string instruments and in human vocals.

The power of an audio signal is dependent upon the elements of voltage and current and their phase-relationship. That is, in two ways the ***Fidelity*** is altered:

First: Timbre is changed due to individual frequencies relational-phase being shifted [supposedly not discerned - as usually accepted] and

Second: the Power of an individual frequency of the signal is changed -lowered-.

In the region of 'crossing-over', phase is severely shifted, which then attenuates the power of a signal by 3-12 dB depending on the frequency and circuit design.



Other researchers like the Center for Strategic & International Studies have pointed out that .3dB to 1dB variances in amplitude are discernable by the ear. Notice the 880 Hz frequency component is attenuated about 5 dB, 1320 Hz attenuated 8 dB, the 1760 Hz attenuated 13 dB and the 2200 Hz component frequency is attenuated about 16 dB .The upper Frequencies of 1320, 1760 and 2200 may be passed on to a Tweeter at higher power levels than is portrayed in the graph, but these signals will still be severely time-shifted by the high pass circuit(s) [capacitor-dominate].

Phase Distortion

The question of Time-Smearing or Phase-shifting of the constituent frequencies may be more relevant than is customarily accepted !

Remember phase shift caused by a time-delay being the same for all frequencies of a signal is not Phase distortion. Whereas, when a few frequencies of a signal experience any phase shift due to a different time-delay is: Phase Distortion.

Audio signals have many components of different frequencies with their individual amplitudes. These various frequencies also have a specific time orientation or PHASE and amplitude with each other.

Timbre is due to these unique characteristic orientations.

When any of the constituent frequencies are changed in amplitude, or are time-shifted from their original 'position', the Timbre and the Fidelity of the audio signal is altered. It has been found that our ability to discriminate Timbre seems to be related to some kind of time-alignment process.

Listed below are some interesting reports on Phase:

1. Audibility and Musical Understanding of Phase Distortion

Andrew Honashon_at_uclink.berkeley.edu
www.ocf.berkeley.edu/~ashon
Music 108Fall 2002; Professor David Wessel

2. AURAL PHASE DISTORTION DETECTION

Presented by Daisuke Koya
University of Miami
Master of Science in Music Engineering Technology
Coral Gables, Florida May, 2000
http://www.music.miami.edu/programs/mue/Research/dkoya/title_page.htm

3. "On the Audibility of Midrange Phase Distortion in Audio Systems,"

S. P. Lipshitz, M. Pocock, and J. Vanderkooy,
J. Audio Eng. Soc., vol. 30, pp. 580-595 (1982 Sep.)

4. The Differential Time-Delay Distortion and Differential Phase-Distortion as Measures of Phase Linearity

W. Marshall Leach, Jr.

Georgia Institute of Technology, School of Electrical Engineering Atlanta, Georgia
J. Audio Eng. Soc. Vol. 37 No. 9 1989 September

- - -

The following list is some of the more interesting findings from these reports:

- a.) The audibility of phase distortion is an audible phenomenon that has been shown by: Lipshitz, Mathes, Miller, Craig and Jeffress.
- b.) Experiments resulted in an audibility confidence rating in excess of 99% with the two-component tone. [Phase tests]
- c.) Experiment demonstrated that phase shifts of harmonic complexes were detectable.
- d.) Small *midrange* phase distortions are clearly audible.
- e.) Mathes, Millerand, Craig and Jeffress; also showed that a simple two-component tone..., changed in Timbre as the phase of the **second** harmonic was varied relative to the fundamental.
- f.) Phase-shifting predominantly affects frequency components below 1 kHz. The highest Q positions were the most audible on both first- and second-order networks from 113 to 1037 Hz.
- g.) The conclusion drawn by Lipshitz, was that midrange phase distortion can be heard not only on simple combinations of sinusoids, but also on many common acoustical signals.
- h.) On normal music or speech signals phase distortion appears not to be generally audible, although it was heard with 99% confidence on some recorded vocal material.
- i.) Audible phase effects were most noticeable with high network Q settings and with frequencies from 113 Hz to 529 Hz.
- j.) Using a **Low-Q**, 1st order networks, the audible signal changes were of a much lower magnitude.

- k.) Pre-recorded music of male & female singing - fed through a 2nd-order all-pass network, [Q of .5], [some] audible effects were noted with a 95% confidence level.

Read these reports for a greater discussion and details of crossover distortions.

Vocals : Male and Female

Now let us consider male and female vocals other complex Audio signals that are hard to reproduce accurately with a male voice range of ~ 85 Hz - 190 Hz and female voice ~ 260 - 520 reaching up to 2 kHz.

Using a portion of the Fletcher-Munsen graph of Equal Loudness, we will look at some of the 'losses' in male and female vocals.

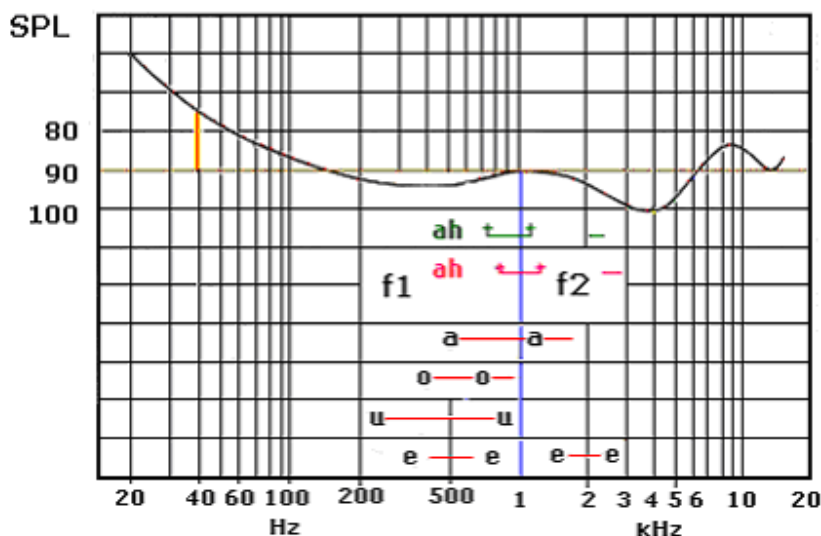
As shown by the following chart of a few vowels, you will notice that the vowels: 'a', 'o', 'e' and 'u' and their 2nd harmonics are engulfed in the 'crossover' region.

Other sounds [Hz]: **e** 480-800 / 1500-2800; **uh** 520-1100 / 900-1750

aw 480-710 Hz / 500-1250 Hz

These vowels are attenuated as per their frequency content and the frequencies are also Phase-shifted changing the Timbre of the vocals. These hidden changes or

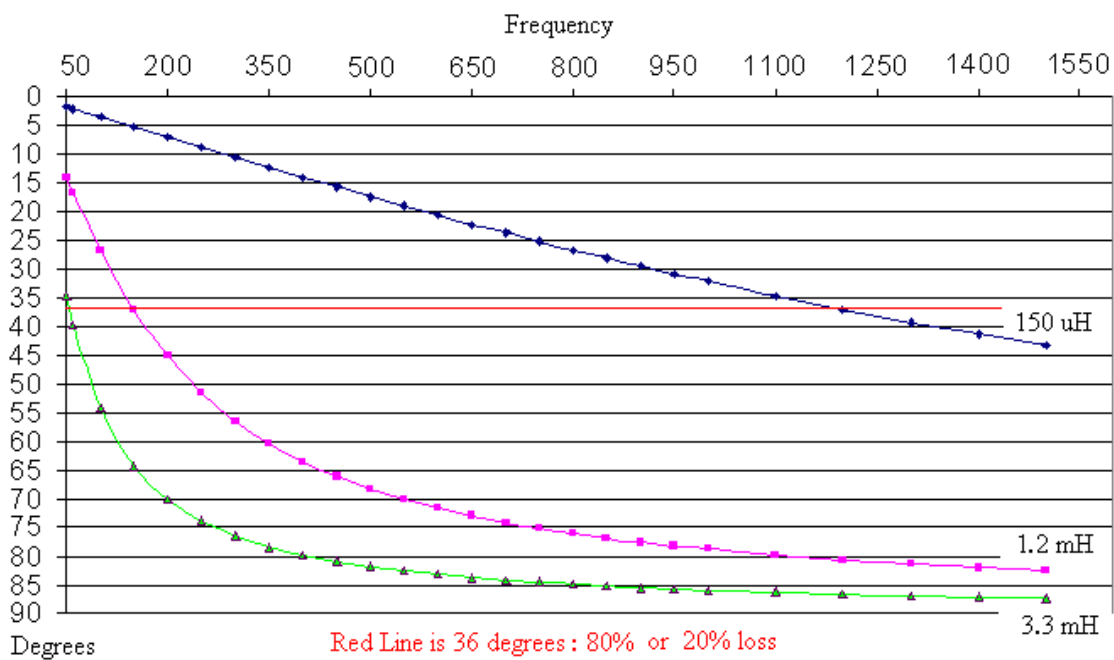
Voice and Vowel Frequencies			
		f1	f2
Male Voice	'ah' 730, 1090 Hz	a-a 500-1,000	1,000 - 1,700
Female Voice	'ah' 850, 1220 Hz	o-o 400 - 700	700 - 1,000
		e-e 400 - 700	1,700-2,200
		u-u 200 - 300	500-900



'Smearing' contributes significantly to the lack of 'clearness' of vocal recordings.

By looking at some Phase plots of typical round inductors,
[values of: 150 uH, 1.2 mH and 3.3 mH]
we can see how Phase response of these inductors alters the Audio signal.

Note that a Phase shift of 36-degrees is a relative power level of ~ 80 %.
So at a phase shift of 36-degrees the power has been reduced by ~ 20 %.
 $E \times I \times \cos(\text{phase angle})$ is the power level.



Time Smearing

Unfortunately the vowel's frequencies of 400 Hz to 1500 Hz of human Vocals are in the main-distorting-area of a typical 1 kHz crossover.

For the **150 uH** coil 36 degrees or 20 % loss is at ~ 1150 Hz; the **1.2mH** is at ~ 150 Hz and the **3.3 mH** is ~ 55 Hz.

That is, in the 400 to 1500 Hz 'vowel' regions the

1.2 mH coil is 63 - 82 degrees 'shifted'; loss of: 55 to 86 %.

3.3 mH coil is 79 - 87 degrees 'shifted'; loss of: 81 to 95 %.

This smearing in 'time' [phase] causes a discernable dissonance in vowels, in a violin's timbre and in the Fidelity of instruments and human voices.

Listening Test

For your first test, make up new BRIICe circuits for your speakers if you can, or use an old set of speakers with BRIICe circuits, if you have some. This may take sometime to set up and do, but you will personally hear what damage crossovers do to the human voice.

Then record the following 6 different groups of letter sound as repeated by someone of your family or associates.

1	2	3	4	5	6
A H J K R,	B C D E G P T V Z,	F L M N S X,	I Y,	O,	Q U W;

Play back these recorded sounds on your current Audio system while making mental and physical notes of the sounds. The most noticeable differences are in the audibility of softer words and the clarity of phrases.

Then consider the compounding of all the 'notes' of a musical selection's component frequencies - which are time-smeared, thus creating a hundred fold increase in the audible dissonance of the violin, vocals and most all other instruments. This smeared signal causes what we refer to as mental-dissonance, for the audio signal is actually mentally-tiring to listen to. Steve Larsen, a close neighbor, noticed he could listen to his speakers without becoming weary or tired of listening to his speakers, while working in his shop. We had replaced the 'crossover' circuits with BRIICe, non-crossover, circuits and the effect of becoming weary or 'tired-out' was eliminated. [Chicken Test, Appendix 211]

- - -

Some solutions to compensate for acoustical problem of *Time-smearing* have been adopted over the past years.

One such famous 'solution' is to center the speakers' voice coils inline with the other two speakers' voice coil centers - time-align - in order to correct for the difference in their 'phase' of the three separate speakers.

Another is to place a tweeter in the middle of two mid-speakers in an attempt to realign, time-wise, the audio signals. Several manufactures use various correction circuits to compensate for one loss or another, ending up with a 'New-mix' of faults and distortions.

All that is accomplished - in Time Alignment - is that the Sweet-spot and room nodes are shifted and distorted differently giving a false sense of a more acceptable Fidelity.

SWEET SPOT

May seem odd and out of order to discuss the SWEET-SPOT in relation to the current topic of crossovers instead of under the topic of Speakers, but we feel that SWEET-Spots are not a Speaker or Room-placement problem.

When you go to a concert, not everyone can sit in the 'Sweet-Spot'.

In fact, you can sit most anywhere in the audience and still be in a good listening 'position'. The notion of a 'Sweet-spot' should have been an indication of something being Wrong, [and is now] an obvious demonstration of an induced problem of distortions when using 'crossover' circuits.

A 'Sweet-spot' is that singular point in space where it is the best SPOT to listen. What 'a-sweet-spot' really indicates is that a speaker system is being 'contorted' into producing mistimed audio signals that generate wave fronts that are out of 'PHASE' with each other compared to the original complex audio signal(s).

This Poor-Phasing sets up voids and acoustical aberrations in the three speaker's wave-fronts. [3-way-system] And to add insult to injury the 'certain spot' placement immensely destroys the Fidelity of the recorded music and severely limits the size of the listening area.

None-the-less, we appreciate the many attempts to correct this common audio problem, but the source of this 'distortion' is the 'crossover' circuits.

Before we do the following test, let us consider the power spectrum of an audio signal on a spectrograph.

[See the Graph of a Trumpet at the [University of Whales](#) website.]

If the frequencies, amplitude or phase, of the Trumpet's signal, are changed the spectrograph would be very different in appearance and the trumpet would sound different.

Now let us setup a Phase shift Test.

Phase-Shift Test

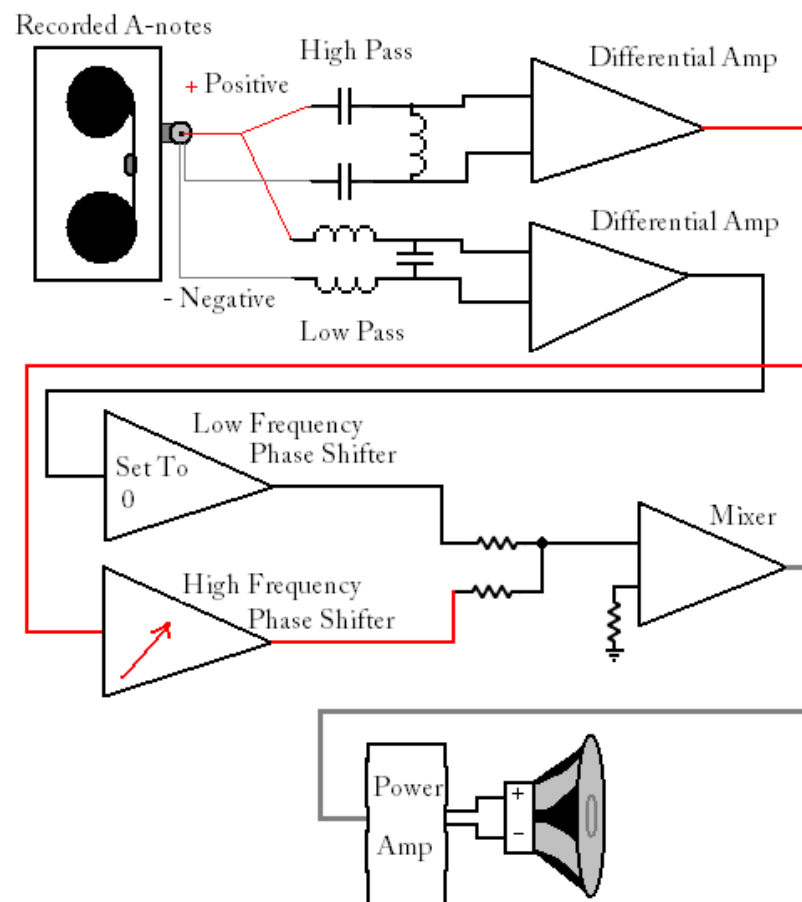
The following lay out is easy to put together with common equipment. The outlined circuit layout shown below was used to check for phase-shift variances in different types of audio sounds.

The Low-pass and High-pass circuits used were our BRIICe circuits. Notice the system has a balanced topography, with equal time-delayed layout.

We started our tests by using a violin's concert 'A' note that was recorded continuously for 2 minutes and then this recorded source was our source of sound for the initial Phase-test. {Violin ~ 16 Hz to 4 kHz}

By having our listeners sit in front of the speaker [4-6 ft. away], we would Vary the High Pass Phase-Shifter without the listener knowing.

Phase Shift Test - Set Up



Richard was our best listener. Richard indicated hearing a 'difference' in the violin's note when the signal was delayed between 6-8 degrees. Most of the other listeners (32) indicated a 'difference' when the Phase-shifter varied from 12-18 degrees and a few could not tell if they heard a difference or not.

This simple test demonstrated the damage done when complex Audio signals are fed through 'crossover' circuits.

To continue our discussion of crossovers, let us look at the following table, which points out some interesting correlations of these two frequency bands.

Frequency Band	Normal Response	When Distorted
250 Hz to 2 kHz	This range is the lower Order of Harmonics of musical instruments	Adds a compression quality sounding like a telephone 500 to 1 kHz. Produces a Tinny sound 1 kHz to 2 kHz, Causing Listening Fatigue
> 2 kHz to 4 kHz	Helps with good Speech Recognition	> 3 kHz Listening Fatigue, with smearing of m-v-b being hard to discern.

Information from: <http://www.bcpl.net/~musicman/freqchrt.htm>

[Visit this site for more details]

Crossovers Components

Coils, Capacitors and Phase

Now let us turn our attention to the components of a crossover circuit and their individual harmful artifacts to the complex process of reproducing Fidelity.

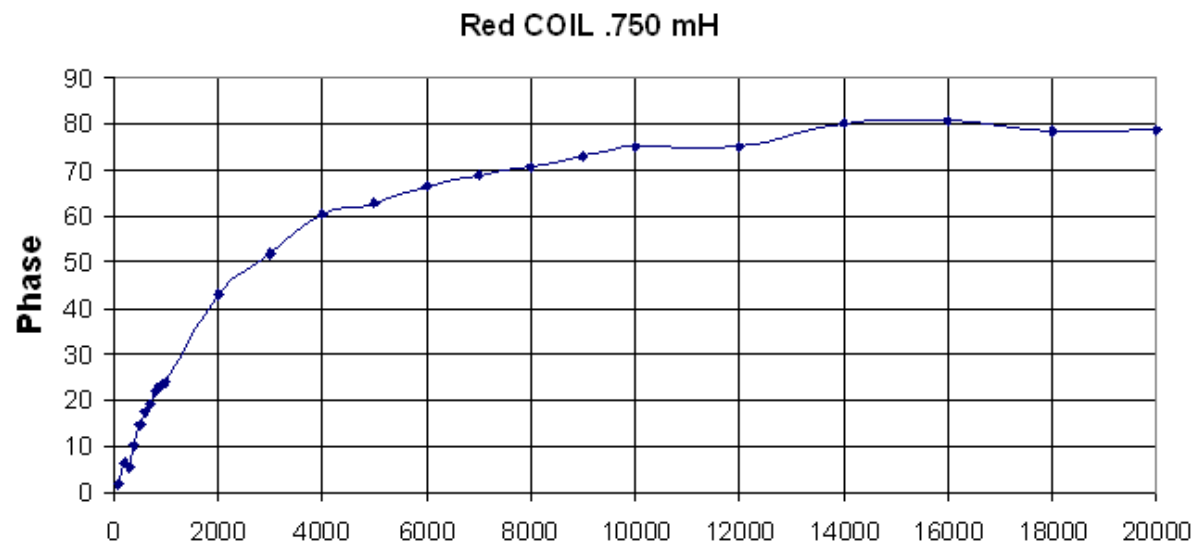
COILS / INDUCTORS

In actual use, coils shift the phase of each the original sound's frequencies E/I [voltage - current] positively from ~ 2 to ~82 degrees depending on coil type, value, and circuit design.

The power, coincidentally, varies from ~ 99 % to ~ 14 %.
[Example .750 mH coil]

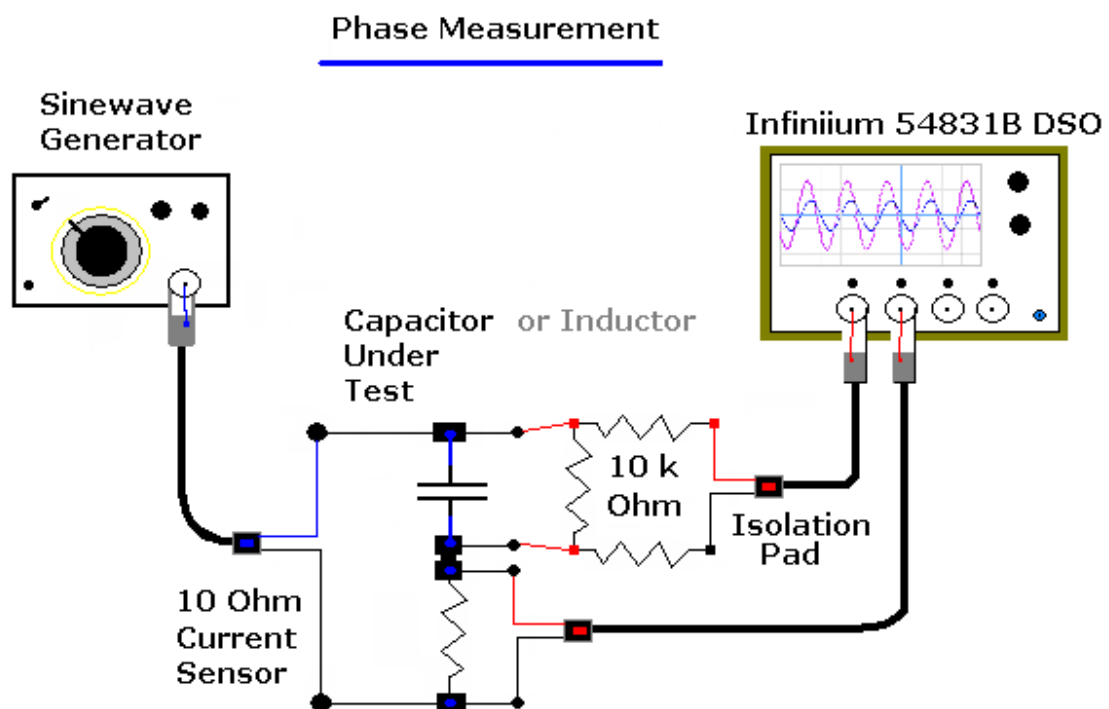
A common coil / inductor was tested and graphed, as shown below, using frequencies from 20 Hz to 20 kHz.

[see the following circuit at Phase Measurement, further down]



This Coil is an AIR-core Type – Hi - “Q” type.

Phase Measurement Circuit.



The most used and accepted design of inductors is the air-core, which are wound into a 'flat shape', diameter to length - not long like a solenoid-coil.

FLAT-COILS



This air-core type design is great for a high Q coil, having low dc-R [dc resistance] and relatively high X_L [inductive reactance], but this is not the best 'coil' for the reproduction of Fidelity.

As will be pointed out all inductors should not be used, or very small in value. The following graph shows the PHASE shift of coils over the frequency range of use.

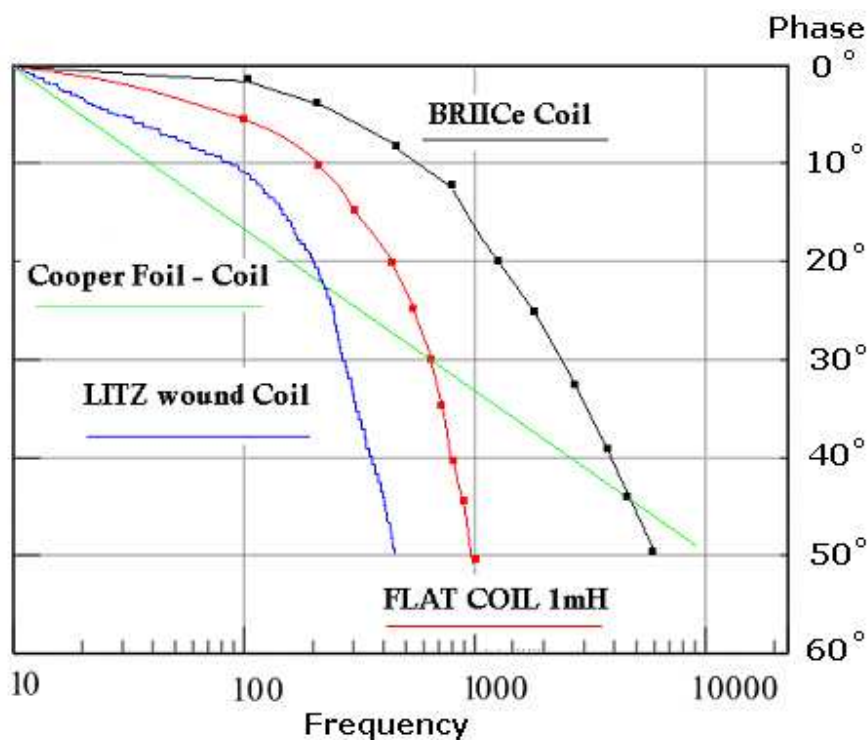
COILS relatively graphed:

BRIICe: long solenoid type on copper pipe,

LITZ, multiple parallel strands of wire - not a true Litz wire -

AIR CORE, no metal in the center of a coil

Flat Copper foil coils: thin flat copper sheet rolled into a coil.



Phase / Frequency
of Various Coils.

Litz coils [Blue line] have a fluctuating phase [as shown above] and a high Q.



Litz coil - type -

Flat air-core coils also have sharp phase shifting and a high Q. Flat copper foil wound coils have a high Q and near linear phase shift; whereas the long, more magnetically stable solenoid [BRIICe], 'coil' has lower-Q and less phase shift per frequency change.

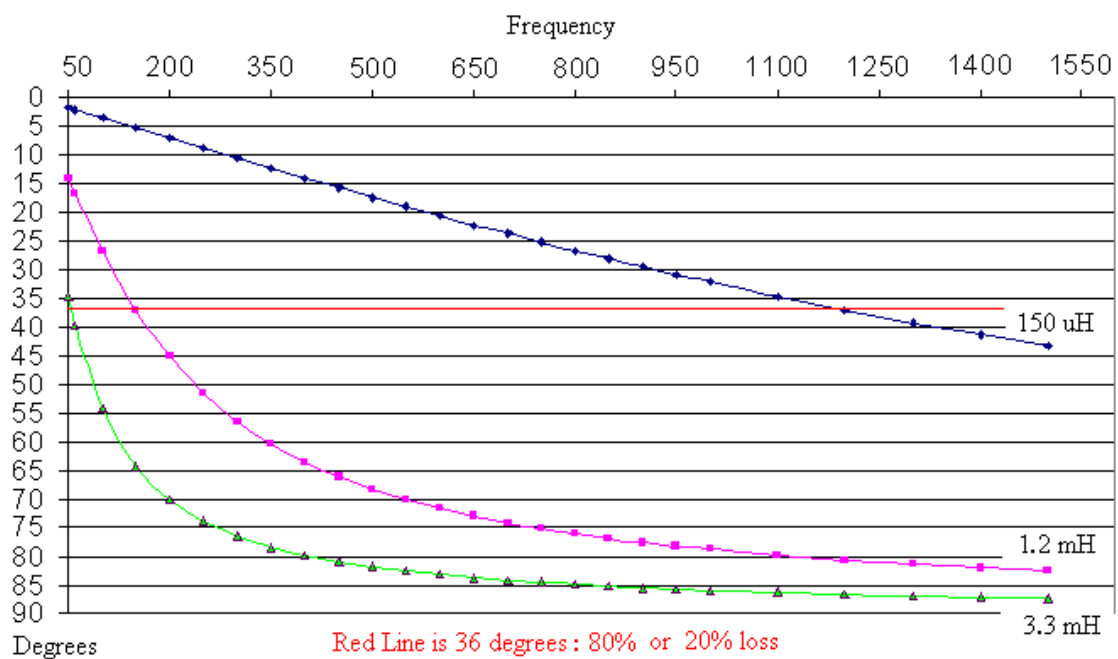
High Q is great for tuning in a narrow band of frequencies and ignoring the lower and upper adjacent frequencies, but high-Q coils also have significant phase -time- shifting characteristics.

15-AWG	10mH	10mH	Time Shift	Percent
	L3 XI	Tan-1 * XI/Rdc		
Frequency	Z-Ohms	Rdc 1.2		
20	1.26	46*	6,388 uS	12.70%
40	2.51	65*	4,514 uS	18.05%
60	3.77	72*	3,333 uS	20%
80	5.03	77*	2,674 uS	21.40%
100	6.28	79*	2,194 uS	22.00%
200	12.57	85*	1,181 uS	23.61%
400	25.13	87*	604.2 uS	24.17%
600	37.70	88.17*	407.4 uS	24.44%
800	50.27	88.6*	307.6 uS	24.61%
1,000	62.83	88.9*	247.0 uS	24.70%
2,000	125.66	89.45*	124.2 uS	24.80%
20,000	1,256.64	89.945	12.49 uS	24.98%
Time Shift =	1 Cycle / 360*	times Degree* Shift		

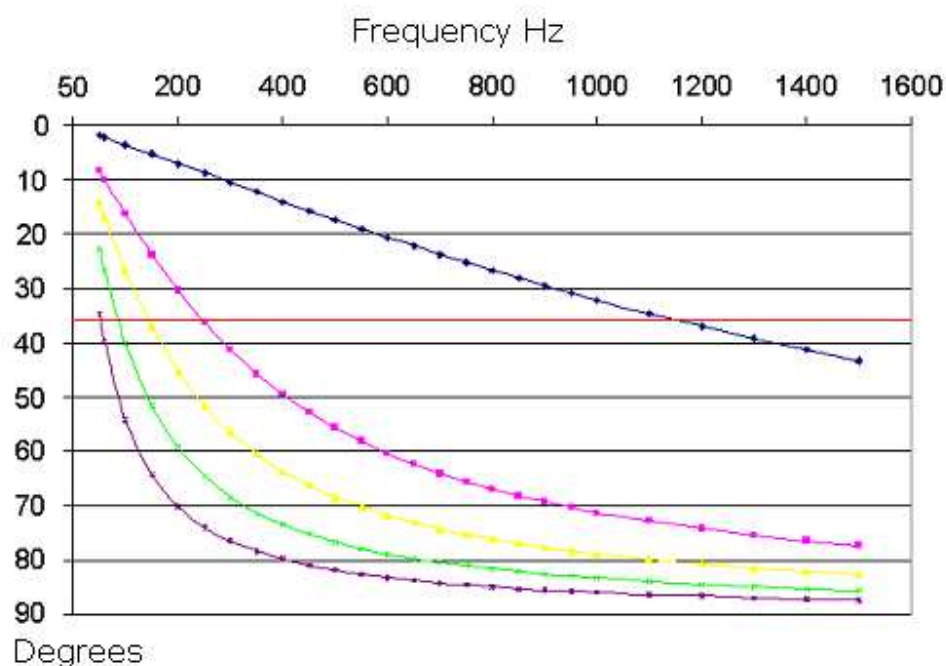
The attenuation and phase-shifting of frequencies in a High -Q- Crossover circuit, as we see it, is OPPOSITE to what we need to conduct frequencies in an audio circuit to obtain good Fidelity.

The 'low Q' coils that we used were solenoid in shape with 6/1 ratio of length to diameter, wound on a 1/2" - 3/4" copper pipe. Longer the length of a solenoid 'coil' the more stable the magnetic fields.

Copper is diamagnetic so by using this copper core the phase is shifted back 6-8 degrees [towards 0-degrees]; that is, in contrast with an 'air-core' coil.



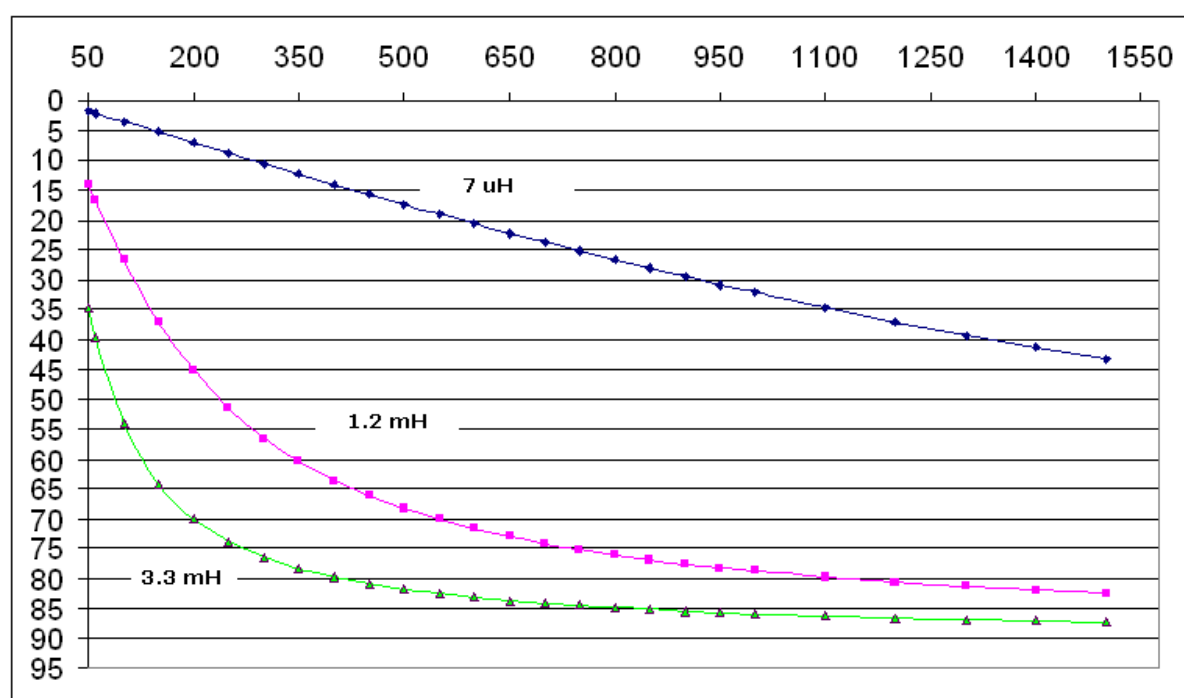
The following graph of coil phase shows most coils have greater than 10 degrees of phase shifting well before 100 Hz !

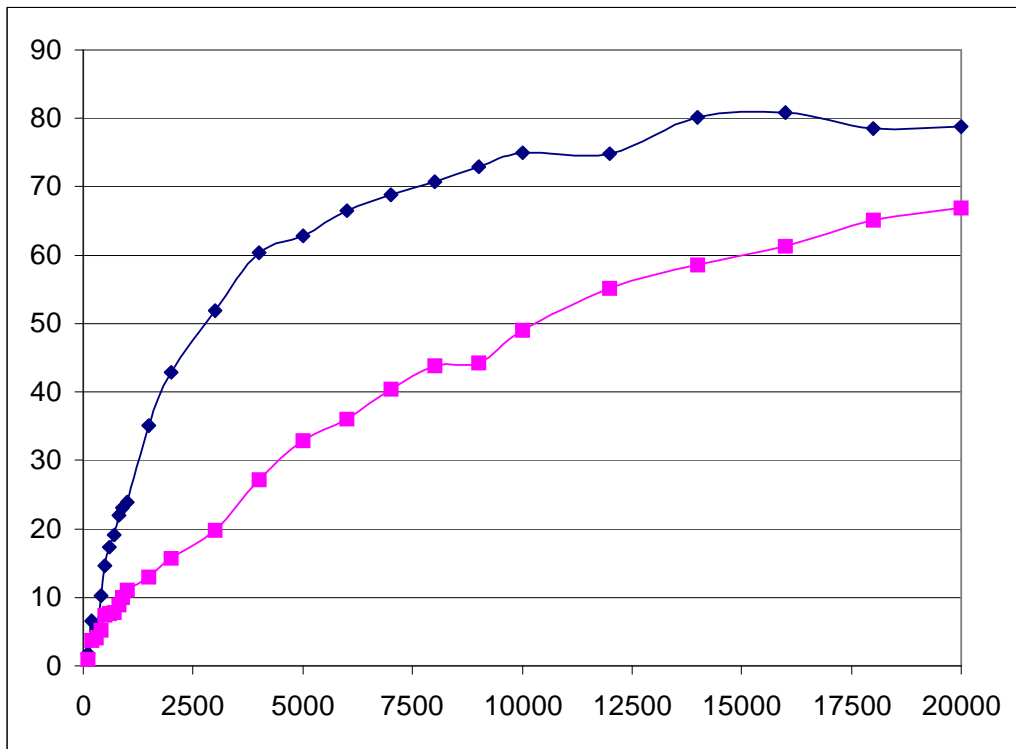


This graph is of 5 standard coils. The lower line [Purple] is the 3.3 mH coil as shown before. 35 - 87 degrees shifted'; loss of: 81% to 5 %

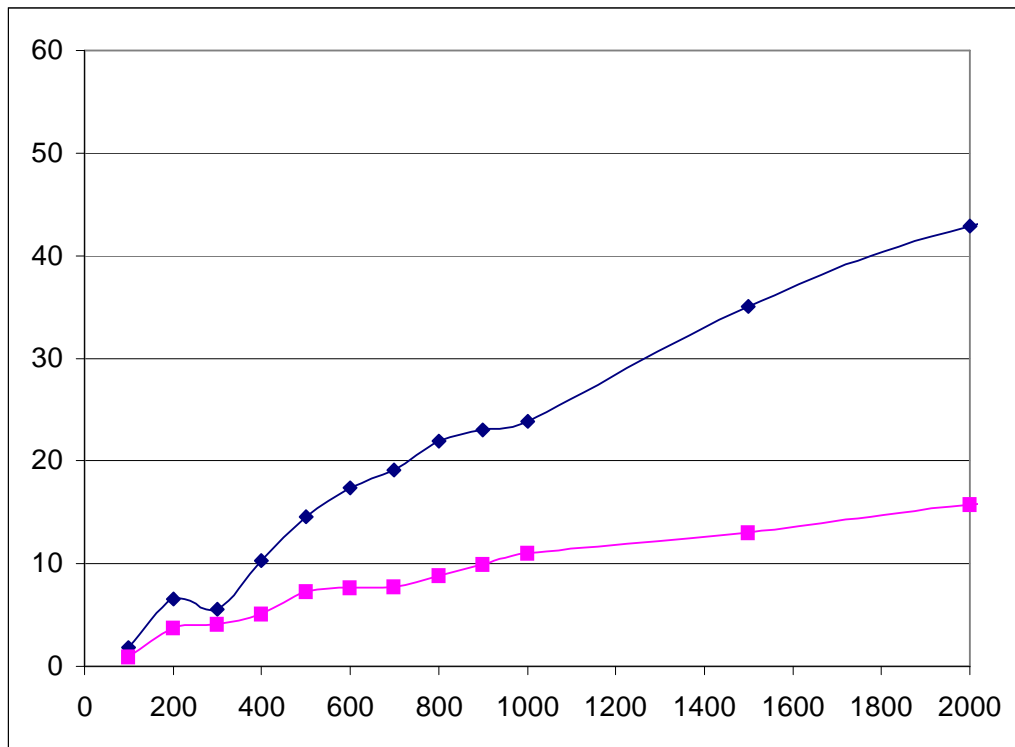
John [a friend from Australia] wanted to know why his woofer was sounding weak; his circuit was using a 3.3 mH coil on the high-input leg of the manufacture's suggested circuit.

At 400 Hz the power loss is 83% using a 3.3 mH coil !





150 uH Pink : 750 uH Blue



200 – 1,000 Hz: Blue 750 uH, has 20degrees of change

We suggested using very small valued coils or a low Q coil, or better yet one of the resistive BRIICe circuits.

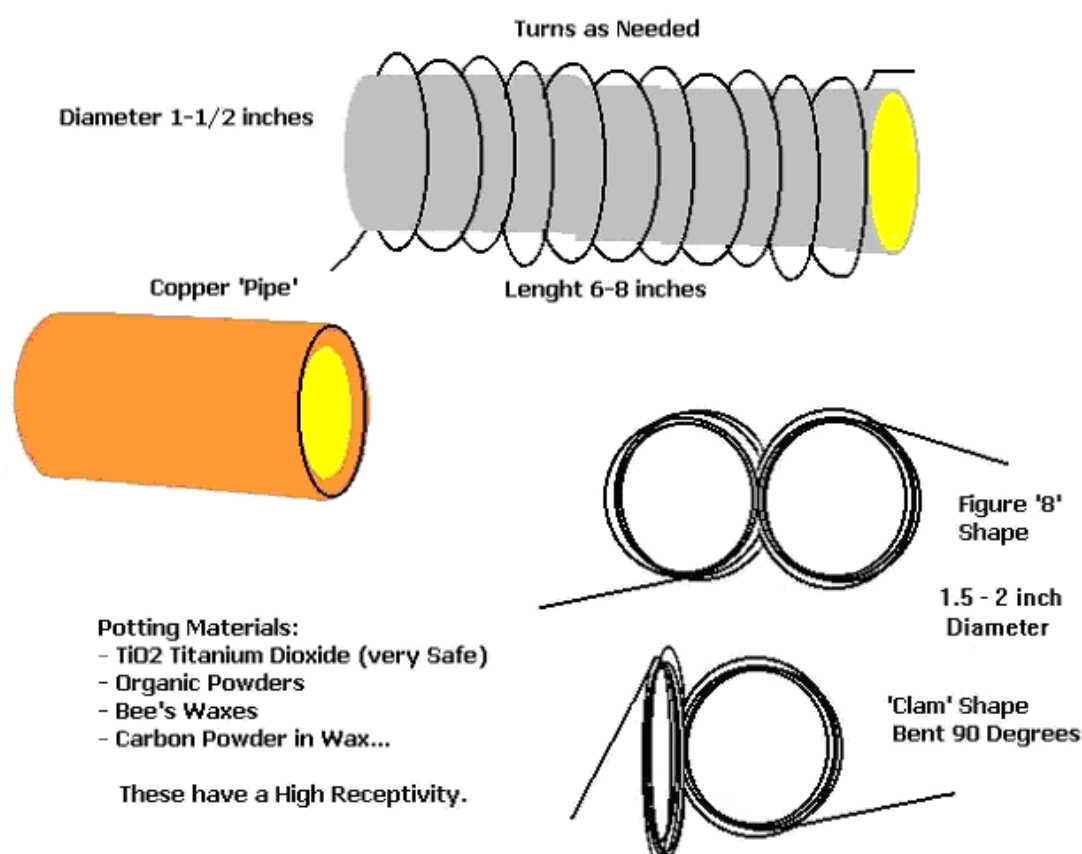
Coil Design for Low 'Q'

Curtis Larson

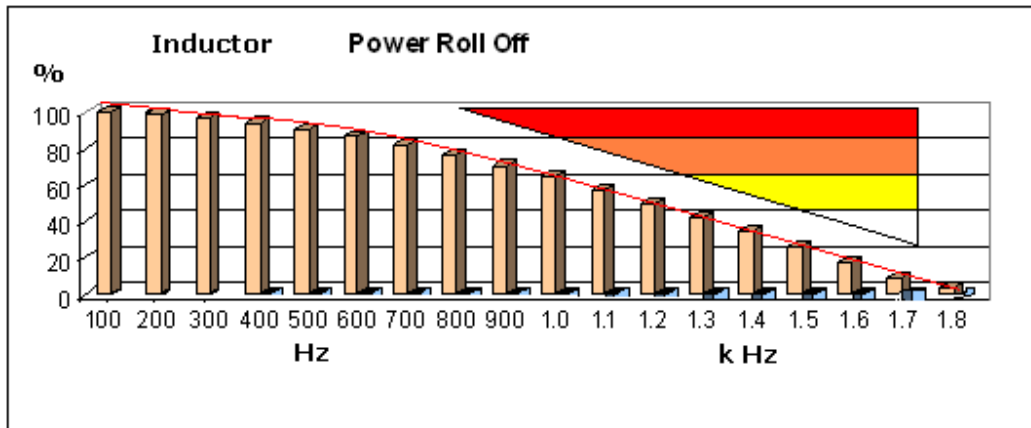
Traditional Coils are short in length, 'fat' and with L/D ratio of 1:4 or worse. This 'shape' produces a High 'Q'.

Low 'Q' coils can be made in different ways

1. Long length over width 6 to 1 or better
2. Copper core: to adjust Phase, 1/4" wall thickness or solid
3. Figure '8' flat shape or 'Clam' style : bent 90 degrees.

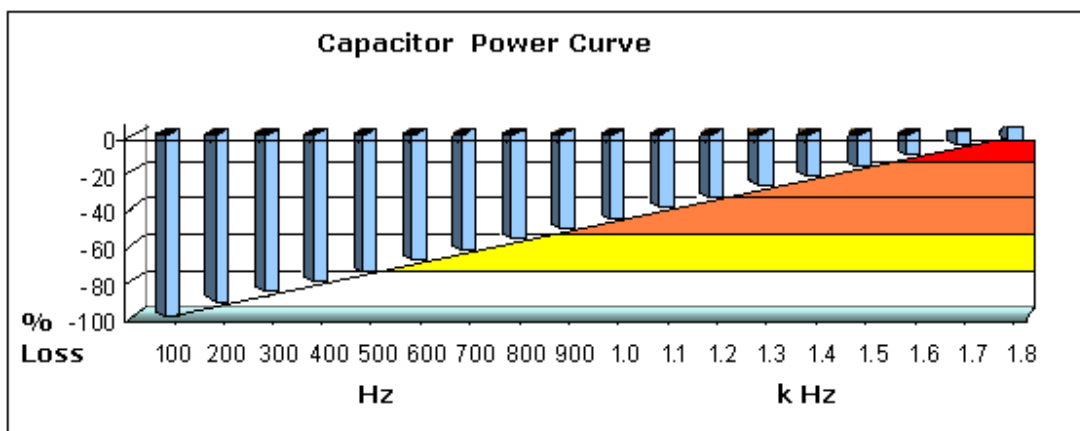


Since a HIGH 'Q' coil is undesirable for FIDELITY try some of these LOW 'Q' coils. These coils can be potted in or with various materials, as listed above-have a large Dielectric-Constant, producing various nuances in the sound.



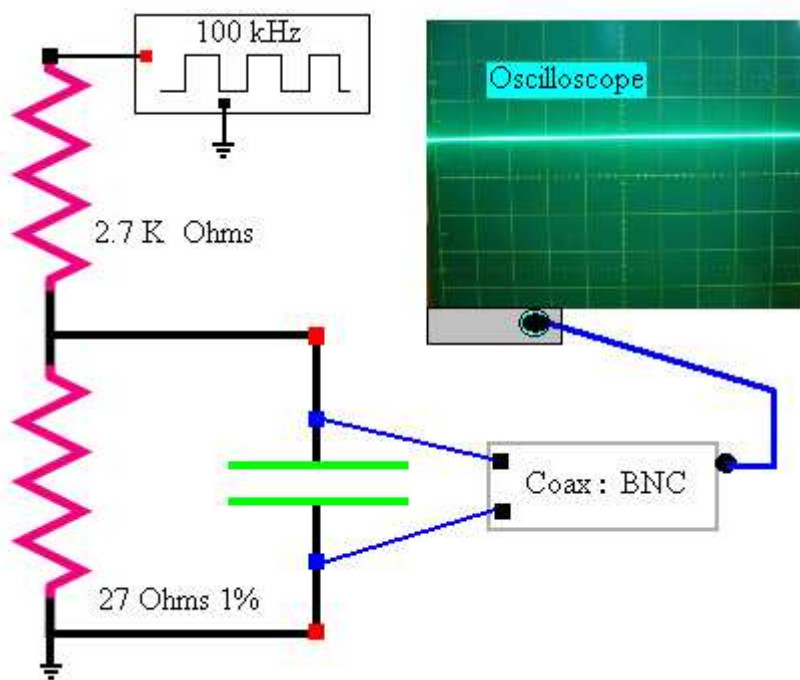
Capacitors

Capacitors have come a long way in power handling, storage capacity and capacitance-value per size, but these too have added to the 'weakness' of crossover circuits. Capacitors shift the E/I signals negatively from 10 to 89 degrees as per capacitor type, circuit design and frequency. The loss in amplitude of a signal through a capacitor is greatest at low frequencies.



Old capacitors of paper and oil are 'slow' electronically speaking and the new plastic-insulator capacitors are fast, have a better Q and a lower dissipation factor; but some newer capacitors are '**noisy**' as compared to the 'old-caps'.

By using a pulsing signal on several types of capacitors we soon see the 'differences' in the signal handling of various capacitors. By applying a square wave at ~ 3 Vrms across a 100:1 resistor-dividing circuit with the capacitor in parallel with a 27 ohm 1% wire-wound [non-inductive] resistor.

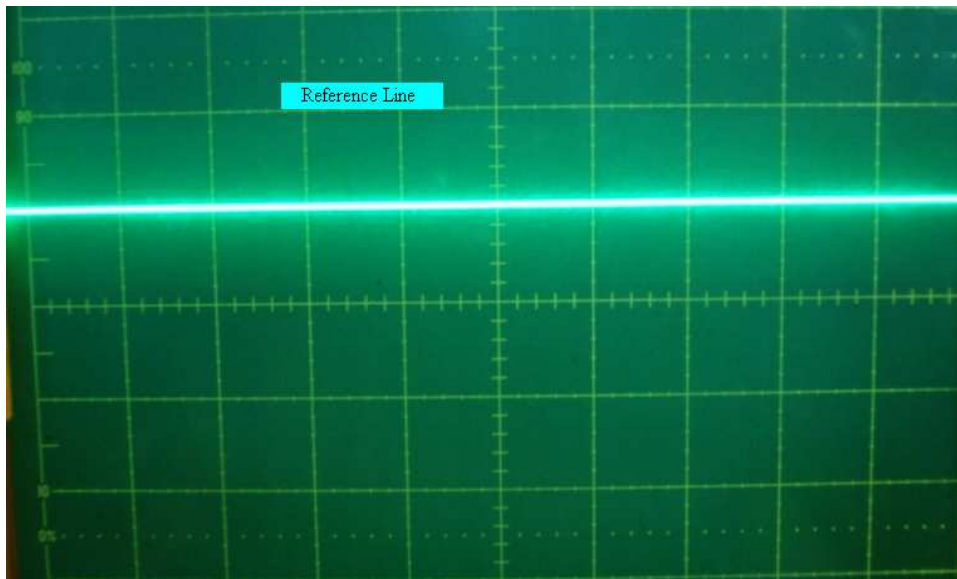


E.S.R.

ESR is a measurement of 'resistance' to the signal passing through a capacitor, or the Equivalent Series Resistance. [AC-resistance: impedance not dc-resistance]

These ESR pictures are of several types of 'old' and 'modern' capacitors.

The 'zero' line is 1 cm above the center line.

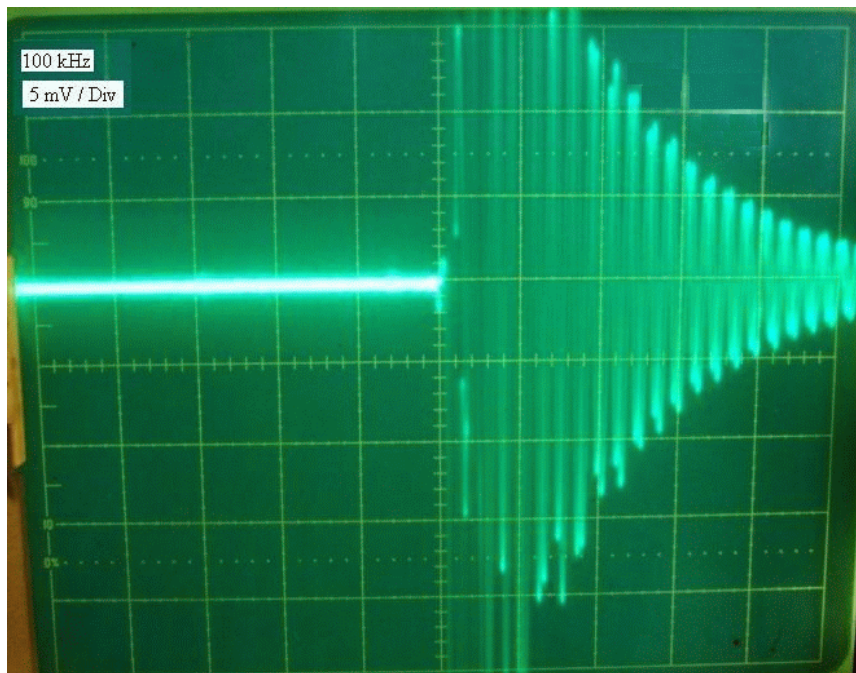


As you can see this Aeon capacitor slopes down about .05 mV.
The scale was set [using a 1 Ohm 1% wire wound resistor]
to be 1 Ohm of ESR per 1 sub-division. [5-mV division]

This Aeon Capacitor sample has then about .5 Ohms of ESR with some ringing.

Two Setups were used to test these Capacitors.

1. A Ringing test used 1 foot of 'coax' on the Resistor / Capacitor junction on the test fixture.
2. ESR test setup used an RCA to BNC connector [1-2 inches total] connected directly to the oscilloscope.

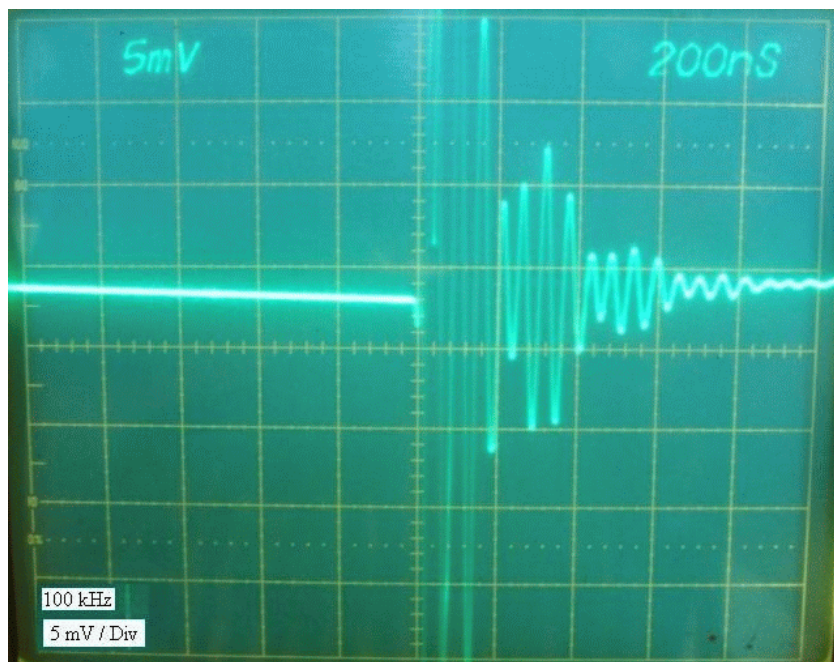
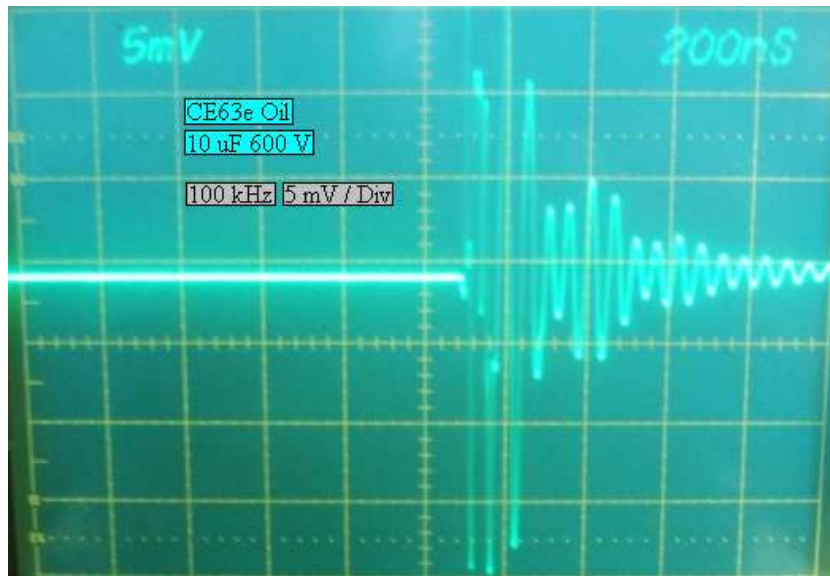


This picture is of a Poly-wrap type Capacitor 6.8 μF , 350 Vdc, a 'circular' wrap design. This capacitor's ESR is negligible [.2mV?], but has excessive ringing showing its inherent 'inductance'.

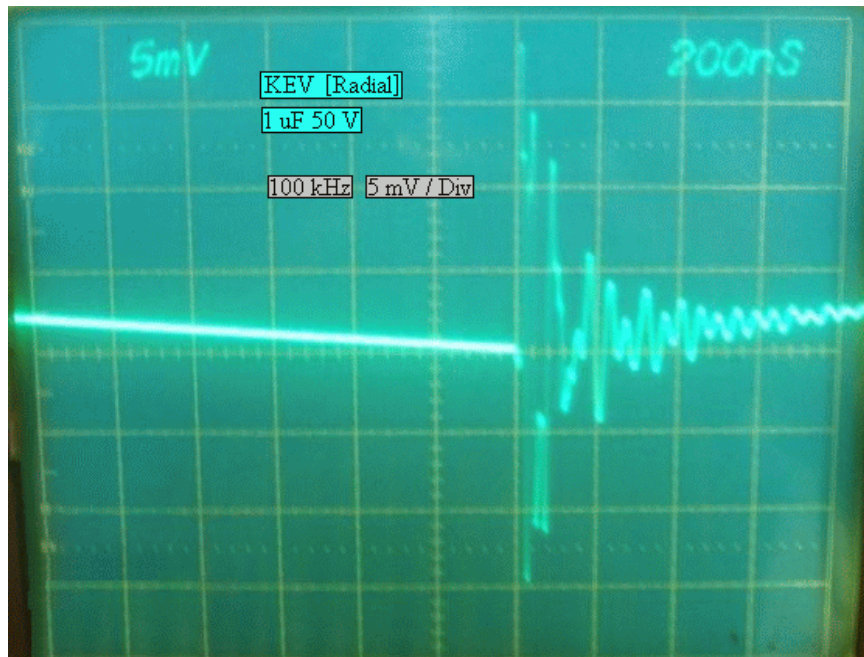
[Scale is: 1 Ohm ESR per 1 sub-division]

- - -

An old oil-type [paper] Capacitor was marked: CE63e 10 μF 600 V, has an unique multiple-ringing amplitudes; but a constant ESR level of 1ohm and having no apparent slope. Notice that this oil-capacitor, in a unique metal-case [rectangular], has three levels of ringing cycles or 'steps' of different amplitudes.



This is a picture of a KEV capacitor: 10 uF / 300 Vdc.
This capacitor has 2 ohms of ESR, obvious slope, with 3-4 levels of 'ringing'.



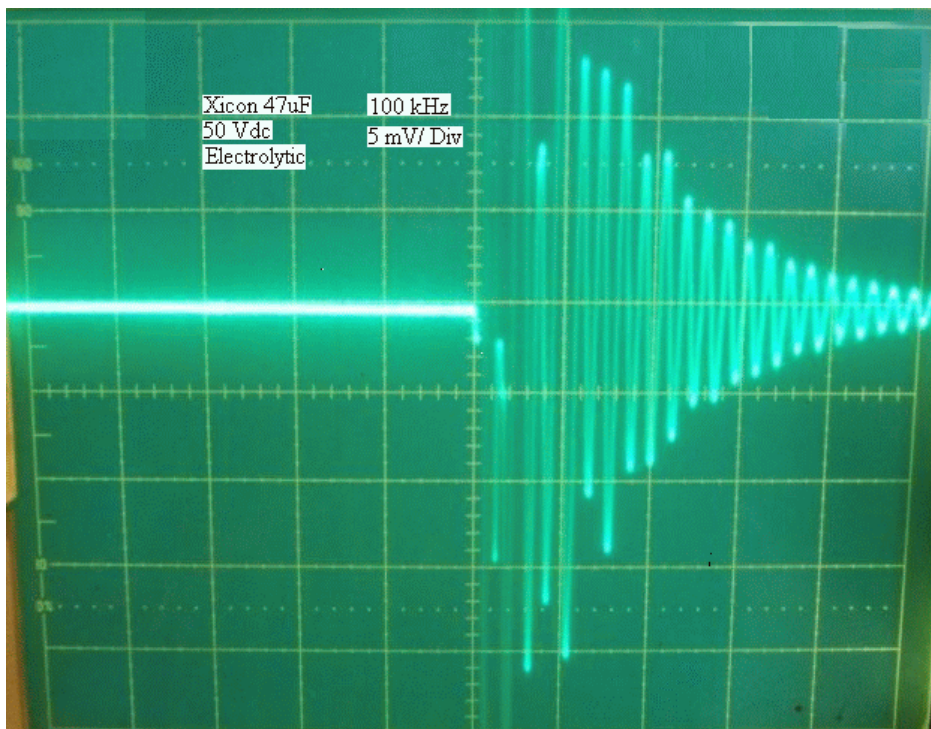
This KEV Capacitor is an 'old-poly' in a round tin can.

This KEV capacitor [a radial design] with has a value of 1 uF, rated at 50 W Vdc, with 5 Ohms of ESR , a moderate slope, with some ringing.

- - -

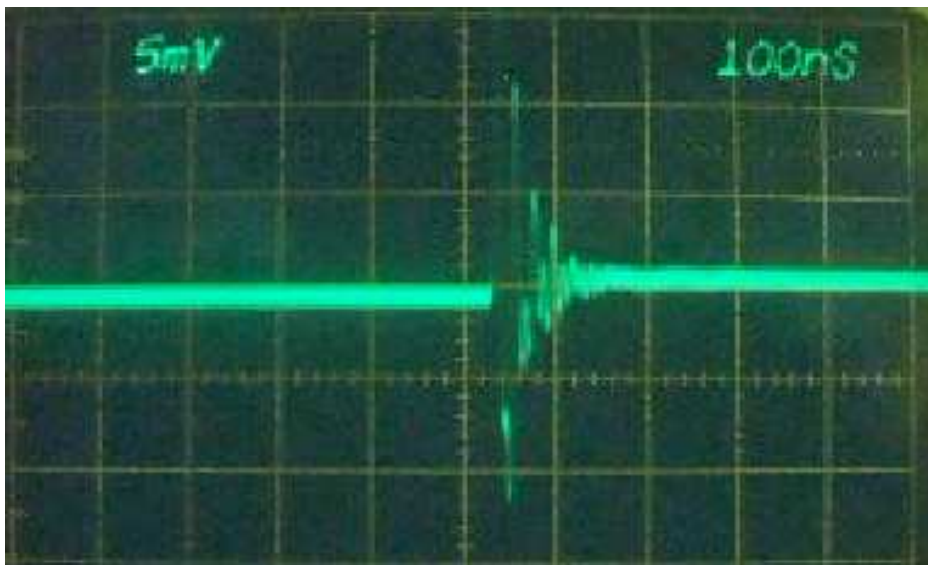
'Silver' Capacitors [used for special military timing circuits] has a large slopping ESR trace, 8 Ohms of ESR and unique ringing characteristics.





Xicon - the ESR is .2-.3 ohms having an extremely small slope characteristic with moderate ringing.

- - -
The electrolytic capacitor has been ignored for audio use for many years. We use these capacitors connected with the negatives connected to the input and speaker connections; the positives connected to each other. The short BNC ESR test shows how these capacitors would react.

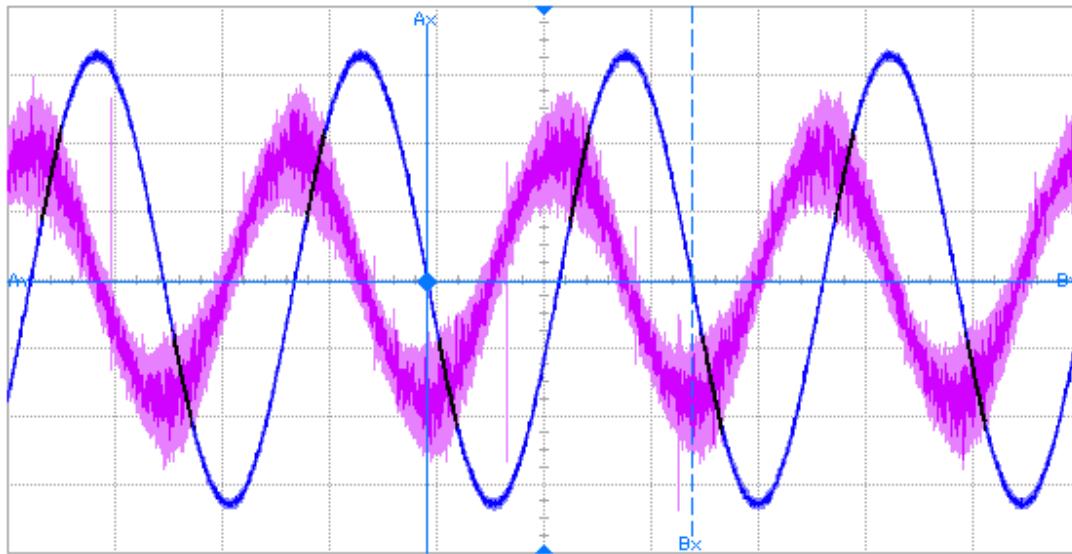


Xicon 47 uF 50 Vdc [same one as above]

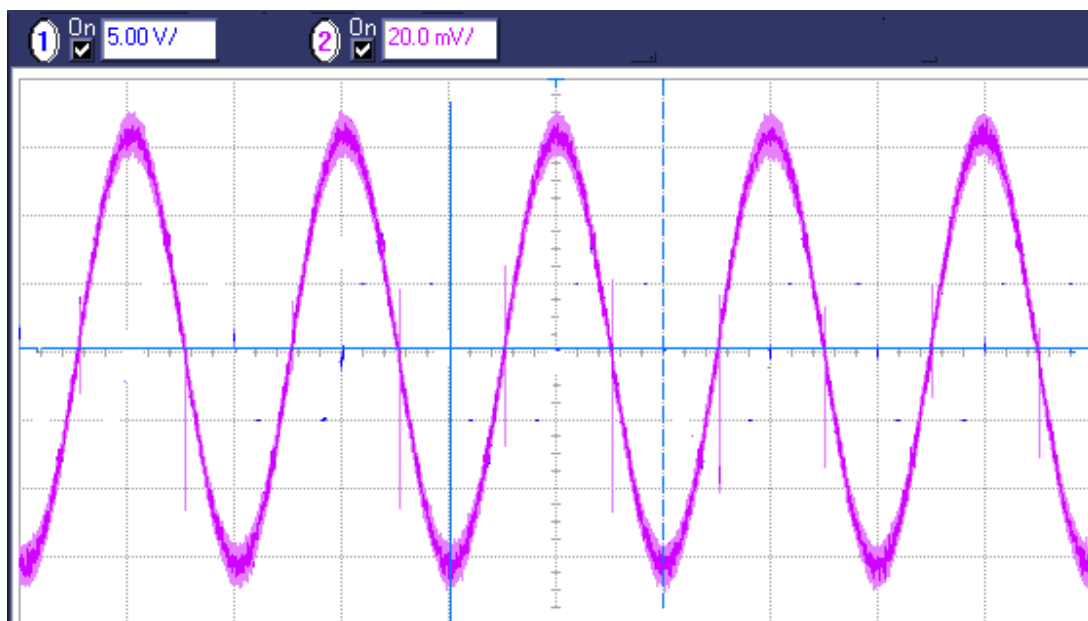
By using two electrolytic capacitors connected positive-to-positive you can use this type of capacitor for audio work and save a lot of money - too !

Due to the 'plastic' insulation in modern capacitors - the dielectric - has tiny amounts of fluctuating static fields, which are easily built up and [in our case] passed on to, or induced upon the audio signal producing a high upper band of 'hiss', or 'noise'.

This picture is of ELPAC at 20 Hz



Whereas this picture of ELPAC is at 100 Hz, 40 mV spikes...



This upper band of frequency ‘noise’ is what eventually lead Erick Alexander to develop his two-component ‘crossover’ circuit(s). By eliminating the capacitor Erick opened the door to the notion of totally re-designing ‘crossover’ circuits.

- - -

Capacitors also have a mechanical noise which has been measured as shown in the following graph prepared by the research of *Clarity Cap* engineers.

The following graph represents the audible mechanical noise measured by a microphone.

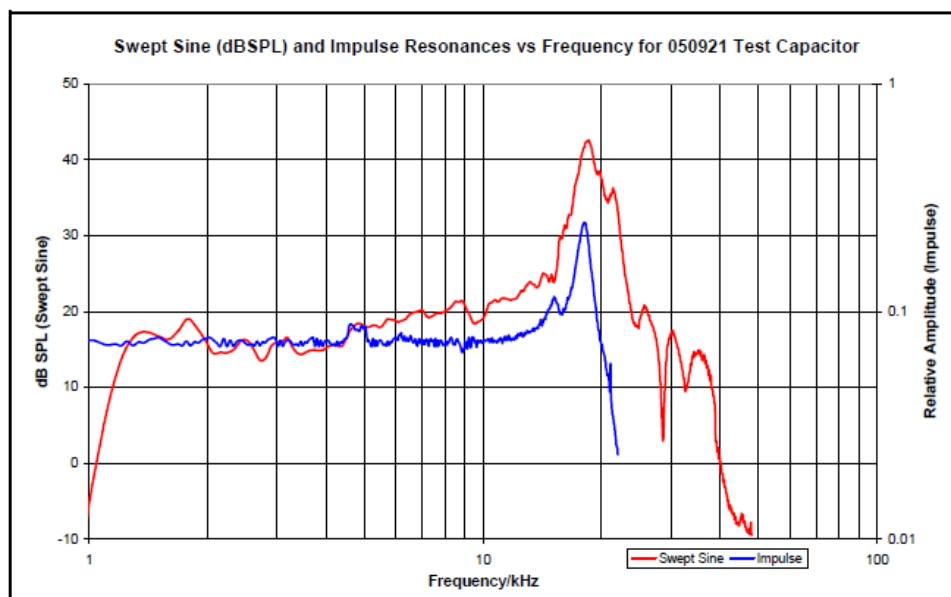
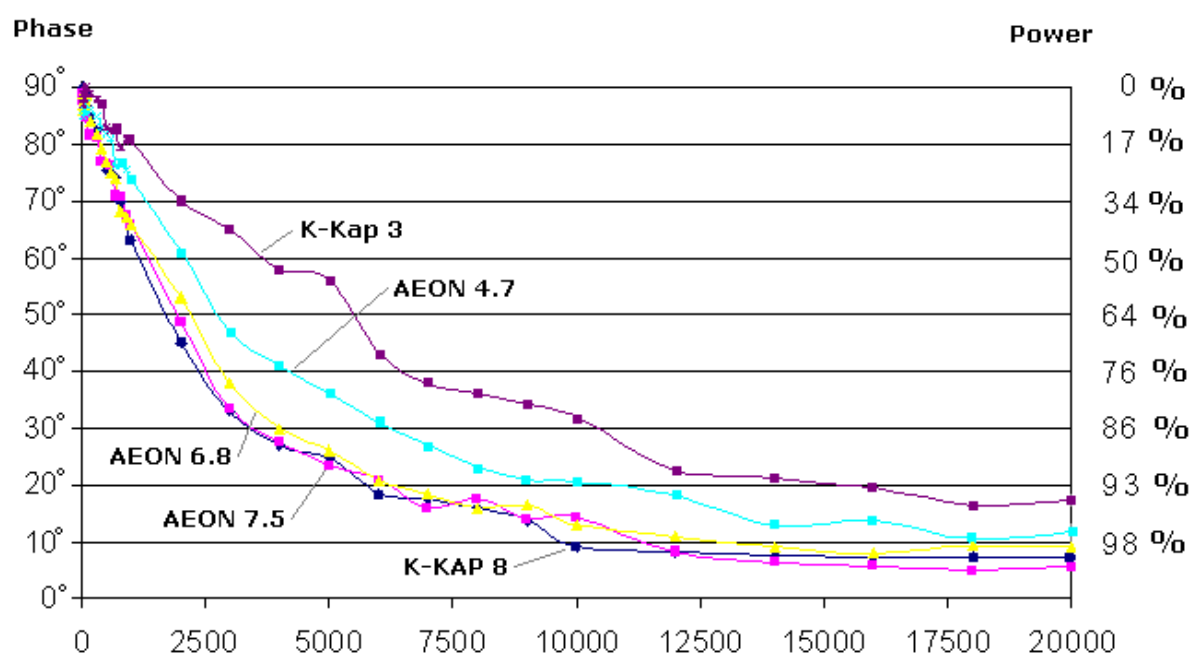


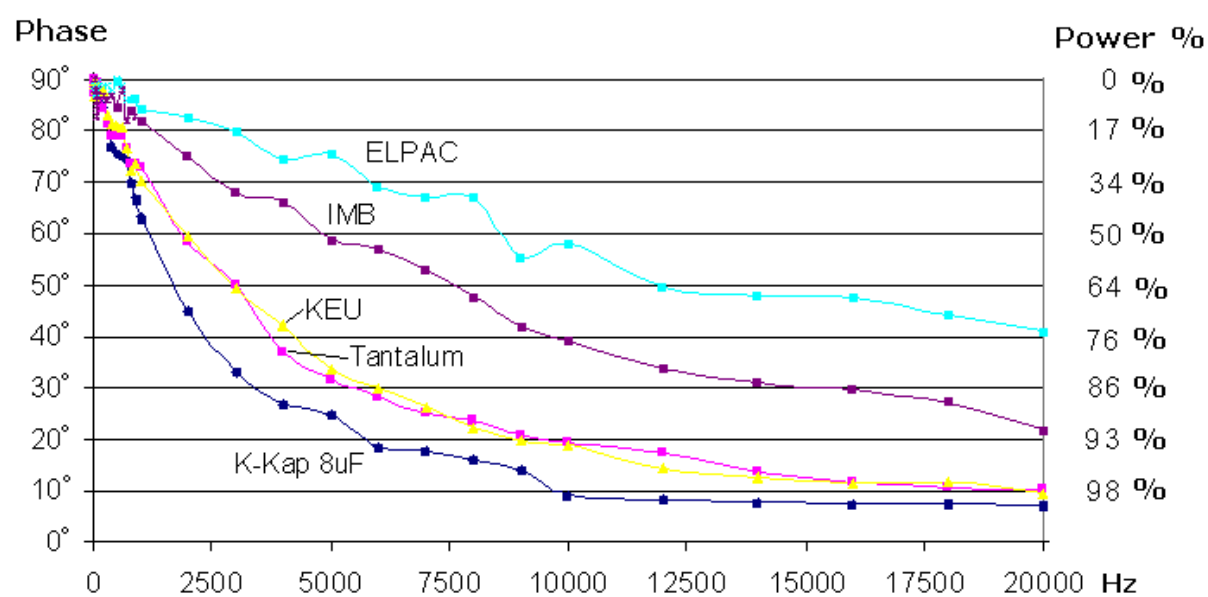
Figure 2. Typical results obtained using swept sine and impulse excitation.

[Used with permission from: David Parkinson **Sales Manager**. www.claritycap.co.uk]
 [Sales@claritycap.co.uk URL.]

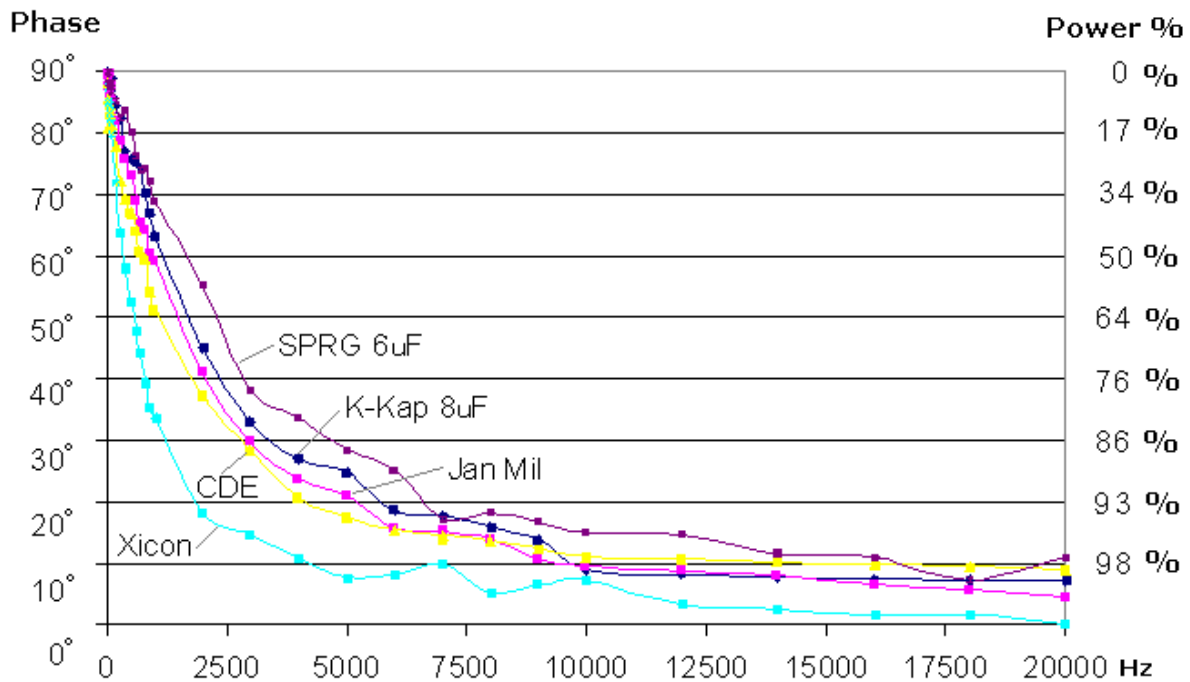
You can watch a video: Paul Dodds, Engineer of Clarity Cap at:
<http://www.sonicstate.com/news/2008/05/27/aes08-if-the-cap-fits-it-must-sound-better/>



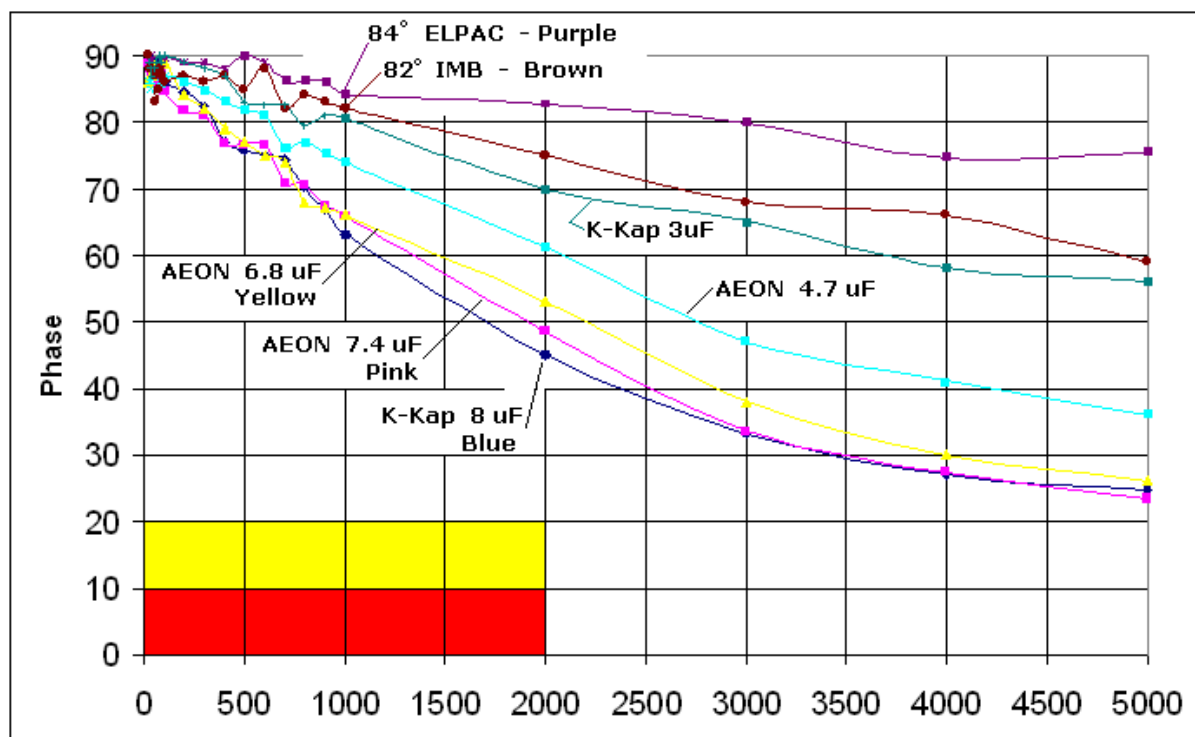
Kimber-Kaps 3uF & 8uF, Aeon Caps 4.7uF-250, 6.8uF-630 & 7.5uF-250

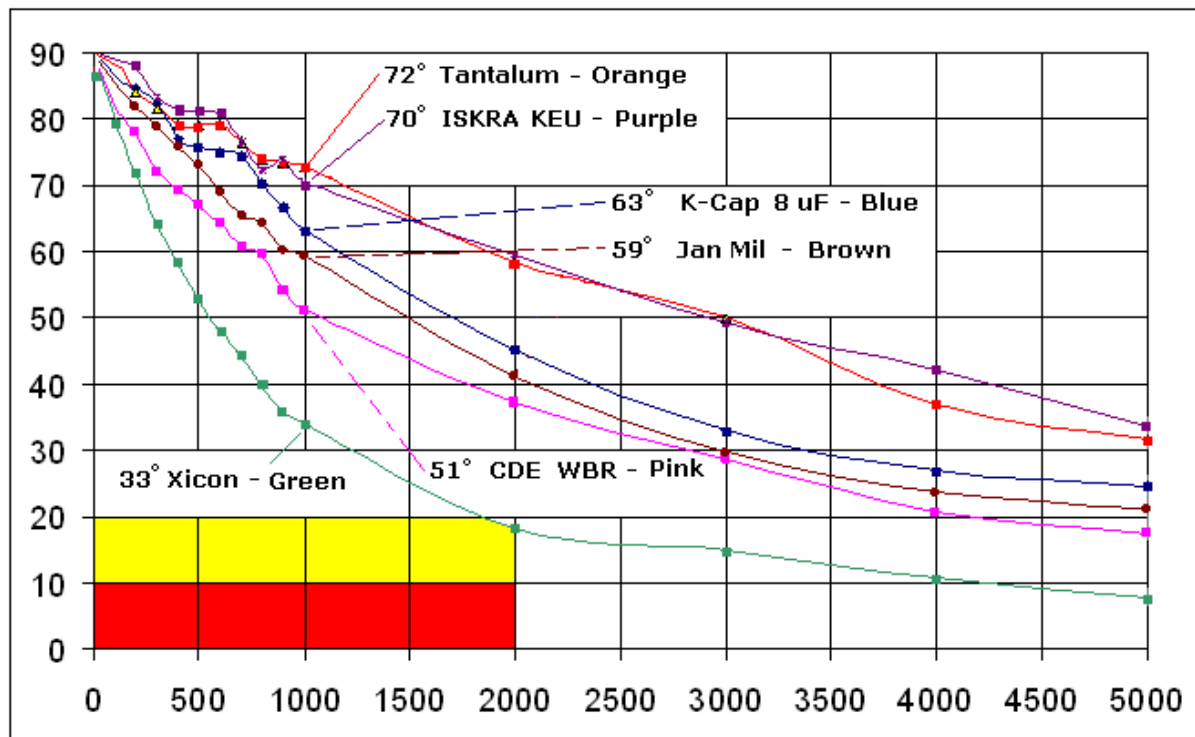


ELPAC 1uF-100V, IMB 2uF-440 VAC, ISKRA-KEU 4.7uF-400 VDC
Tantalum 6.8 - 15VDC



Sprague OIL-paper 6uF-600 VDC, JAN-MIL 10uF-50V, CDE-WBR 10uf-25vdc, Xicon 47uF-50v (2 in Series: + to +)





Tantalum & ISKRA KEU have the most Linear phase change, the Electrolytic Xicon capacitors have the Lowest Phase shift above 1,500 Hz.



We then turned our attention to investigating many different ways of connecting the speaker to the main amplifier output and eventually developed what we call BRIICe inter-face circuits.

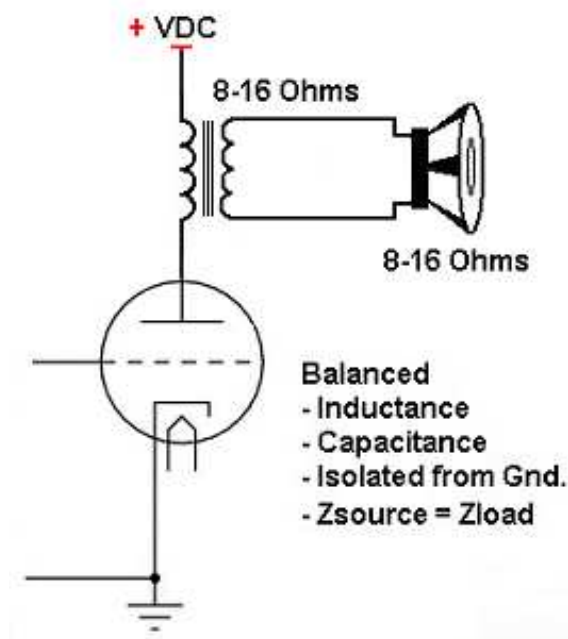
These circuits have Balanced-Reactance, which is Isolated from ground, in both Inductance and Capacitance – electronic circuits. This configuration of the circuit elements helps to reproduce Fidelity at a newer, more significant level.

- - -

B.R.I.I.Ce

[Balanced-Reactance, Isolated-Inductance & Capacitance, electronics]

The old tube out-put circuits had a balanced circuitry, with small capacitance,

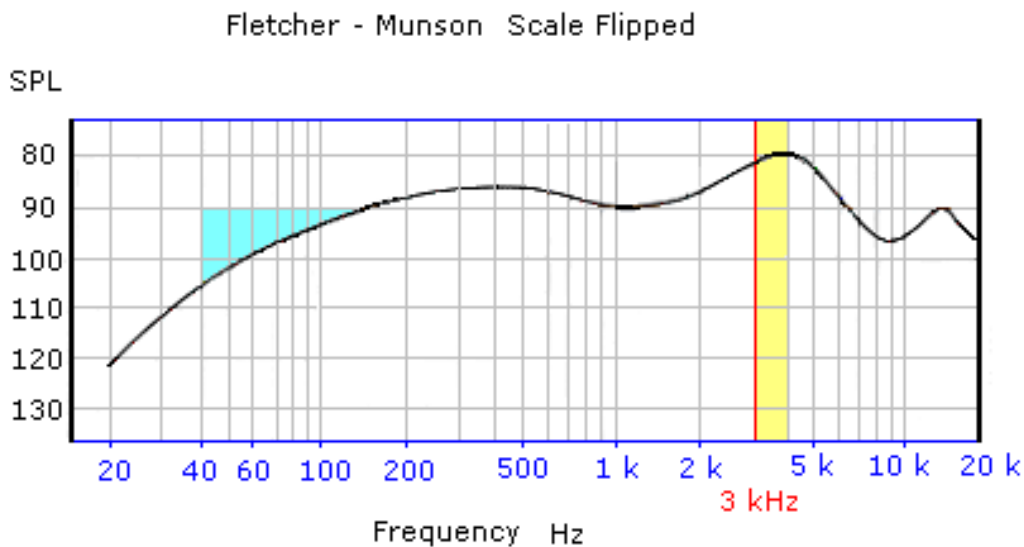


had matching impedances and was isolated from ‘ground’ or a common reference.

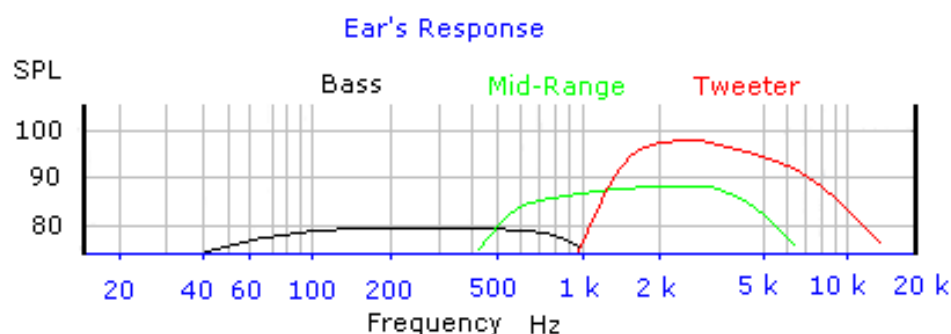
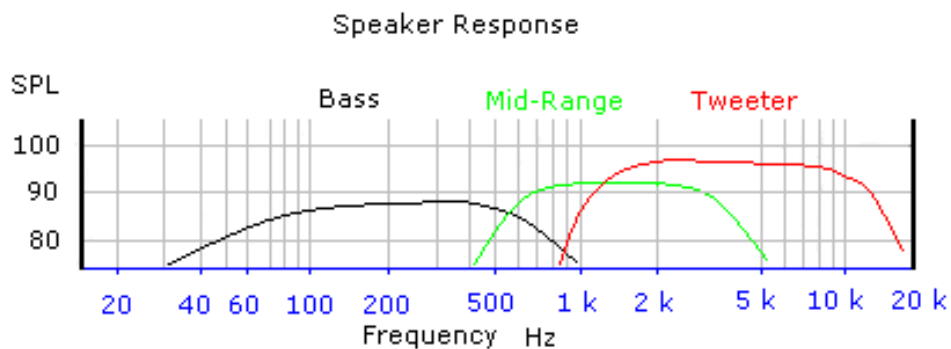
With BRIICe we also have balanced circuitry, lower value of capacitance, low-Q coils and very few parts. The BRIICe circuits have less phase shifting and do not have a 'crossover' region.

We use the old idea of frequency OVER-LAPPING in the design of our three circuits. We are of the opinion that the concept of a flat frequency response has been misapplied when it come to designing ‘crossover’ circuits.

The ideal frequency response of an amplifier should be a FLAT response, that is amplifying all signals equally, but speakers are not flat in their response. The human ear also has a non-flat response, being more sensitive of the upper frequencies and very insensitive to the lower frequencies.



Looking at this inverted Fletcher–Munson graph we can see the extreme difference in ear sensitivity at 3-4 kHz frequency range as compared to the ear's sensitivity at 40-100 Hz frequency range.

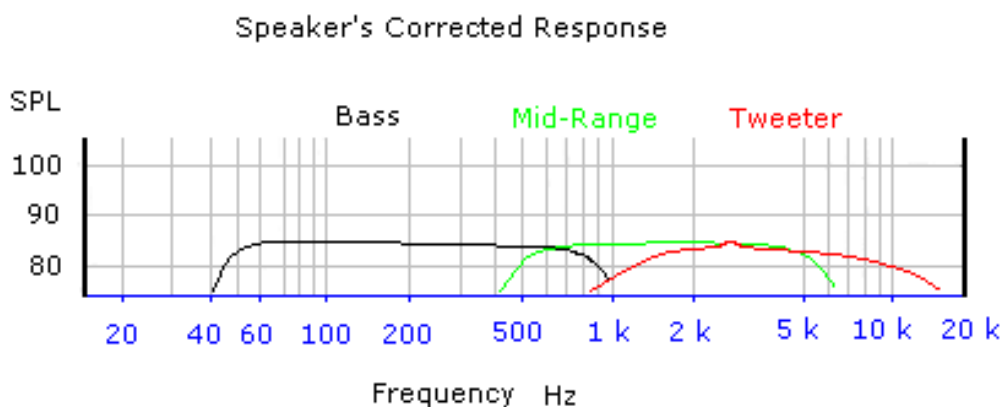


The first Graph above, of three general speakers, shows their individual Frequency Response. The second graph is how the Ear would respond to or 'detect' the three speakers outputs.

These two graphs show that a Flat Frequency Response is of less use to produce a higher level of Fidelity than we may suppose.

That is, to design crossover circuits to produce a TRUE-FLAT response is deleterious to Fidelity; not only due to 'crossover-distortions', but also due to incorrect amplitude Settings. A flat response would favor the highs making the audio system bright. Low frequencies would be less or diminished according to the ear's response.

To acquire a correct 'RESPONSE' we suggest that the lower frequencies be higher in amplitude, the mid-frequencies relatively the same and the Higher frequencies diminished to a level little less than the mid-frequencies.



Due to the modern speaker's ability to handle a wider frequency range, over-lapping three speakers is easily accomplished.

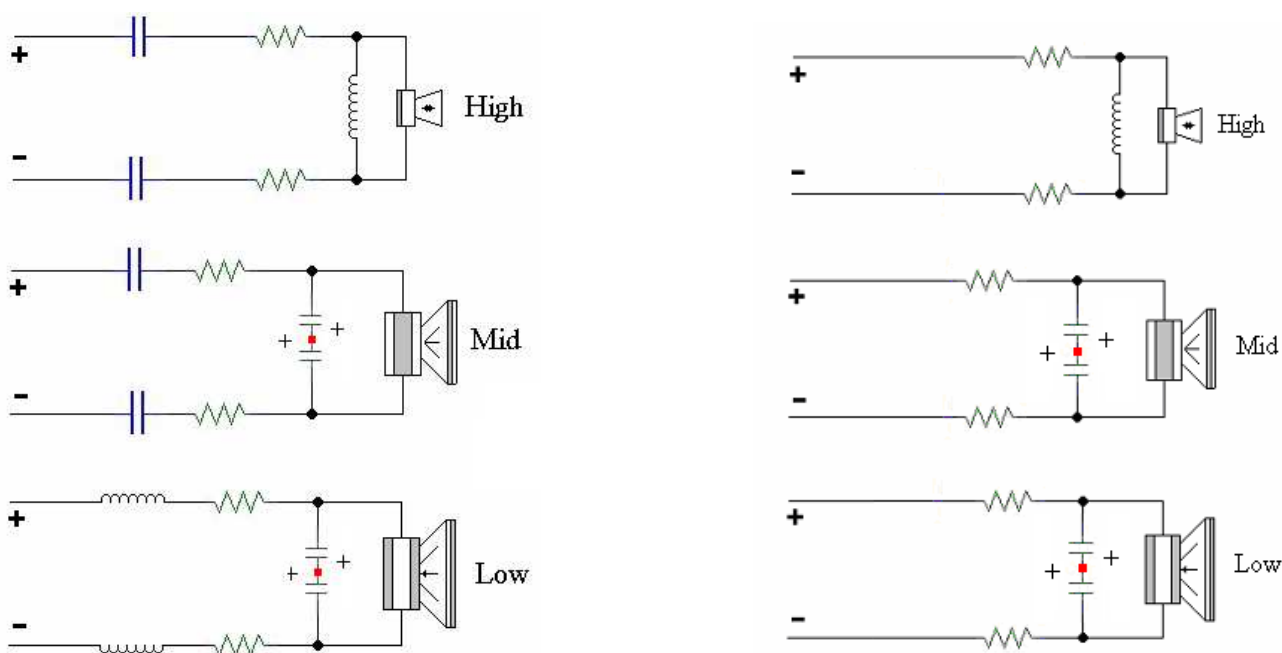
Voicing of the speakers becomes easier to do since the three 'over-lap' circuits allow a fuller frequency response of the speakers with out excessive individual speaker concerns.

The 'noise floor' [inherent ground noise] is very low since the mid point is in the center of the speaker's voice coil, which cancels the common-mode noise. In use, the first thing you will notice is the sound stage is very open, with a diminished, far less noticeable 'SWEET-SPOT'.

Details of the recorded music will be so noticeable it will sound like you have a new system. Voices will be more natural; piano will be more real, organ music easier to listen to, air and space of the Sound-Stage fuller and more defined. But nonetheless, try them for yourself.

Here are some basic samples of the BRIICe circuits.

Suggest you try these simple circuits first and then try the more complex circuits as you learn to 'tweak-in' your system as per your taste.



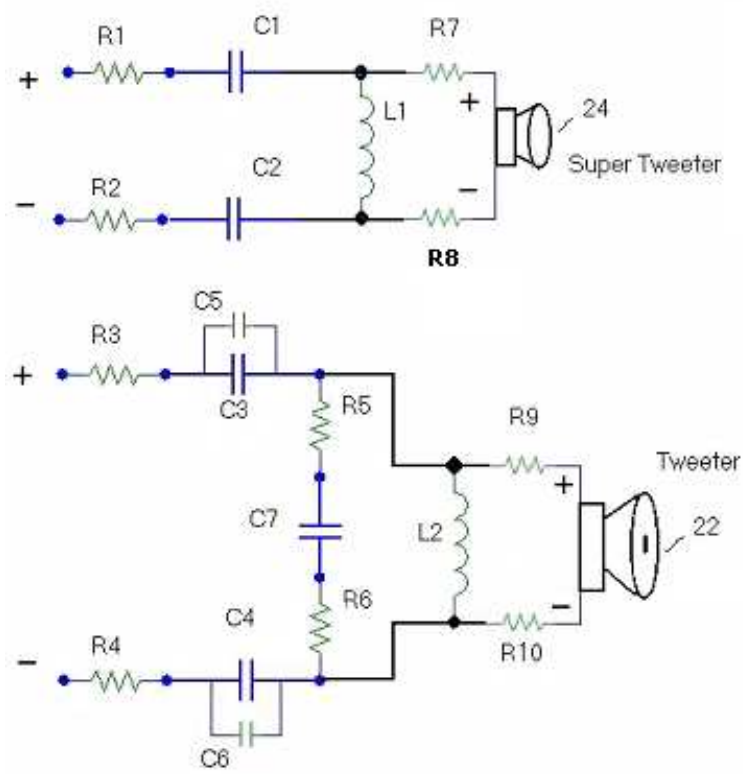
These BRIICe circuits were turned in for patents years ago as you can see. Tried to offer these circuits to several speaker companies, but they said their engineers have designed useful crossovers for year and were not interested.

Well - OK - so use these circuits audiophiles as you see fit !

These circuits were used in speakers selling for \$15,000 to \$38,000 !

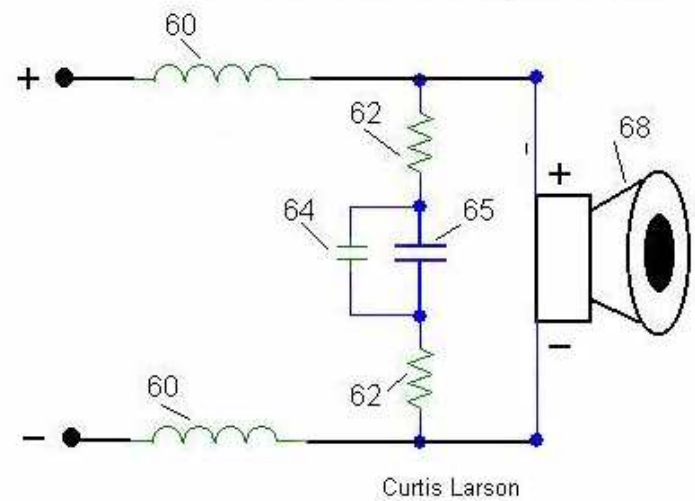
Have Fun... C. "J" L.

Super Tweeter and Tweeter Speakers

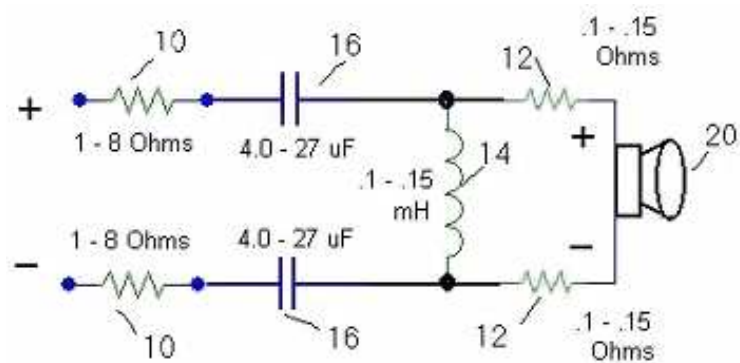
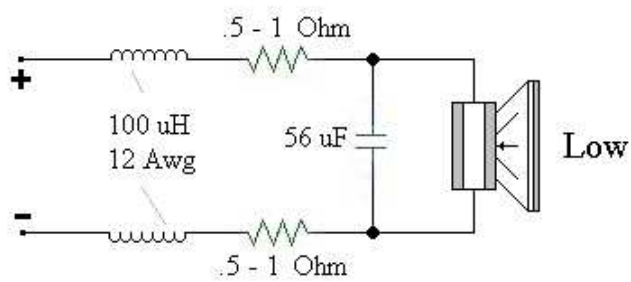
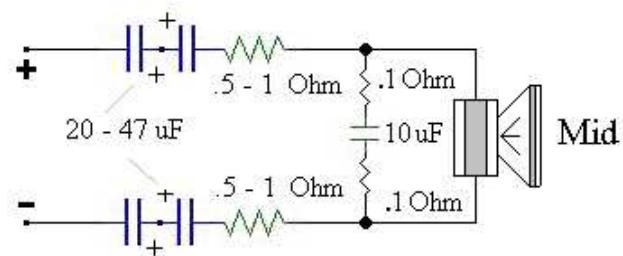
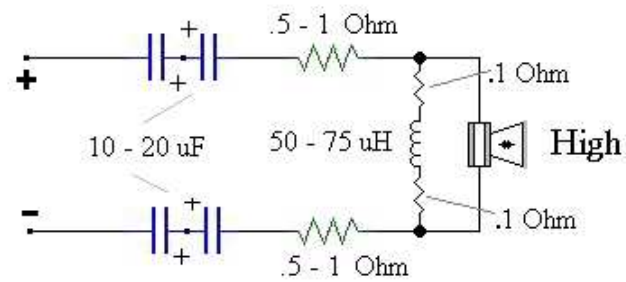


Woofer Circuit

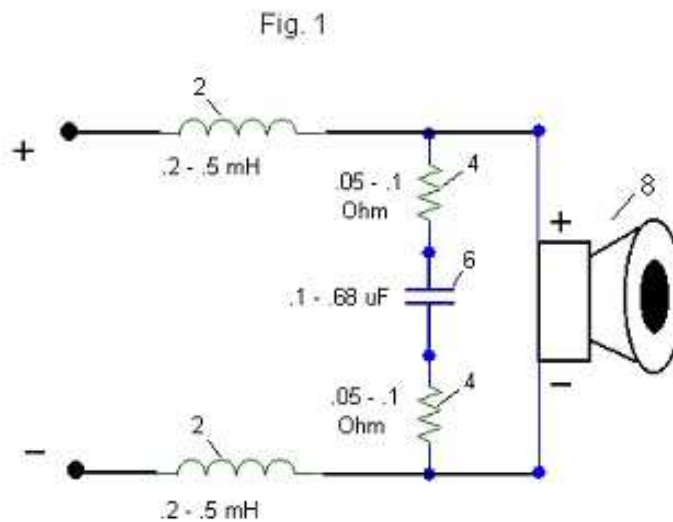
Speaker Interface Networks for Tweeters, Midrange and Woofers



Two Electrolytic Capacitors : 50 V or 100 V



Tweeter or Super Tweeters or
Mid-Range Speakers



Basic Balanced Interface Circuit : Inductor
Large Mid-Range or Woofer Speakers

Use R1, R2, R3, and R4 from values of: .1 or .5 to 1 Ohm depending the speaker's DC resistance, in order to obtain approximately 8 Ohms.

The all-resistor input parallel capacitors circuits also use various values...

Resistors R5, R6, R7, R8, R9, R10 and '62' are .1

Tweeter coils are .1 uH to .15 uH selected as required per tweeter being used.

- - -

MID-range Speaker capacitors 22uf to 47uf, input Resistors as noted...

- - -

Capacitors in all circuits are from 10 uF to 100 uF Zicor type electrolytic reversed-connected. C1, C2, C3, C4, C5 and C6.

The Positive of the electrolytic capacitors is connected to the speaker's resistor and the Negative is connected to the input resistors.

In all of the circuits, the positive connection is on the 'inside', while the negative connection is 'outward' being connected to the input circuit elements.

Any non-polarized Capacitors can be used for C7, '64' and '65' with 10 - 22uF for **C7** again: 56uF [65] and 1uF [64] [smaller: .47uF].

- - -

Woofer coils are as explained earlier, 70 uH to 150 uH, large .5 to 1.2 mH for Sub Woofers. [for conventional use - thump-thump]

Woofer capacitors are 56uF [65] and 1uF [64] [smaller: .47uF] as testing requires.

- - -

Room Reflections

Many problems like: collapse of the whole musical sound stage, drums, wind instruments, guitar, piano and string instruments, voice smearing, piano smearing, time-phase alignment of the three separated bands of frequencies (as mentioned), are part of the problems generated by the traditional crossover circuits.

Room Reflections problems are also due to the traditional crossover circuits in use and not the speaker themselves. Reflections do occur in rooms due to walls and room objects, but they would not be of much concern if the audio 'sources' were in Phase.

As pointed out the three separate speakers being feed 'mis-timed' audio signals will produce their separate audio wave fronts. These wave fronts will travel as per their individual phase.

By using BRIICe, or **any** simple *non-crossover* circuits, you will notice reflections, but they will fill the room in a 'natural' manner and you will realize that the speakers do not need to be toed-in! [Broader sweet-spot]

- - -

Since crossovers circuits, and the associated parts, are harmful to the audio signal we need to find a different way to handle the complex Audio signals.

We know inductors pass low frequencies with low attenuation, and block higher frequencies due to higher attenuation; and that capacitors pass high frequencies and block low frequencies. Both capacitors and inductors are inherently 'reactive' inducing their individual and cumulative influences upon the audio signal.

So our need is to find elements or processes that can act like an inductor or a capacitor without having a severe 'reactive' characteristic.

Gas devices are hard to 'dope' and are large in size, solid-state devices can be 'doped', but are hard to make. Doping is the process to create a unique electrical response in an electronic 'element' or device using different and various materials.

Liquids are easy to acquire, simple to 'dope', shape, change as required and are very inexpensive.

Liquid Crystal Circuits

So our next endeavor was to test and see if we could make 'crossover' circuits using liquids 'doped' with various **conductive salts** and materials having distinctive properties to act like an inductor or a capacitor.

Our test system uses three separate differential amplifier circuits and unique L.C.C.s as needed.

Using 'salt-water' as an -interconnect- on the 'low-level' side of an audio amplifier avoids most, if not all, of the problems associated with 'crossovers'.

Our Liquid Crystal Circuits [LCC's] were made by using four 'poles' in a 'salt-water-medium'. By placing the four 'poles' in unique physical alignments we found that we could adjust these LCC's to make 'tunable' low-pass, band-pass and high-pass 'filters'.

These filters exhibit very little phase shift as compared to traditional reactive elements; being about 10 degrees of shift up into the low Mega Hertz range.

The 'salt-water' is made of metallic salts like: Copper-sulfate, Sodium-chloride, Potassium-hydroxide, Sodium-hydroxide, Iron chlorides and other soluble metallic salts.

These salts are 'stabilized' by using any semi-rigid organic **jells** like Agar-Agar, pectin or gelatin.

The shapes of the containers help 'form' the 'space-charge' around the contacts. The size of the three containers is about 1 to 1.5 inches in diameter or length and width, and the depth of the container is about 1 inch. Copper and other metallic discs are used to 'shape' the frequency response of some of the filter circuits.

The 'contacts' that are in the 'salt-medium' are made of carbon, copper, silver, aluminum or platinum as required.

The input signal levels should be kept low in amplitude [in order to avoid unwanted chemical reaction] ranging from approximately 25 milli-Volts to 100 milli-Volts.

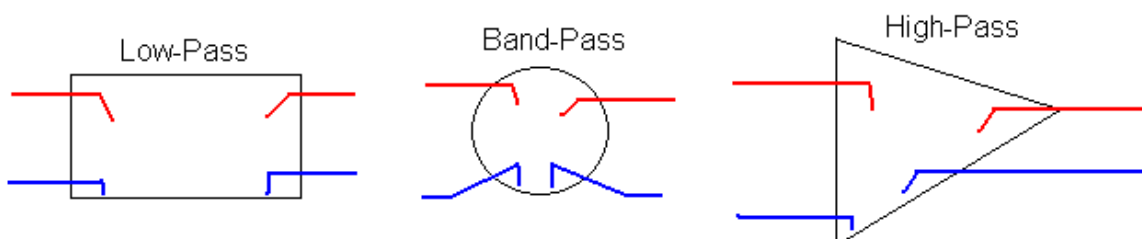
The Platinum [or carbon] contacts are used for the input-side of the audio signals and other 'types' of contacts are used as required to 'tune' the frequency response of the LCC filters.

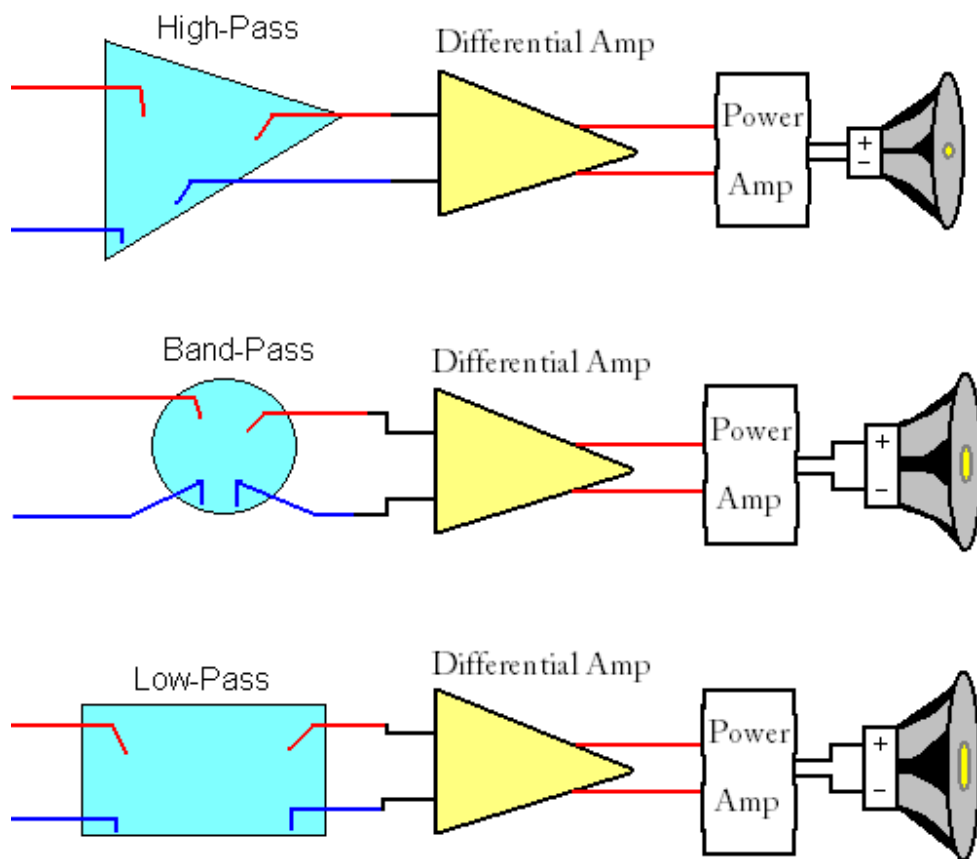
The Phase response, of the LCC circuits, is individually unique. Since Phase changes are dependent upon reactance, and that these LCC filters have no reactance; phase change is very low and stable. Noise is also low since the LCCs are isolated from ground being feed differentially and are connected to a differential amplifier. With out some stiffening 'agent' [jells] un-wanted dc level changes would occur. The LCC filters are sensitive to physical movements.

Tuning is possible due to the differences of the various metal-contact's voltage gradients and what type of 'salt' medium is used. At this low level of signal the chemical properties of the metals and salt solutions are of great interest.

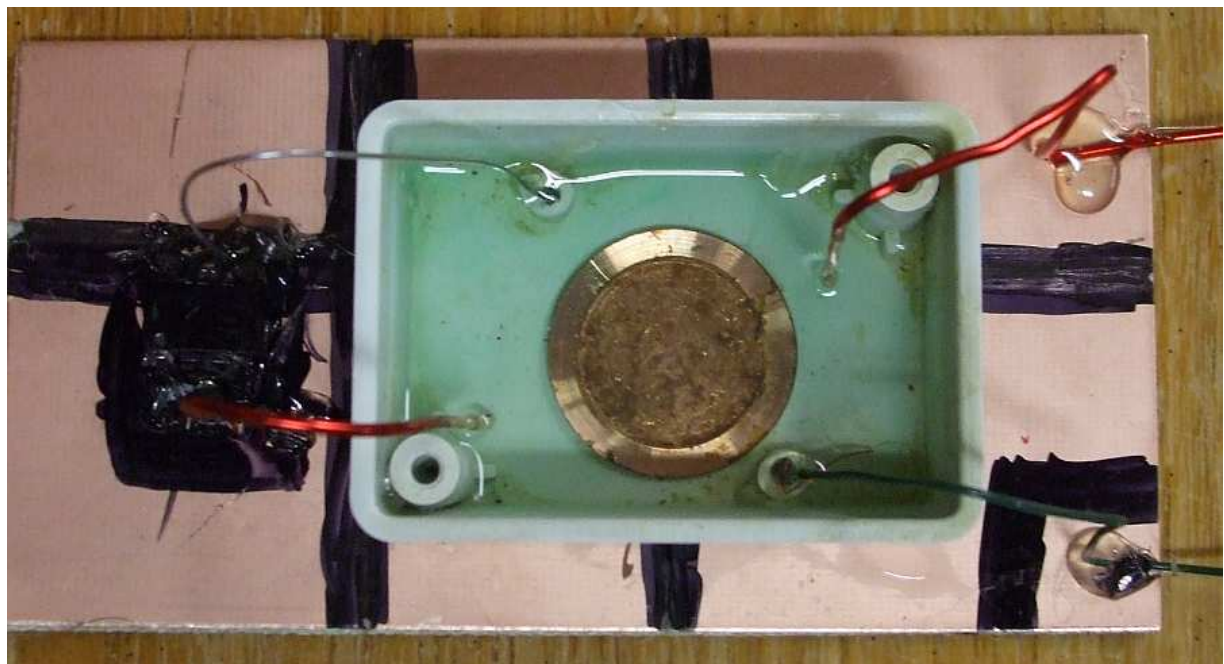
Silver may be the best conductor, but silver has a high 'affinity ' for chlorine; so very clean water is needed. Aluminum and copper will form various compounds easier than silver. Silver, though, once reacted with chloride is lost to the filtering 'system', since Sliver-Chloride is very stable and non-conductive.

So by using various combinations of these materials as mentioned, the tuning of the filters, mildly complex, can be accomplished by any experimenter using simple test equipment.

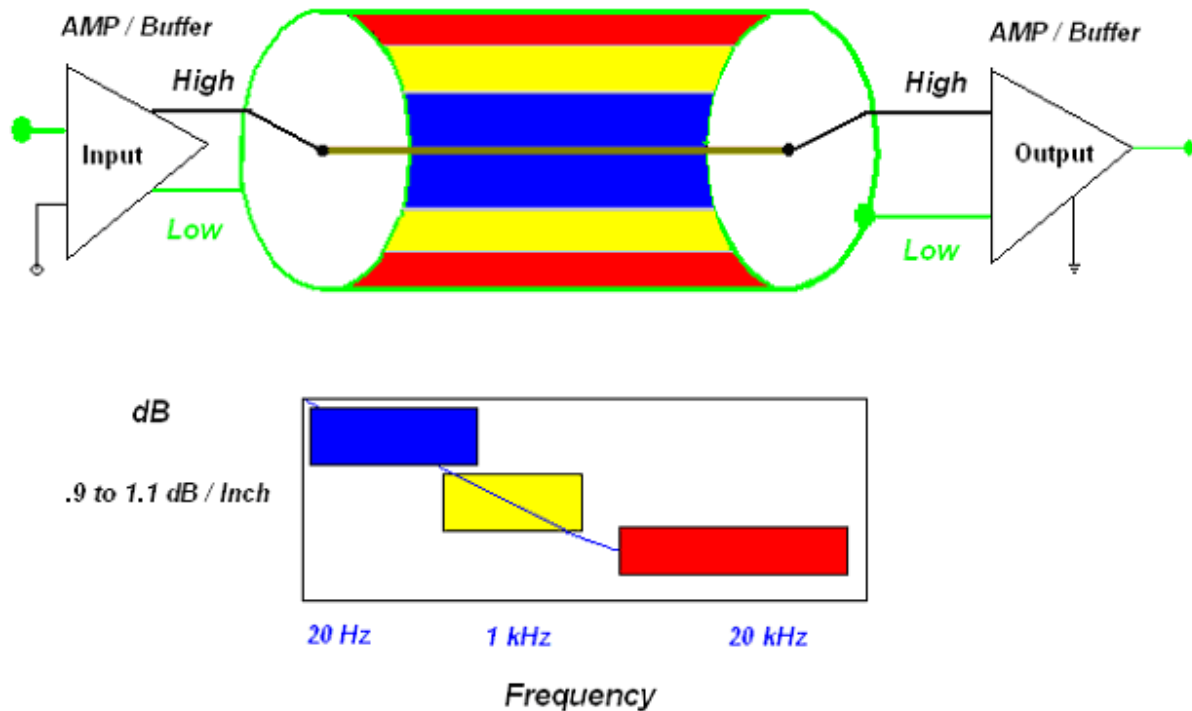


LCCs

Sealed Op-Amp. [LM733C]: Cu-Disc, CuSo₄, Iron & Copper wire



LCF Low - Pass

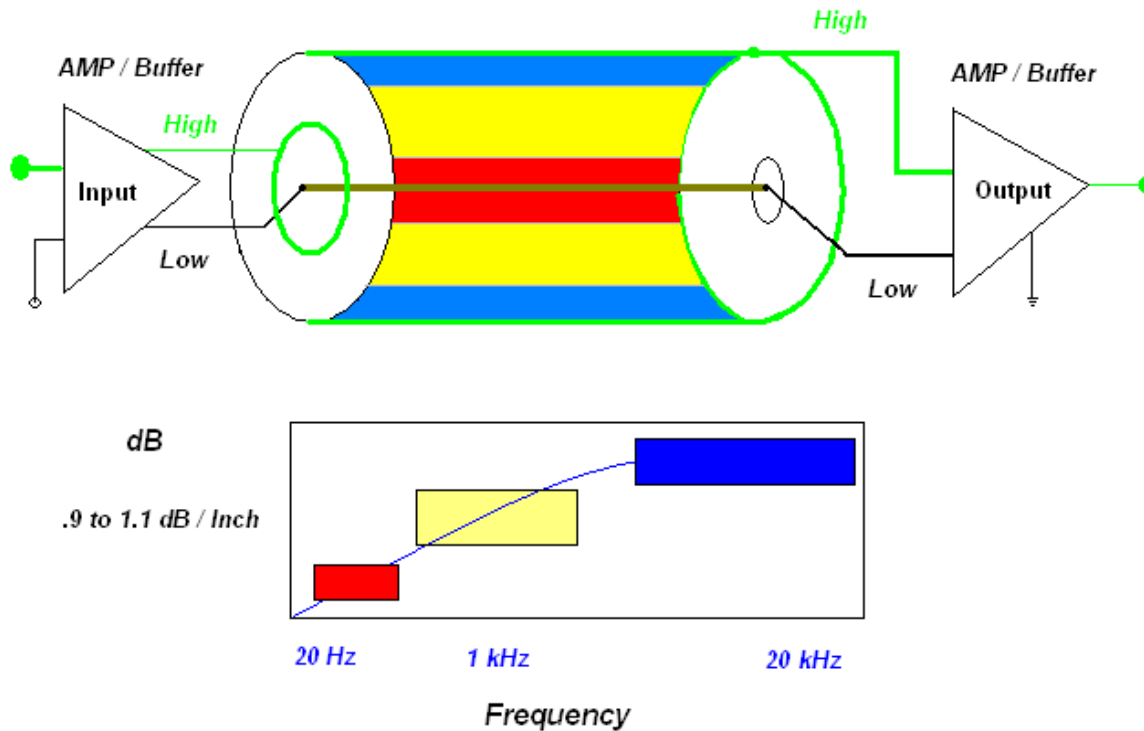


Using what we know about the Skin Effect property a low-pass liquid crystal filter can be made. Remember the low frequencies travel almost completely through out the area of a conductor or, in this case, a 'conductive' material.

The High or Upper frequencies travel near the outer surface. So by arranging to have the low frequencies on the High-side and the upper band of frequencies on the Low-side of the L.C. Filter, the upper frequencies will be attenuated as the signal travels towards the Output Amp/Buffer.

The slope [attenuation] is about .9 to 1.1 dB per inch. It is possible to change this a little by adding more metallic-salts or increasing the depth of the container, in this case a round *copper* tube and by changing the materials of the connecting leads. [Copper, Iron, Carbon & etc.]

LCF High - Pass



A High-Pass filter is made by reversing the connections [as shown] to use again the interesting properties of Skin Effect. In the High-Pass filter the Upper frequencies are passed onto the output Amp/Buffer, while the lower frequencies are attenuated. [.9 to 1.1 dB / Inch] This LC filter is longer than the other filter to allow more attenuation of the lower frequencies since they penetrate deeper than the higher-frequencies.

The phase shift of a LCC filter in degrees is: 0°, zero, none. Since the Liquid Crystal filters are non-reactive the *Phase* is constant ! [that is < 1°]

Band pass LCC-filter is more complex, but it is possible to build.

More LCC information included in a Supplement section found after the INDEX [p.225], **Liquid Crystal Circuits continued...**

Now on to **Cables...**!

Chapter 2



Cables

Inter-Connects - - - Speaker Cables - - - Power Cords

Many years have been wasted, in trying to determine which cable sounds the 'best', due to the traditional Crossover circuits.

The confusion [and endless debating] on which cable or cable designs sound better, of almost endless varieties of designs, is compounded by the 'hype' of cable salesmen. The sales pitch dogma has been talked about and greatly explored by many of the Audio-forums seeking to reveal the 'truth'.

Unfortunately some of these forums fail to totally realize that they also add to the confusion while being 'robed' in their Academia ridicule of those who try to seek answers.

Oh-Well... good intentions . . .

By using the **BRIICe circuits**, or any circuit **not** having a 'crossover' characteristic, you will be able to more easily discern the audio differences inherent in various inter-connects and speaker cables. With crossover circuits out of the way, we then can find different ways to better measure cables.

The Myopic 20-20 tests

The tremendous amount of testing [over the past 5 decades] of cables using the rudimentary testing of a cable's - Rdc, Inductance & Capacitance per foot and testing cables with the frequencies of 20 Hz to 20 kHz has revealed very little.

Many Audio-forums, like that of **Audioholics** and others, have done extensive testing on many inter-connects. [See their Website]

or:

Product Review - Audio Interconnect Cable Shootout - Part 1 - December 2000

Milan Cernohorsky - Editor, EUROPE

(Cables evaluated by Jiri Michalek, Milan Cernohorsky,

Patrik Blaha, Petr Püschel, and Vladimir Rybar)

Here is an earlier report on Speaker cables, to start with... [With Permission]

A cable testing and comparison by Fred E. Davis
[J. Audio Eng. Soc., Vol. 39, No. 6, 1991 June] has shown that these measurements reveal again, that very little difference exists in cables when confined to the **basic** 20-20 tests.

Cable	C - Farad	L - Henry	R - Ohms	Xc	XL	SWR	Zo	Fr
	Measured	Specs						
Ribbon-064-flat	2.35E-09	1.55E-07	0.00878	67,725	0.00097	6.16	8.12	8,339,120
Litz	3.45E-10	3.55E-07	0.00752	461,318	0.00223	1.56	32.08	14,381,239
Weave-16-LPC	2.05E-10	3.05E-07	0.00822	776,364	0.00192	1.30	38.57	20,127,654
Ribbon-036-flat	1.05E-09	1.95E-07	0.02124	151,576	0.00123	3.67	13.63	11,122,645
Weave-4-PR	1.75E-10	2.85E-07	0.01605	909,455	0.00179	1.24	40.36	22,536,090
Weave-8-LPC	1.25E-10	5.15E-07	0.01515	1,273,237	0.00324	1.28	64.19	19,836,333
Vari-Layer-Eq-Speed	4.85E-10	7.25E-07	0.01255	328,154	0.00456	1.29	38.66	8,487,507
Levinson HF10C	8.75E-11	1.13E-06	0.00376	1,818,909	0.00707	2.27	113.39	16,041,306
Krell-Layer-s-Twist	7.65E-11	1.40E-06	0.00585	2,080,452	0.00877	2.70	135.04	15,406,436
Belden-ZIPcord	1.15E-10	1.15E-07	0.04185	1,383,953	0.00072	1.58	31.55	43,859,972
Belden-9718PVC	1.05E-10	7.95E-07	0.01063	1,515,758	0.00500	1.74	87.01	17,419,745
Auto Jumpers	9.15E-11	1.22E-06	0.00518	1,739,394	0.00767	2.31	115.47	15,063,627

This chart shows some of our calculated-electrical characteristics of various cables.

[Fred E. Davis : J. Audio Eng. Soc., Vol. 39, No. 6, 1991 June]

More interesting 'calculated' electrical characteristics of various cables.

Q / Fr is the ratio of the amount of frequencies in respect to 'Q':
the ratio of AC impedance to DC resistance.
- Frequency merit for Q - [RosVeta Audio]

Cable	Xc	XL	Zt	SWR-50	Zo	Fr	Q	Q/Fr
Ribbon-064-flat	67,725	0.00097	67,725	6.16	8.12	8,339,120	7,713,593	0.92
Litz	461,318	0.00223	461,318	1.56	32.08	14,381,239	61,345,425	4.27
Weave-16-LPC	776,364	0.00192	776,364	1.30	38.57	20,127,654	94,448,146	4.69
Ribbon-036-flat	151,576	0.00123	151,576	3.67	13.63	11,122,645	7,136,336	0.64
Weave-4-PR	909,455	0.00179	909,455	1.24	40.36	22,536,090	56,663,844	2.51
Weave-8-LPC	1,273,237	0.00324	1,273,237	1.28	64.19	19,836,333	84,042,017	4.24
Vari-Layer-Eq-Speed	328,154	0.00456	328,154	1.29	38.66	8,487,507	26,147,709	3.08
Levinson HF10C	1,818,909	0.00707	1,818,909	2.27	113.39	16,041,306	483,752,493	30.16
Krell-Layer-s-Twist	2,080,452	0.00877	2,080,452	2.70	135.04	15,406,436	355,632,803	23.08
Belden-ZIPcord	1,383,953	0.00072	1,383,953	1.58	31.55	43,859,972	33,069,362	0.75
Belden-9718PVC	1,515,758	0.00500	1,515,758	1.74	87.01	17,419,745	142,659,559	8.19
Auto Jumpers	1,739,394	0.00767	1,739,394	2.31	115.47	15,063,627	335,790,388	22.29

Table 2 Calculations using cable data from: Fred E. Davis:
Effects of Cable, Loudspeaker, and Amplifier Interactions
J. Audio Eng. Soc., Vol. 39, No. 6, 1991 June]

Some comments on a few cables: [in our opinion: Richard and others.]

Kimber-Weave-4-PR - Neutral fast and good imaging

Kimber-Weave-8-LPC - Neutral fast and good imaging, less 3D or less quiet.

Kimber-Weave-16-LPC - Similar to 8-LPC, but not as 3D sounding or as quiet.

Spectra-Ribbon-036-flat - Typical of ribbon wire: lean sounding - tipped up in response.

Spectra-Ribbon-064-flat - lean sounding - tipped up in response

Audio-Quest-Litz - Not as smooth or clear as Kimber.

Levinson HF10C - veiled sounding

Krell-Layer-S-Twist - veiled sounding

Belden-ZIP cord - a bit harsh and grainy (not smooth)

Auto Jumpers - Good Bass but very **rough** sounding

So by looking at the previous table above [Table 2]:

If Q/Fr is less than 1: the cable is lean - sharp High frequency response.

If Q/Fr is 2 - 5: the cable is neutral, fast and good imaging.

If Q/Fr is 20 - 30: the cable is veiled, harsh, grainy, and rough.

Some audio-enthusiasts have concluded it to be futile 'testing for audio differences' between the various and very expensive high-end cables.

NAME-TYPE	Measured C - Farad	Specifications L - Henry	L/C Ratio	CLR R - Ohms	Reference ---- X-C	Freq 1kHz X-L	XL/XC Ratio	Z-totoal
Kimber-Weave-16-LPC: less <8TC	2.05E-10	3.05E-07	1,488	0.00822	776,364	0.00192	405,120,791	776,364
Kimber-Weave-4-PR: Best K-weave	1.75E-10	2.85E-07	1,629	0.01605	909,455	0.00179	507,873,232	909,455
Kimber-Weave-8-LPC: <3D, Quiet	1.25E-10	5.15E-07	4,120	0.01515	1,273,237	0.00324	393,478,485	1,273,237
FAST, IMAGE-OK, QUIET, NEUTRAL								
Minimum	1.25E-10	2.85E-07	1,488	0.00822	776,364	0.00179	393,478,485	776,364
Maximum	2.05E-10	5.10E-07	4,120	0.01605	1,273,237	0.00324	507,873,232	1,273,237

	SWR-50	Zo-Cable	Freq Resonanc	Reference Freq. --- 20 kHz X-C 20 kHz	XL/XC X-L 20 kHz	Ratio	Q	Q/Fr
Kimber-Weave-16-LPC: less <8TC	1.30	38.57	20,127,654	38,818	0.0383	1,012,802	94,448,146	4.692
Kimber-Weave-4-PR: Best K-weave	1.24	40.36	22,536,090	45,473	0.0358	1,269,683	56,663,844	2.514
Kimber-Weave-8-LPC: <3D, Quiet	1.28	64.19	19,836,333	63,662	0.0647	983,696	84,042,017	4.237
FAST, IMAGE-OK, QUIET, NEUTRAL								
Minimum	1.24	38.57	19,836,333	38,818	0.0358	983,696	56,663,844	2.514
Maximum	1.30	64.19	22,536,090	63,663	0.0647	1,269,683	94,448,146	4.692

NAME-TYPE	C - Farad	L - Henry	L/C Ratio	R - Ohms	X-C	X-L	Ratio	Z-totoal
Minimum	1.25E-10	2.85E-07	1,488	0.00822	776,364	0.00179	393,478,485	776,364
Maximum	2.05E-10	5.10E-07	4,120	0.01605	1,273,237	0.00324	507,873,232	1,273,237
Belden - ZIP Cord: HARSH-GRAINY	1.15E-10	1.15E-07	996	0.04185	1,383,953	0.00072	1,923,689,193	1,383,953
Belden-9718PVC	1.05E-10	7.95E-07	7,571	0.01063	1,515,758	0.00500	303,446,271	1,515,758
Auto Jumpers: VERY ROUGH	9.15E-11	1.22E-06	13,333	0.00518	1,739,394	0.00767	226,911,918	1,739,394

NAME-TYPE	SWR-50	Zo-Cable	Freq Resonanc	X-C 20 kHz	X-L 20 kHz	Ratio	Q	Q/Fr
Minimum	1.24	38.57	19,836,333	38,818	0.0358	983,696	56,663,844	2.514
Maximum	1.30	64.19	22,536,090	63,663	0.0647	1,269,683	94,448,146	4.692
KK-Specs. & +/- 10%								
Belden - ZIP Cord: HARSH-GRAINY	1.58	31.55	43,859,972	69,198	0.014	4,809,223	33,069,362	0.754
Belden-9718PVC	1.74	87.01	17,419,745	75,788	0.100	758,616	142,659,559	8.190
Auto Jumpers: VERY ROUGH	2.31	115.47	15,063,627	86,970	0.153	567,280	335,790,388	22.291

Yet there are many sonic differences in the various cables made by today's cable manufactures. Geometries, different materials, winding configurations, shielding schemes: etc., are used in the make up of these exotic and expensive cables and inter-connects. The previous charts were used and expanded upon to provide the following graphs.

The L, C, R information was collected from many manufacture's web-sites.

Calculations were from cable data from: Fred E. Davis:

Effects of Cable, Loudspeaker, and Amplifier Interactions

J. Audio Eng. Soc., Vol. 39, No. 6, 1991 June

Several cable manufactures would not send us cable specifications or do not publish even the simple L, C, R measurements.

RF Calculations

The characteristic L-C-R and several 'RF' **calculations** were used to generate The following comparison charts.

Columns are:

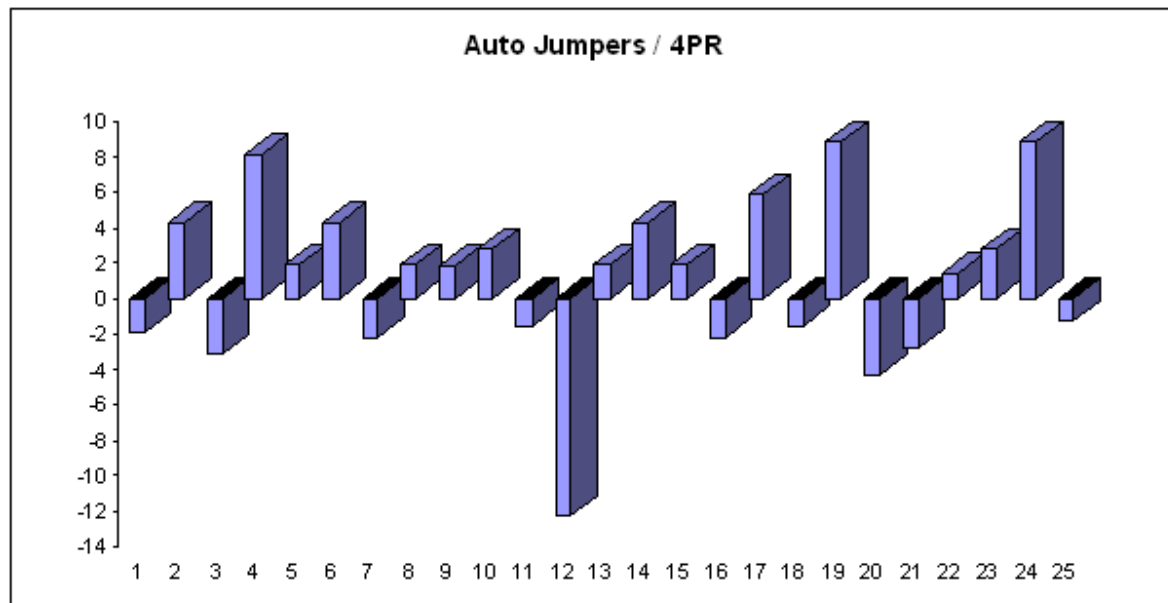
- 1 C - Farad
- 2 L - Henry
- 3 L/C Ratio
- 4 R - Ohms
- 5 X_c
- 6 X_L
- 7 X_L/X_C 1kHz Ratio
- 8 Z-Total [X_c , X_L , Rdc]
- 9 SWR-50 [Z_o / 50 Ohm Reference]
- 10 Z_o -Cable [Z_o of C and L]
- 11 Frequency Resonance [Fr] [of C & L]
- 12 Fr / L-C ratio @ X_c 20 kHz
- 13 X_c 20 kHz
- 14 X_L 20 kHz
- 15 Z_t 20 kHz
- 16 X_L/X_C Ratio 20 kHz
- 17 QZ_t / R_{dc} [$Q = Z_t / R_{dc}$]
- 18 QZ_t / Z_o [$QZ_t = Z_t / Z_o$ (of cable)]
- 19 Q/F_r [QZ_t / F_r ; resonant frequency of the cable]
- 20 F_r / Z_o [Frequency Resonance / Z_o]
- 21 F_r / X_c -1 kHz [Frequency Resonance / X_c]
- 22 Q_a 377 LC [Air Impedance $\sim 377 * \text{SQR}(L*C)$]
- 23 Z Wave 377 L/C [Air Impedance $\sim 377 * \text{SQR}(L/C)$]
- 24 Z_o / R_{dc} (swr) [Z_o / R_{dc}]
- 25 Q - Line [$.085 * \text{SQR } F_r$]

These 'ratios' are derivations of typical Radar-Microwave and RF calculations and esoteric in that no one uses these RF calculations for 'audio'. [In house tests] [Tables & Charts are available, Refer to: CD & Web-site: All-Cable-Pix2]

Test your cable in PIX2 - using yellow areas; and All-Cable-Pix
The '0' reference is for comparison, showing the deviation from the average values of Kimber Kable's woven-wires. These woven cables are geometrically the 'same' and exhibit consistent RF-calculated values.

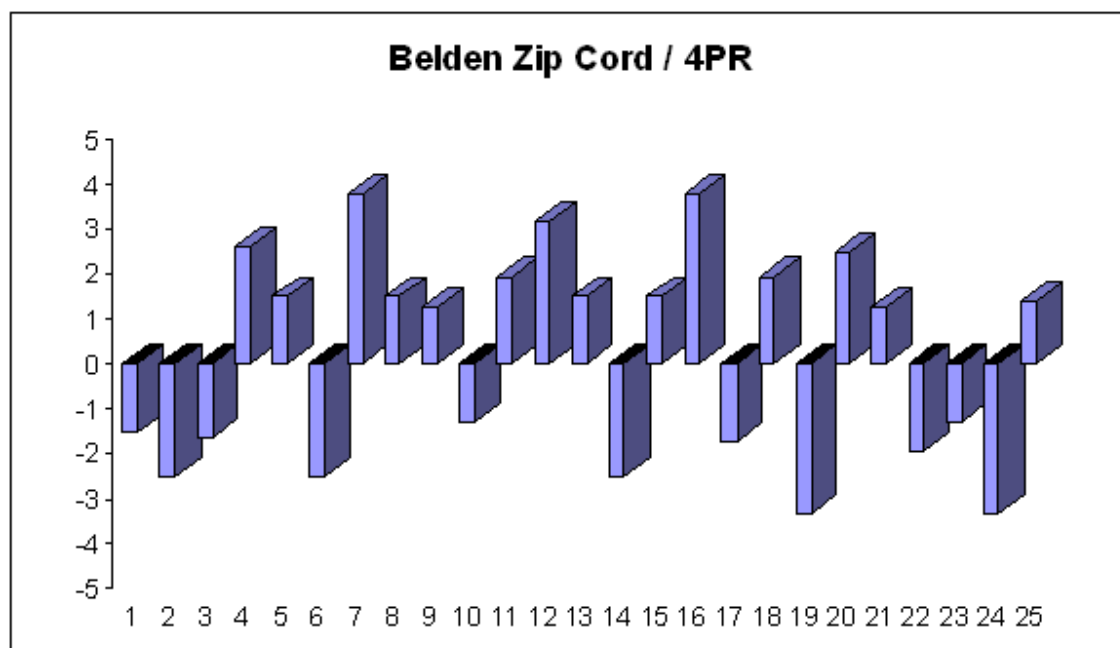
Esoteric Graphs

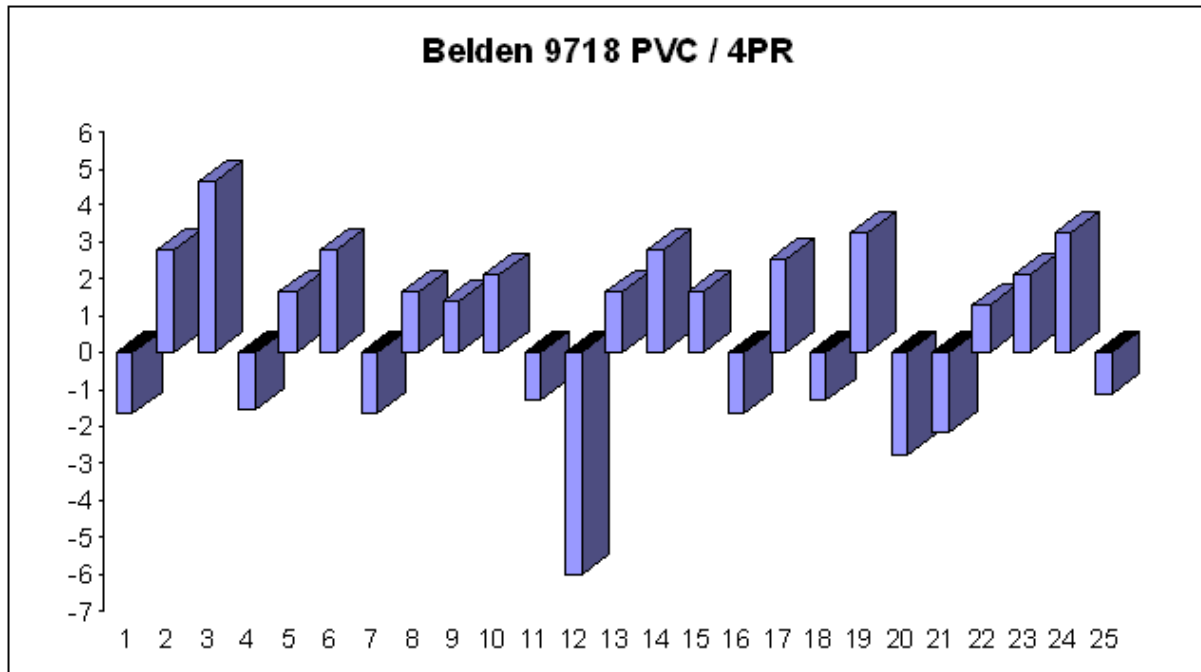
The first charted Cable group is Speaker Cables with 'odd-ball' cables that are frequently used to deride the '**Snake-oil**' cable manufactures. As it turns out, measuring any and all cables helped to establish what a good-cable might look like when using these Esoteric 'RF' ratio-graphs.



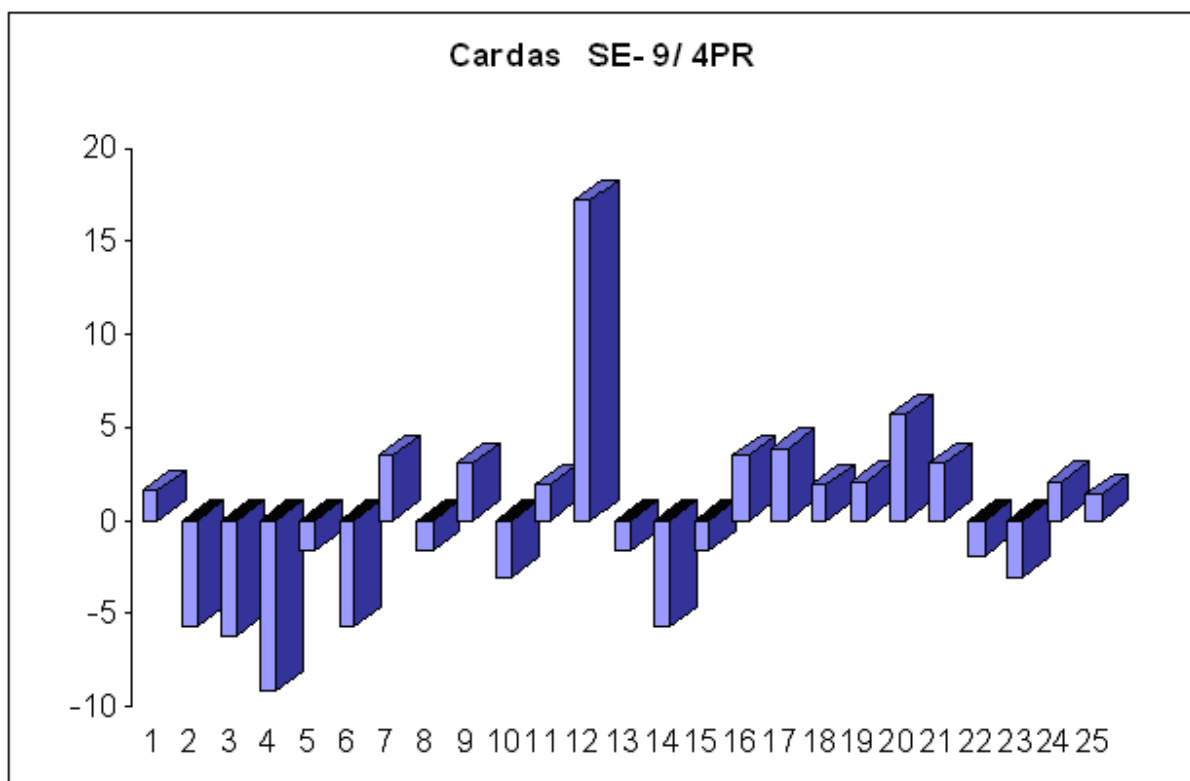
12 : Fr / L-C ratio @ Xc 20 kHz

The positive Columns indicate a value that is more than the Kimber 4-PR weave cable. And the negative columns respectively indicate values that are less than Kimber 4-PR.

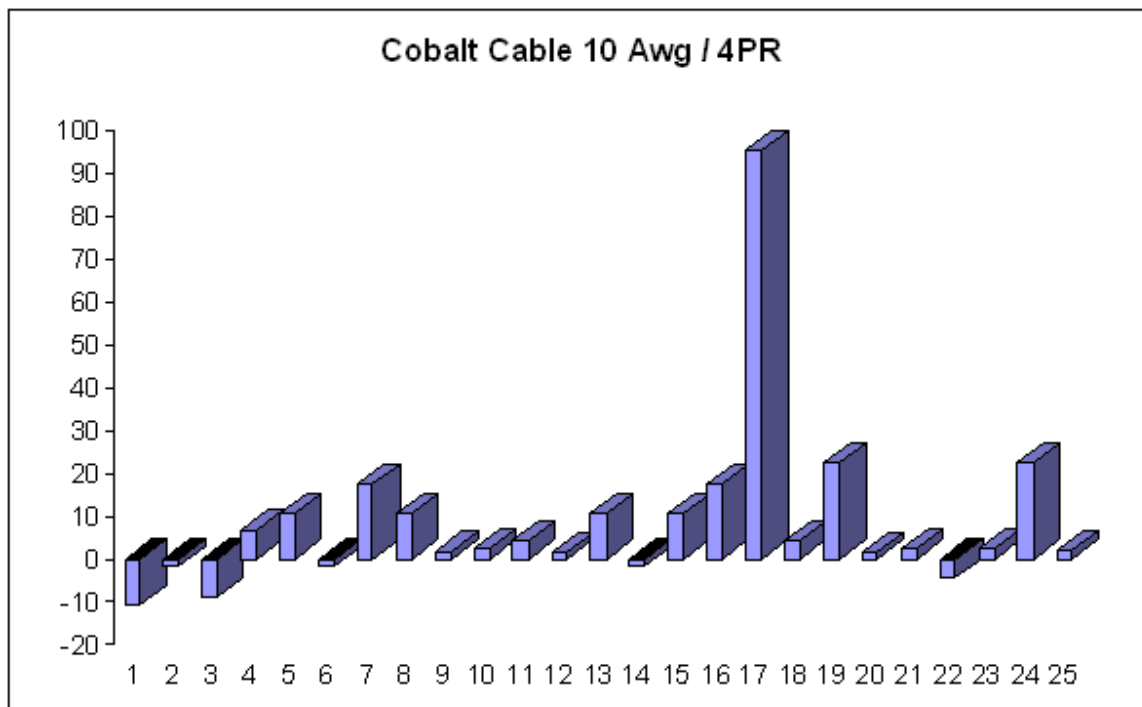
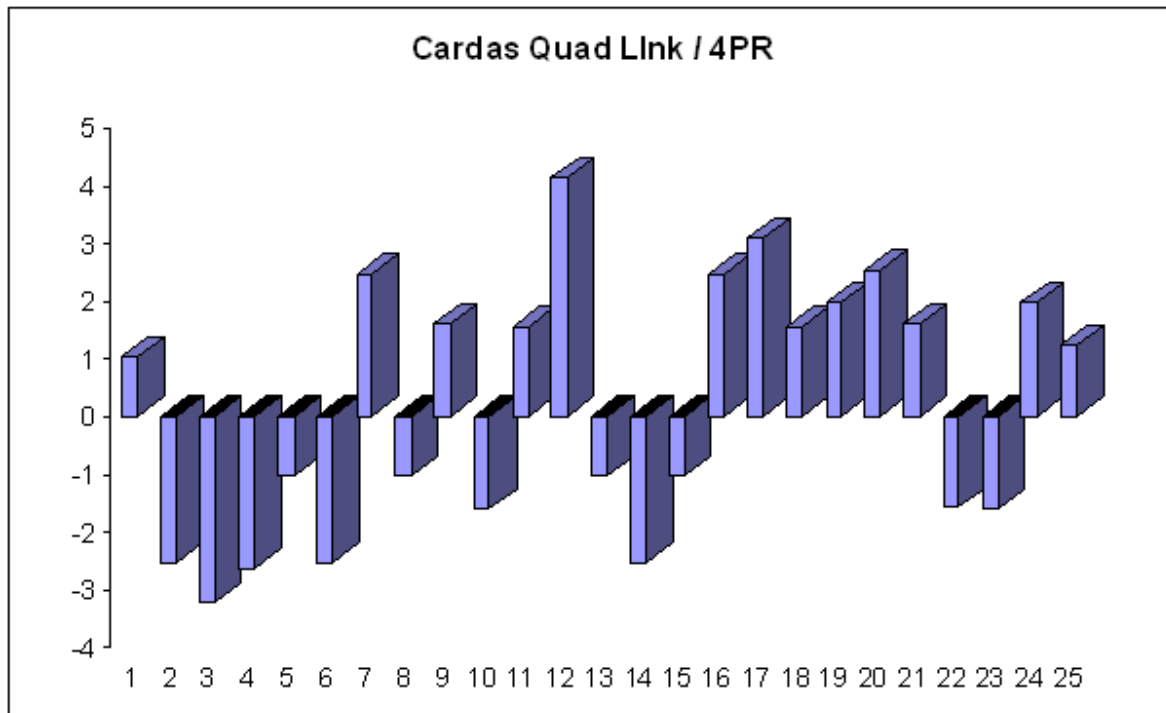




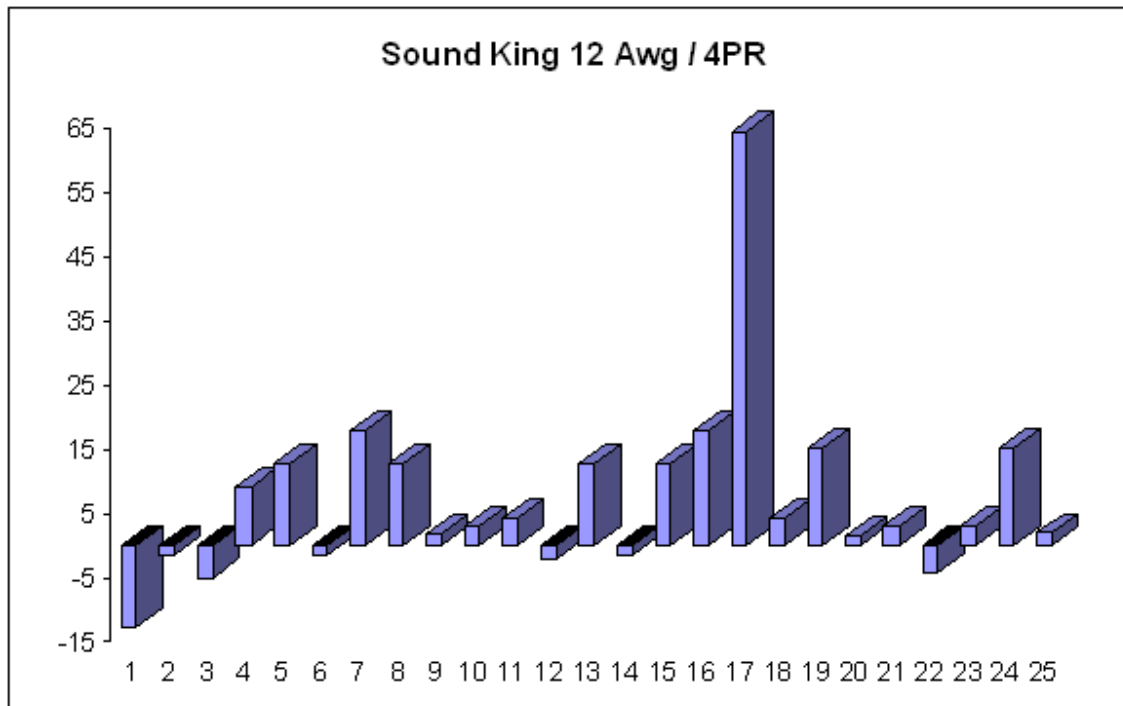
12 : Fr / L-C ratio @ Xc 20 kHz



12 : Fr / L-C ratio @ Xc 20 kHz

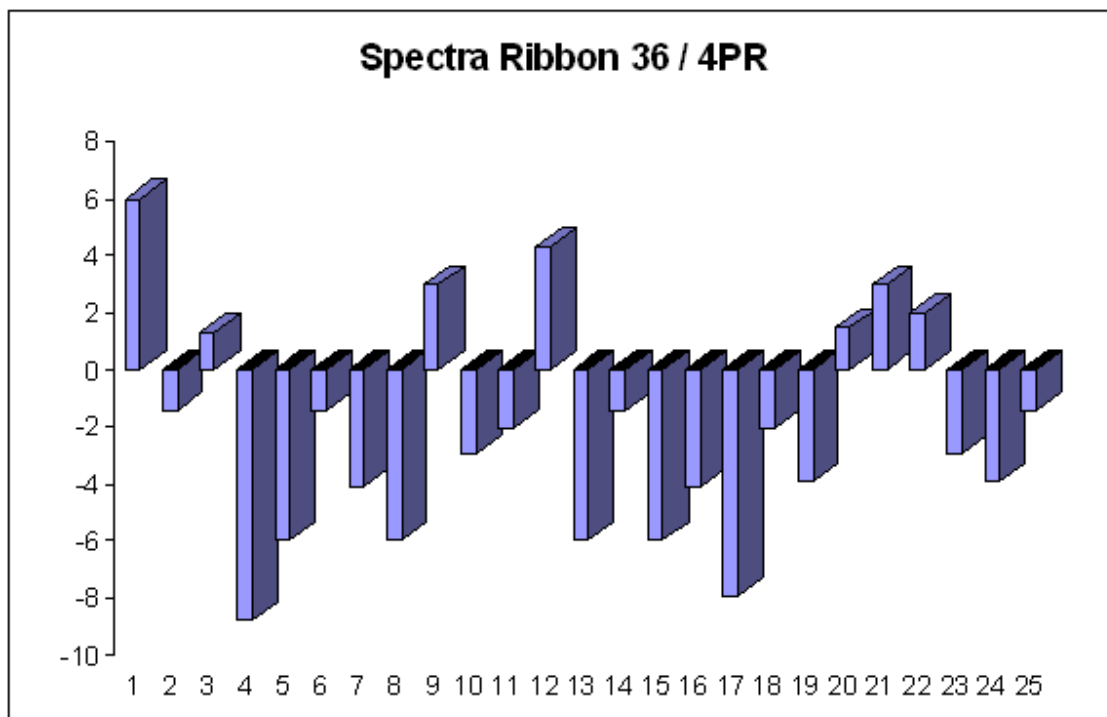


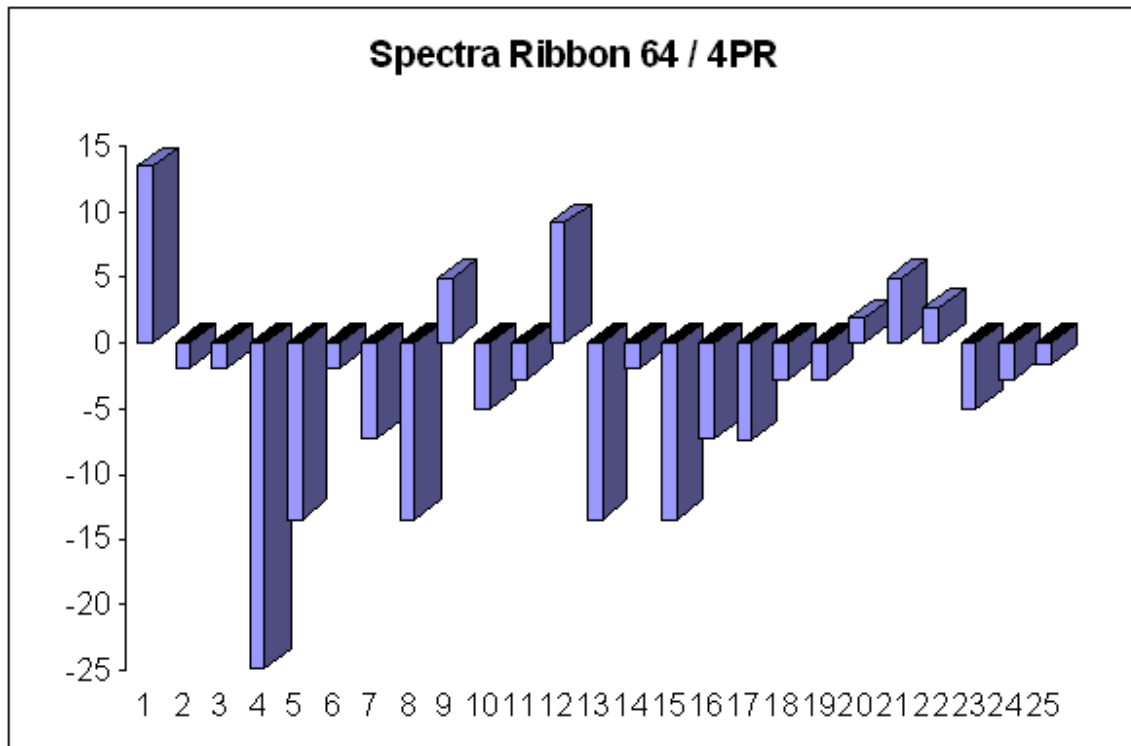
$QZ_t / R_{dc} : [Q = Z_t / R_{dc}] : 17$



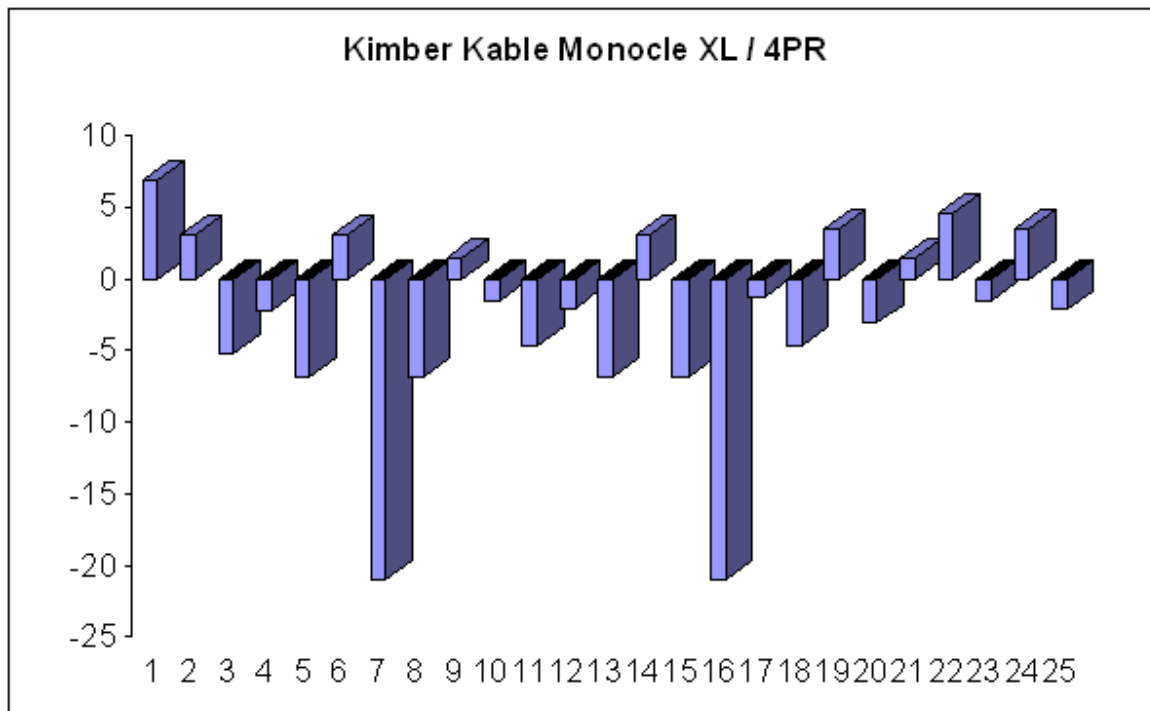
$QZt / Rdc : [Q = Zt / Rdc] : 17$

Flat Cables sounded lean...

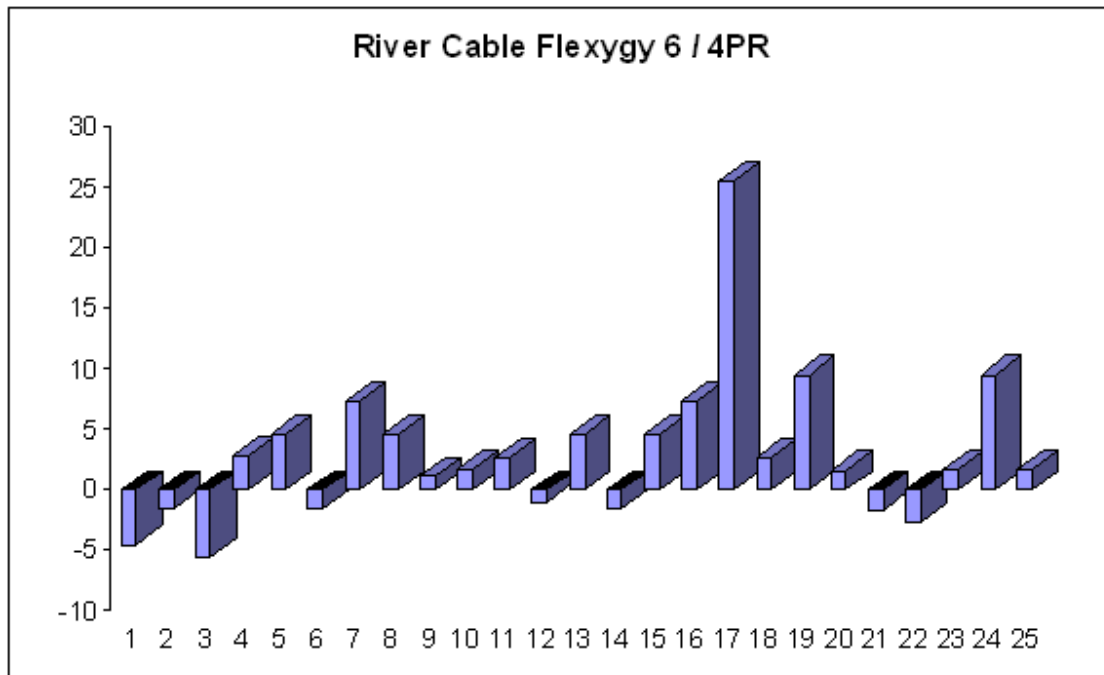




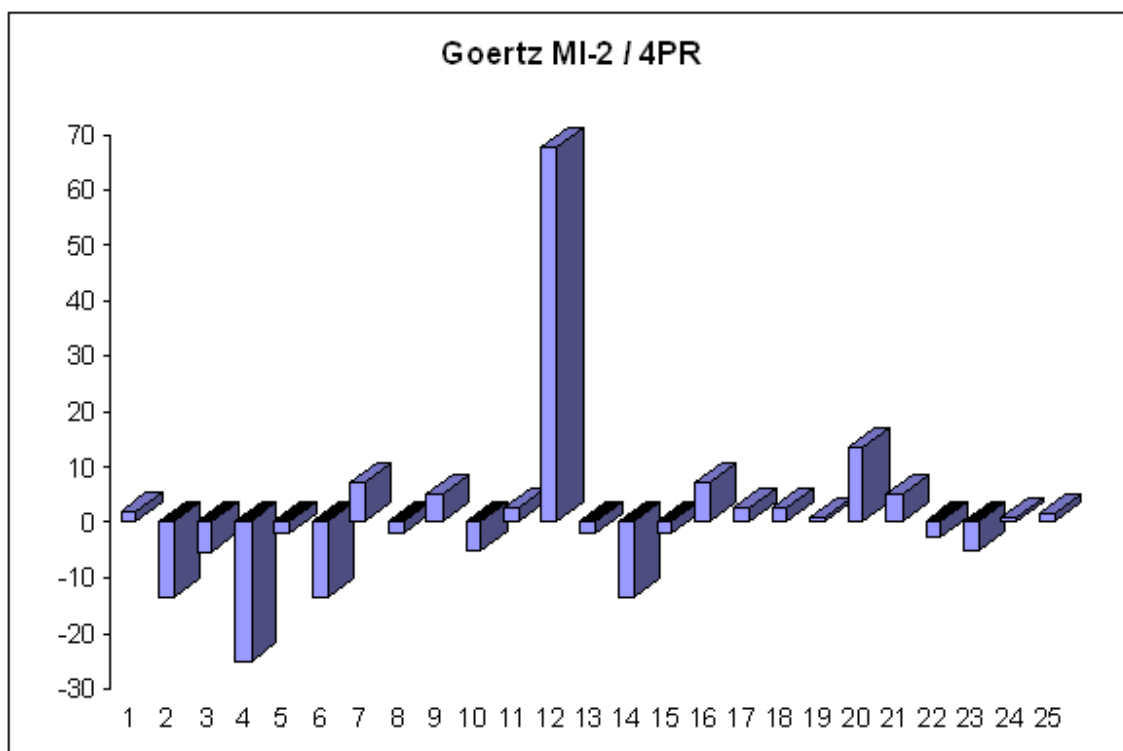
Now let us see how a large round woven cable responds...



7 and 16 : X_L / X_c Ratios



Another style of cable design...



12 Fr / L-C ratio @ X 20 kHz

The previous graphs reveal several interesting insights into Cable design.

We noticed that:

The ratio of capacitance to inductance C-L,
or the X_L - X_C ratios [at 1 kHz and 20 kHz] and
the Frequency Resonance of the cable are important 'parameters'.

The X_L / X_C ratios demonstrate that a certain *pas de deux* or 'balance' of capacitance to inductance is essential in producing a 'good' cable.

To continue, let us now examine the myriad of various cable designs from the manufactures who published their cable specifications or those we were able to calculate the basic L, C and R - from what limited information the manufactures provided. The following manufactures make-up our Test-Group of 'quality' cable designers.

The following graphs show the difference in the various cables as referenced to the values of a PBJ Cable [3-braid] from Kimber Kable.

Notice that the Scales change from one cable to the next, this was done to fit the graph on a page due to the extremes of some cables.

The charts show by numerical magnitude the difference between the various calculated test values. The positive and negative values indicate how much more or less the Test values of various cables in respect to Kimber's interconnects.

Ratio 7: X_L / X_C @ 1 kHz,
Ratio 16: X_L / X_C @ 20 kHz,
Ratio 12 is F_r / L-C ratio,
Ratio 17 QZ_t / R_{dc} ,
Ratio 20 is F_r / Z_o .

The Linear scaled Column-Charts display the Ratio-Deviation from the '0' 'reference-level' and so the shorter the columns [closer to 0] the better [?]

The Balance between Capacitance [1] and Inductance [2] of the 3-Braid is about 12,000 to 14,000 to 1; that is L over C.

Kimber 3-Braid PBJ *	5.50E-11	7.70E-07	14,002
Acoustic-Research	7.10E-12	2.97E-08	4,183

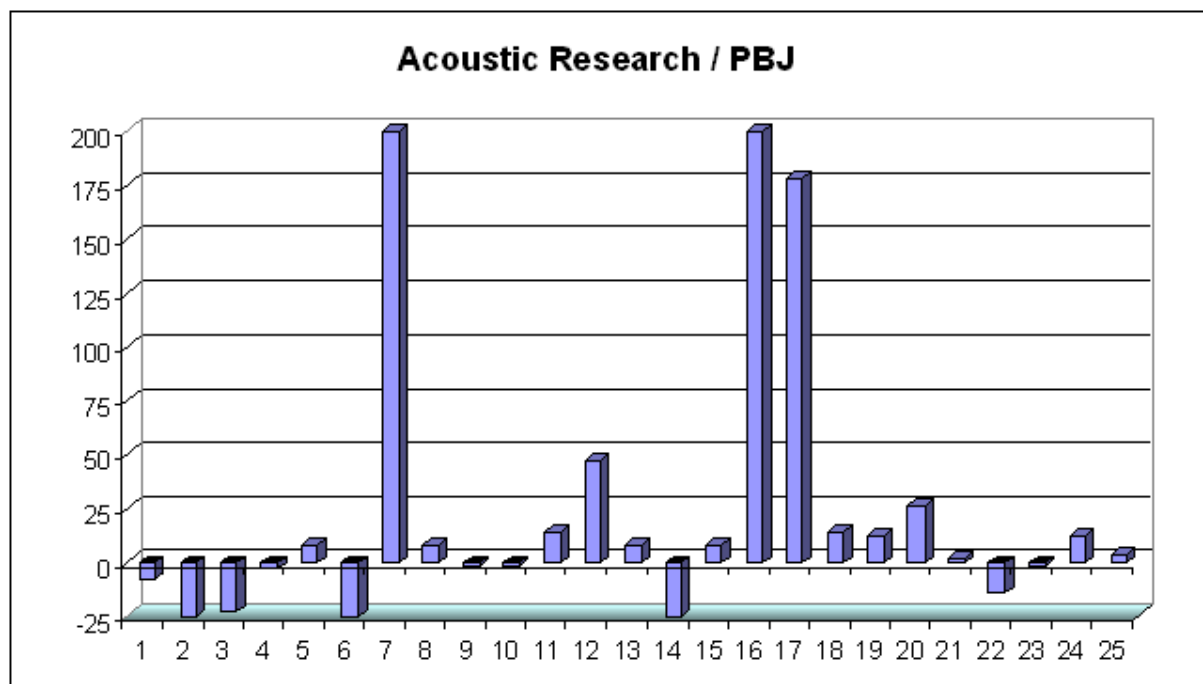
This cable has extreme values of Capacitance and Inductance as per the PBJ Reference: having 8 times more Capacitance & 22 times more Inductance. [?]

This extremely small amount of capacitance may hinder the magnetic fields of the audio signal as per the ***pas de deux*** relationship, because the static fields are electrically and mutually supportive of the magnetic fields in the propagation of the Audio signal.

Point 17 is $Q Z_t / R_{dc}$; very large X_c lends to a very large Z_t being divided by small R_{dc} [d.c. resistance]. Q then is very large in value being 180 times more than the 3-Braid 'reference'.

$$\begin{aligned} & Q Z_t / R_{dc} \\ & 51,686,980 \\ & 9,703,955,303 \\ & 187.74 \end{aligned}$$

[See Appendix B: IC Graphs Folder, File: ALL-IC-PBJ.xls]

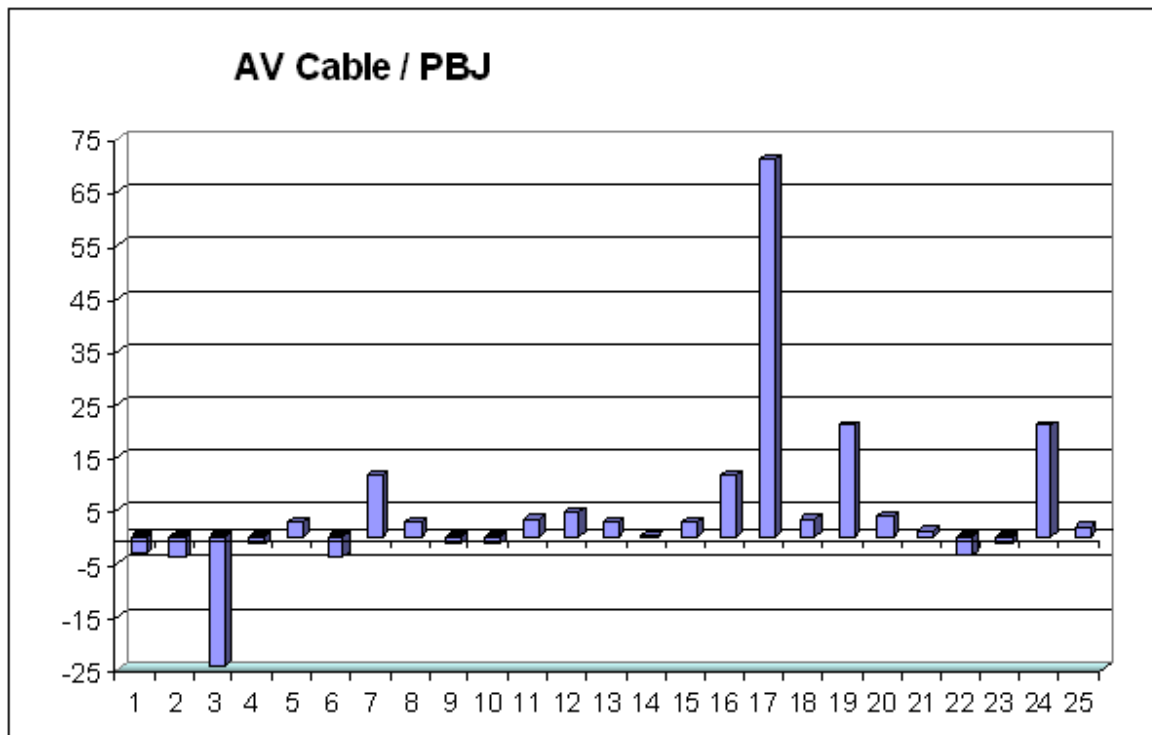
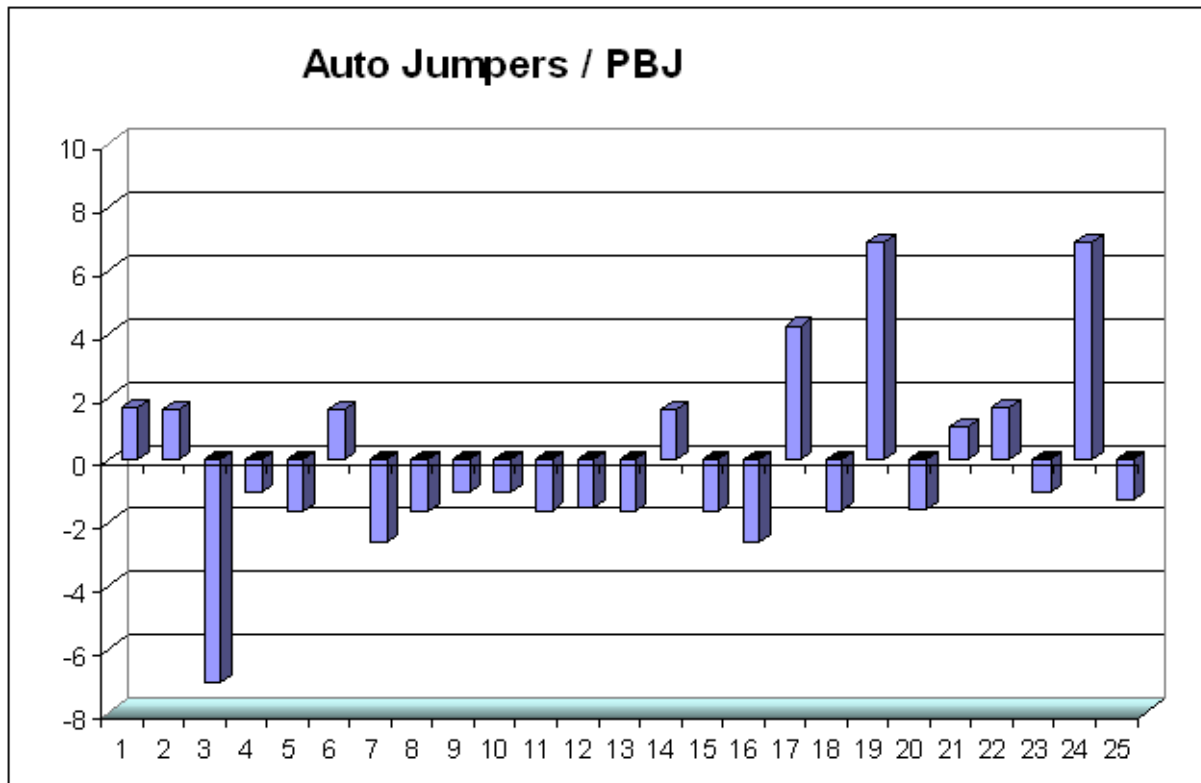


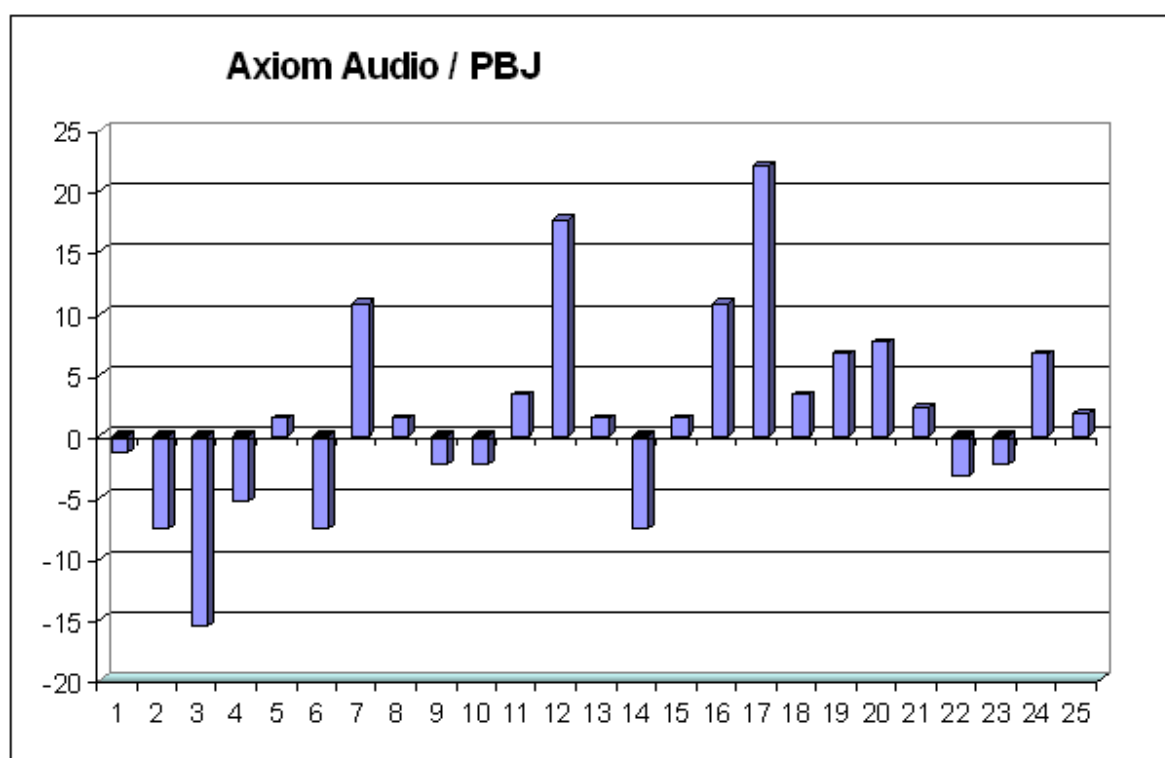
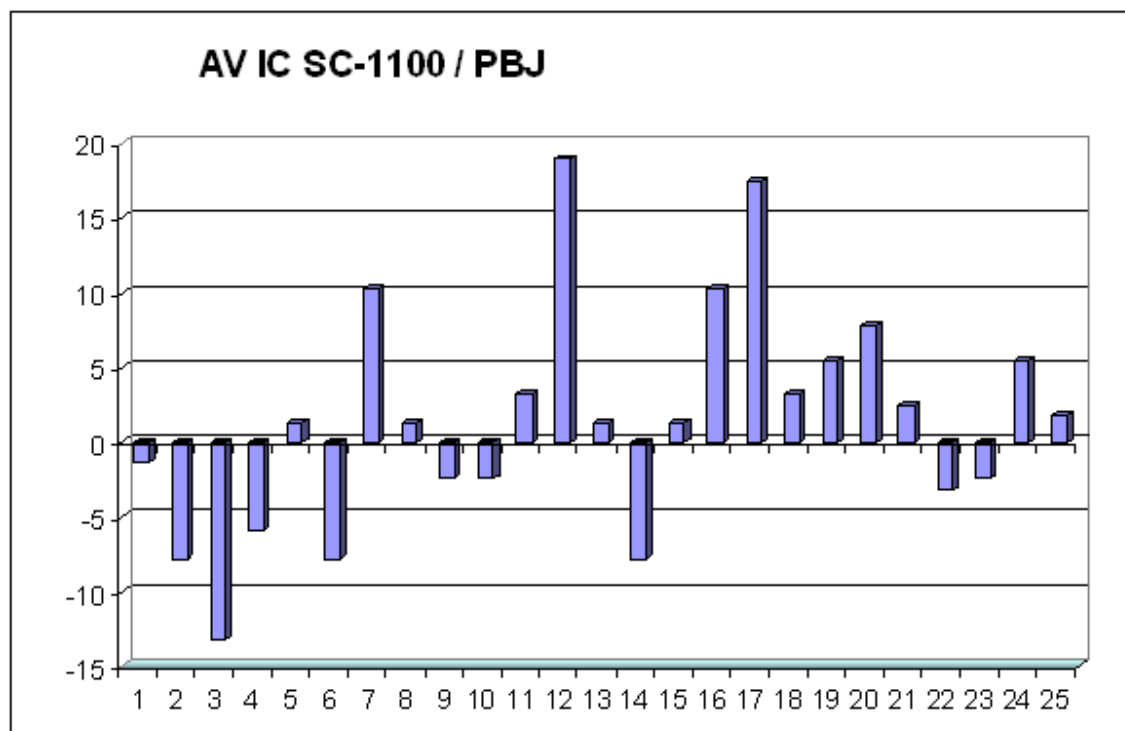
7 XL/XC 1kHz Ratio

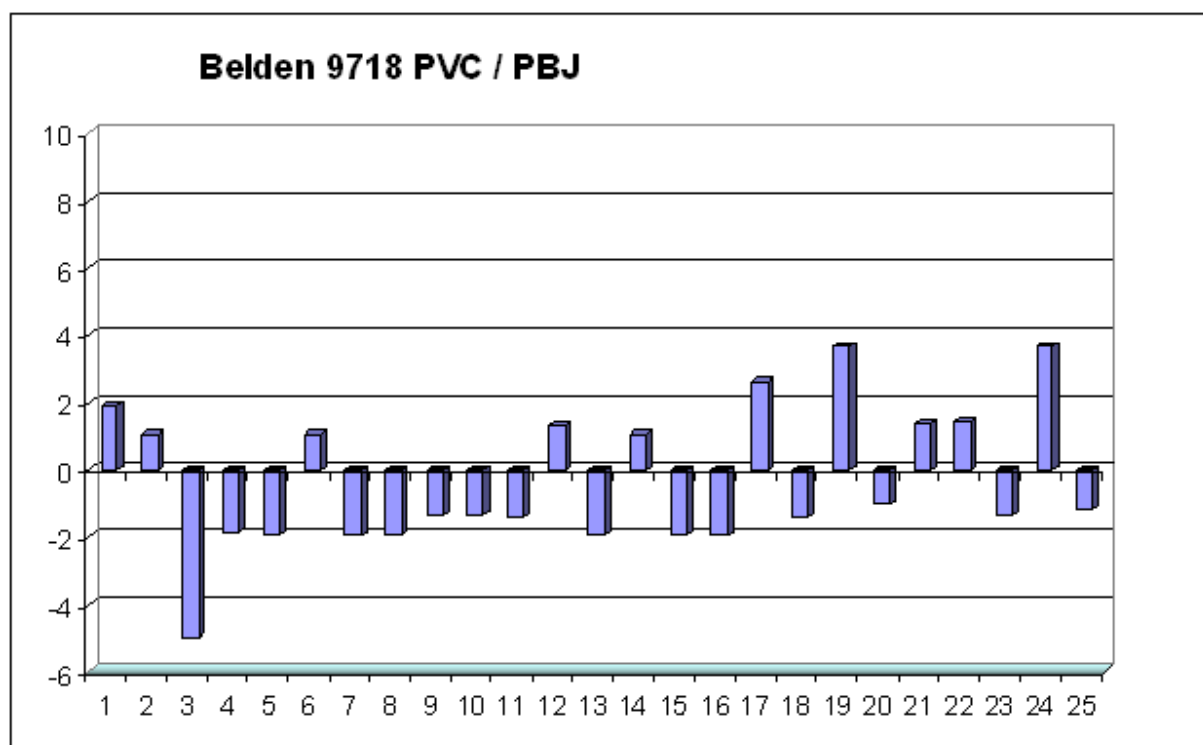
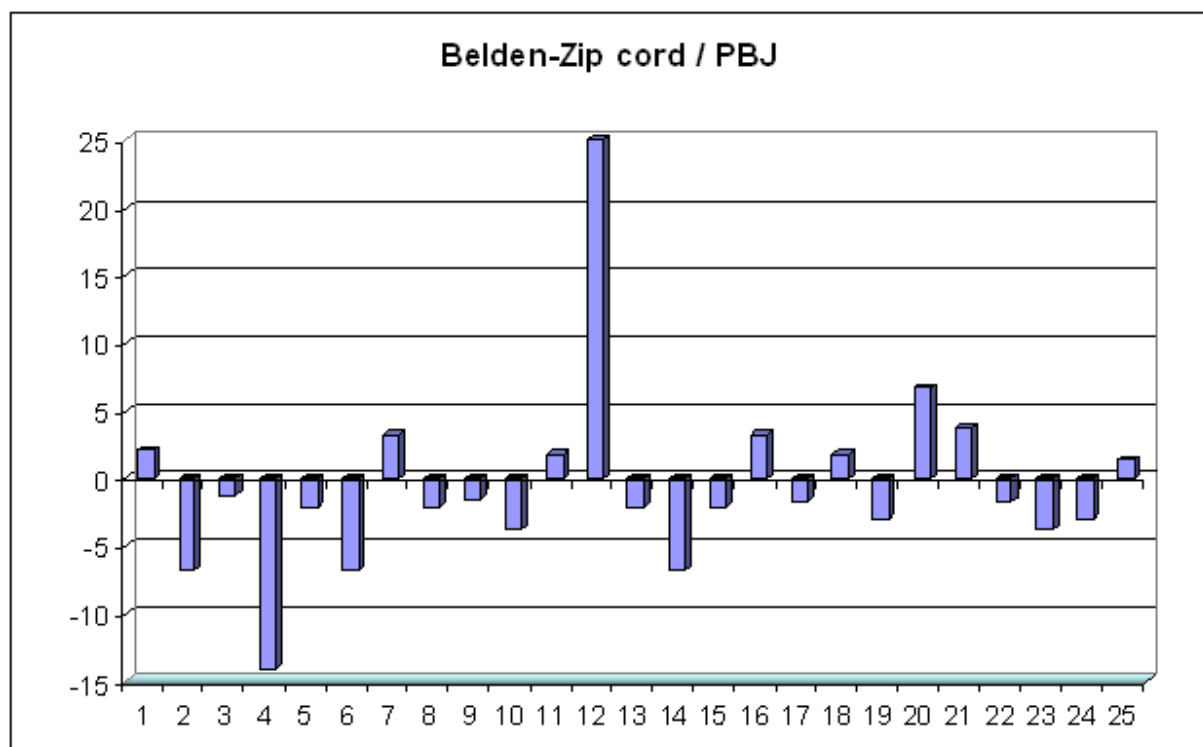
12 Fr / L-C ratio @ X 20 kHz

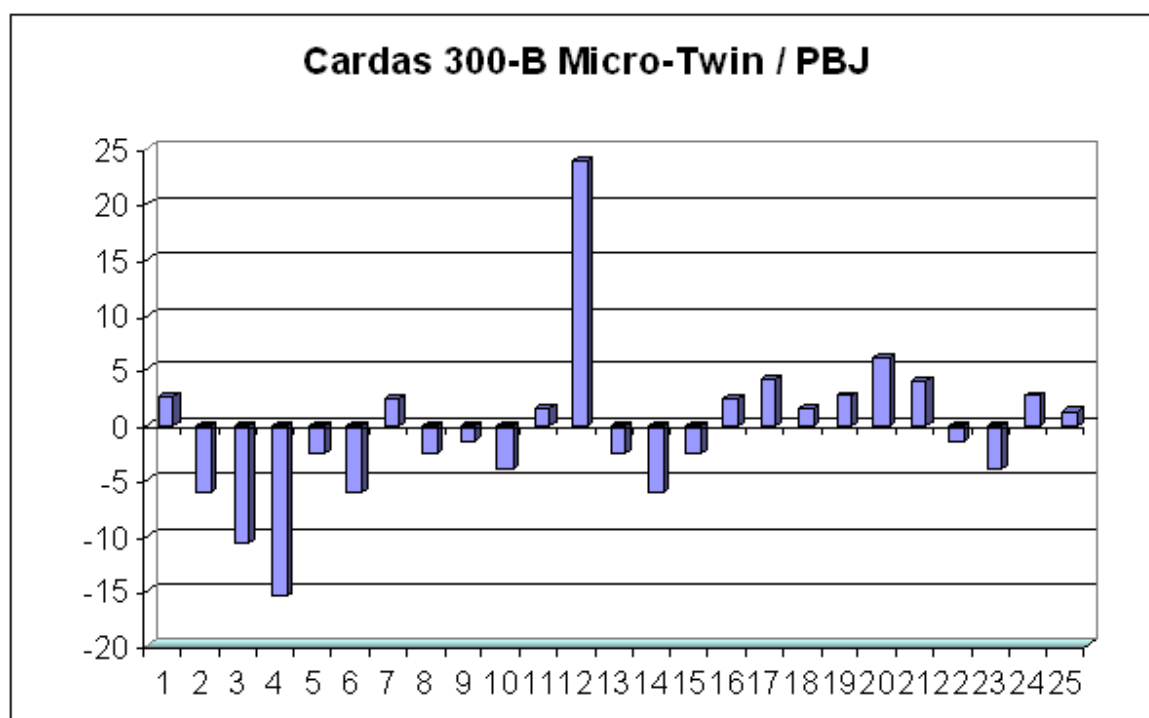
16 XL/XC Ratio 20 kHz

17 $Q Z_t / R_{dc}$ [$Q = Z_t / R_{dc}$]









Column		1	2	3	4	5	6
Name	Brand	C - Farad	L - Henry	R - Ohms	L/C Ratio	Xc	XI
Cardas : 300B MicroTwin		1.41E-10	1.27E-07	0.005	901	1,128,756	0.00080
Kimber Braid : PBJ	IC	5.50E-11	7.70E-07	0.0530	14,002	2,898,719	0.00484
Ratio		2.56	-6.06	-10.60	-15.55	2.57	-6.07

7	8	9	10	11	12	13	14
XI/Xc-Ratio	Z-Total 1 kHz	SWR-50	Zo-Cable	Freq Resonance	Fr / L-C	Xc 20 kHz	XI 20 kHz
1,414,540,540	1,128,756	1.67	30.01	37,610,456	41,756	56,438	0.0160
598,037,503	2,893,719	2.37	118.33	24,454,856	1,747	144,686	0.0968
2.37	-2.56	1.42	-3.94	1.54	23.90	2.56	6.07

15	16	17	18	19	20	21	22
Z-Total 20 kHz	XI/Xc-Ratio	Q (Zt / Rdc)	Q (Zt / Zo)	Q/Fr	Fr / Zo	Fr / Xc-1kHz	Qa 377 LC
56,438	3,536,351	225,751,164	37,610	6.002	1,253,188	33.32	1.60E-06
144,686	1,495,094	54,598,480	24,455	2.233	206,668	8.45	2.45E-06
2.56	2.37	4.13	1.54	2.69	6.06	3.94	-1.54

23	24	25
Z Wave 377 L/C	Zo / Rdc (SWR)	Q - Line
11,314	6,002	521
44,610	2,233	420
-3.94	2.69	1.24

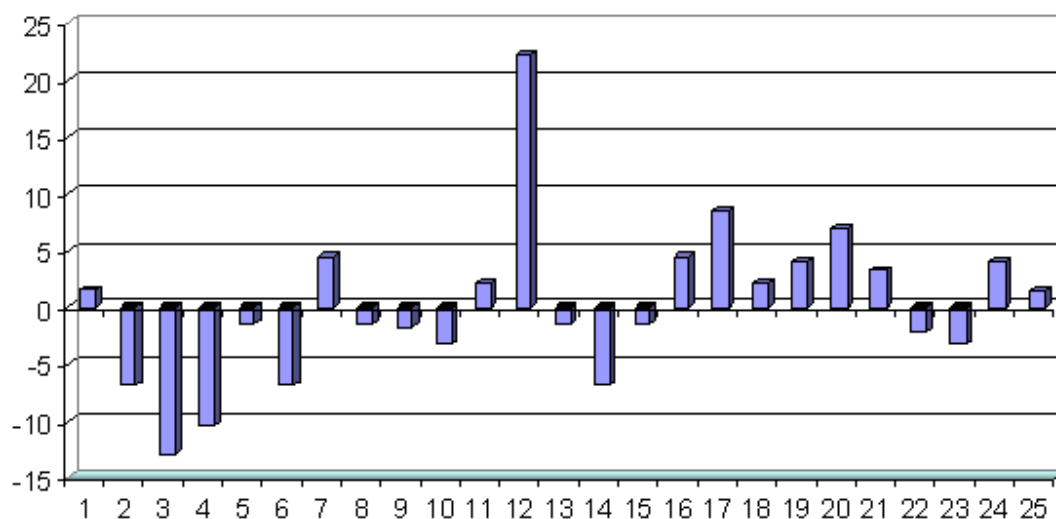
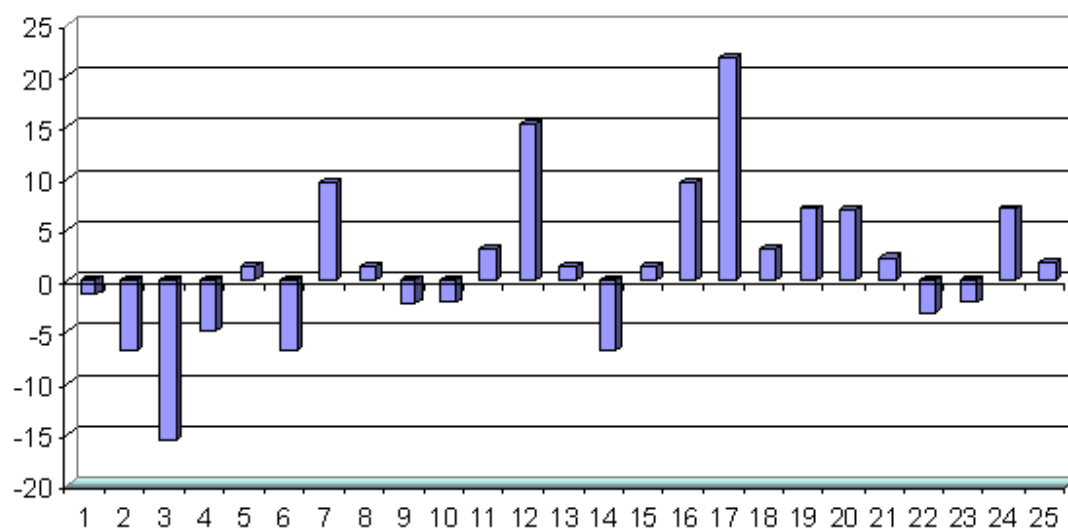
These 25 columns of ratios, as shown above of the Cardas 300B MicroTwin and the Kimber Kable PBJ, numerically shows the differences in these two styles of cables.

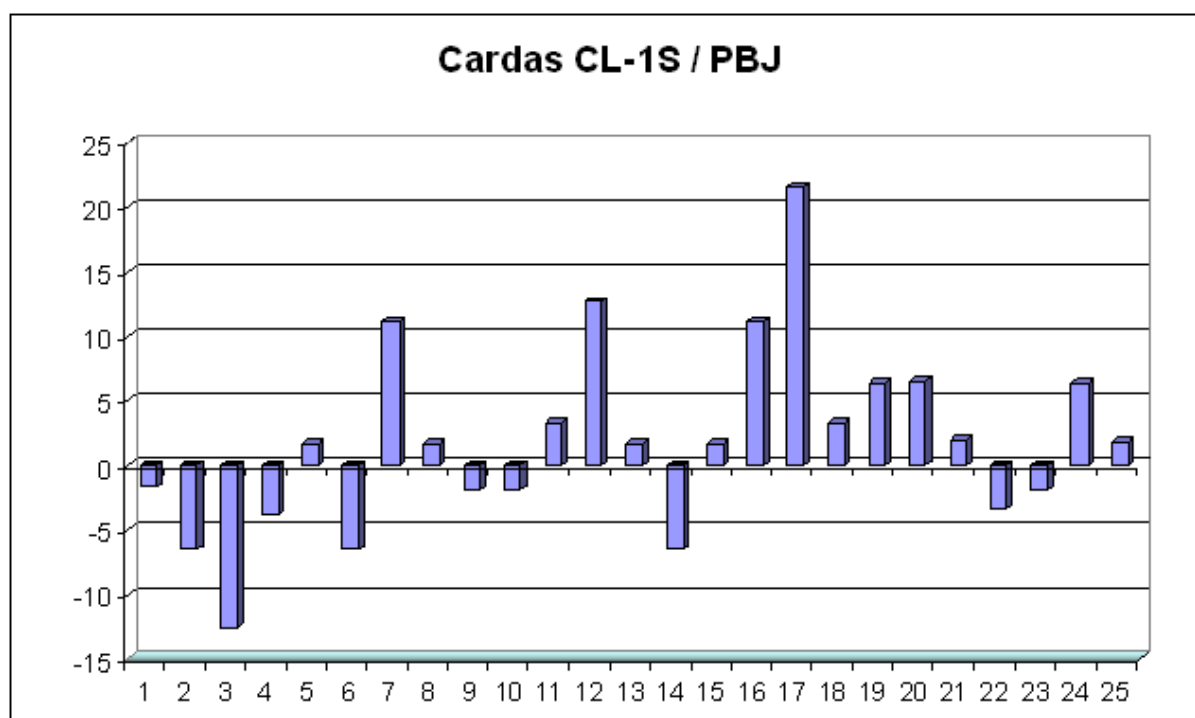
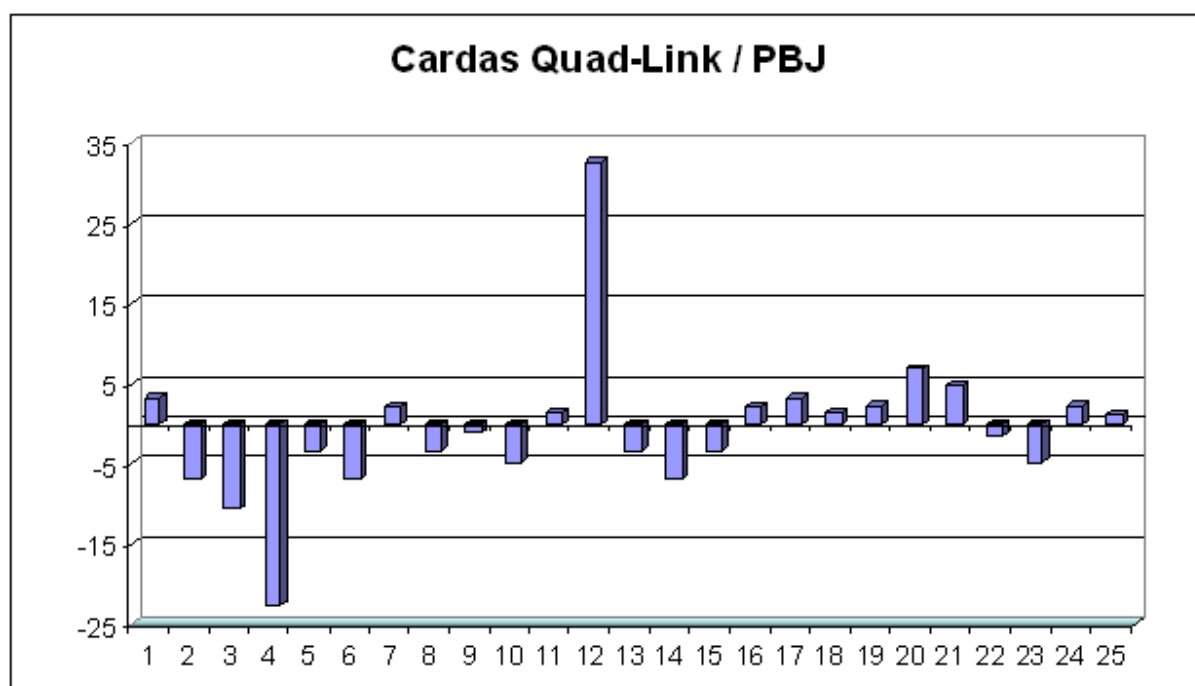
The Micro-Twin has:

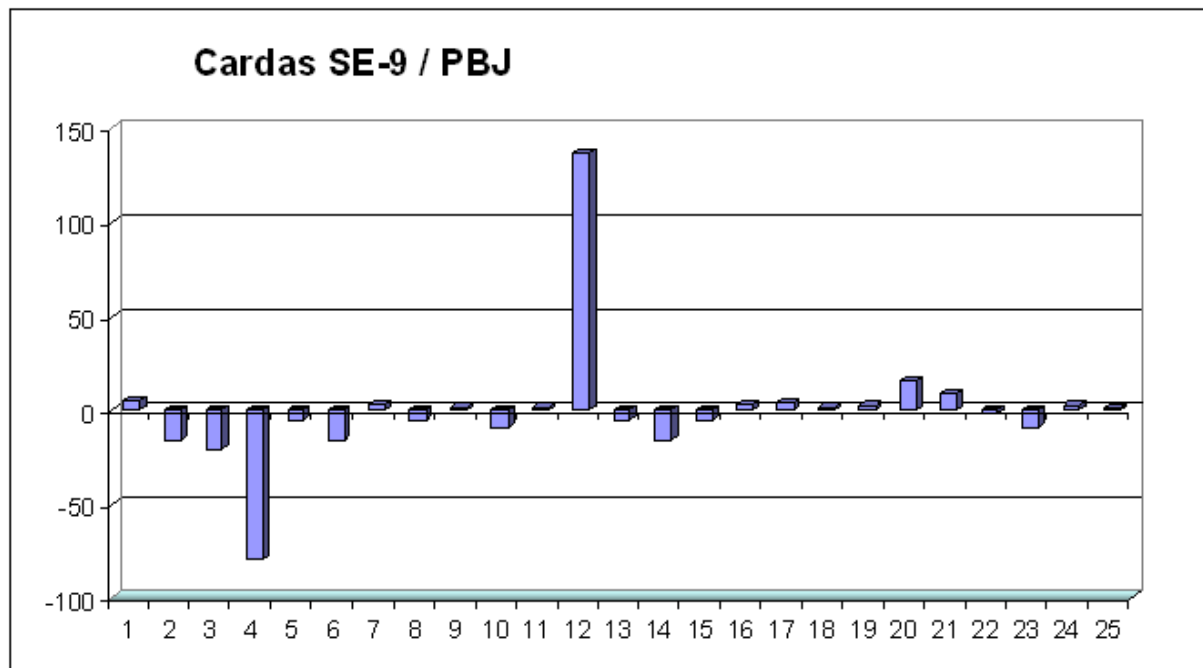
- 1.) 2.56 more Capacitance
- 2.) $\sim 1/6$ the Inductance,
- 3.) $\sim 1/10$ the DC resistance,
- 4.) L/C ratio is $\sim 1/15$,
- 5.) less X_c : $1/2.57$
- 6.) less X_l : $1/6$,
- 7.) a greater X_l/X_c ratio by 2.37 times,
- 8.) less Total Impedance Z : $1/2.56$,
- 9.) SWR is less by $1/4.2$,
- 10.) Cable Z_o is $1/4$,
- 11.) Calculated Frequency Resonance is 1.54 times higher,
- 12.) L/C ratio compared to the Resonant Frequency is 24 times greater.

13, 14, 15 and 16 same as the 1 kHz ratios.

- 17.) Cable Q is 4 times greater
- 18.) Q of Total impedance and Cables Z_o is 1.54 greater
- 19.) Q and ratio of Resonant Frequency is 2.23 greater
- 20.) Resonant Frequency and Cable Z_o is 6 times more
- 21.) Resonant Frequency and X_c is 4 times more
- 22.) $Q_a 377 / [L/C]$ is less: $1/1.54$
- 23.) Z Wave $377 L/C$ is less by $1/4$
- 24.) Z_o/r_{dc} (SWR) is 2.69 times more
- 25.) Q-line is 1.24 more.

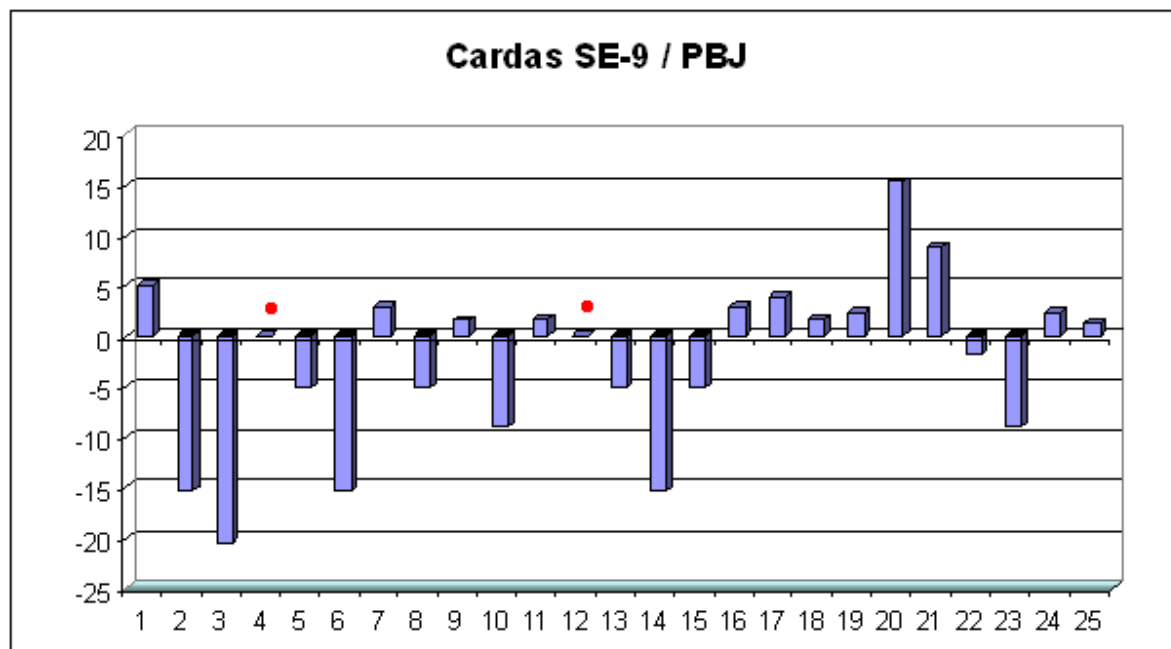
Cardas Golden-Cross / PBJ**Cardas Golden Reference / PBJ**





The SE-9 cable has two values that are extreme:

1. Ratio 4: L/C is 177 to 1, which is 79 times smaller than the PBJ value of 14,002 to 1.
2. Ratio 12: Fr/L-C is 238,757 to 1, which is 136 times larger than the PBJ value of 1,747.

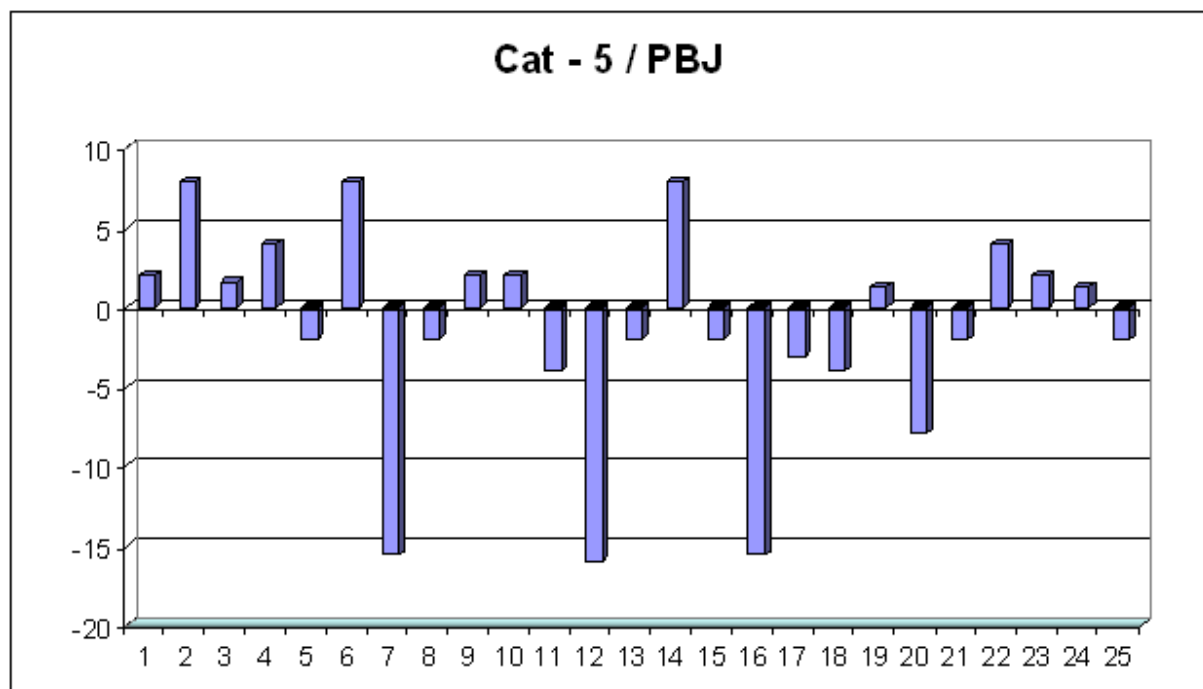


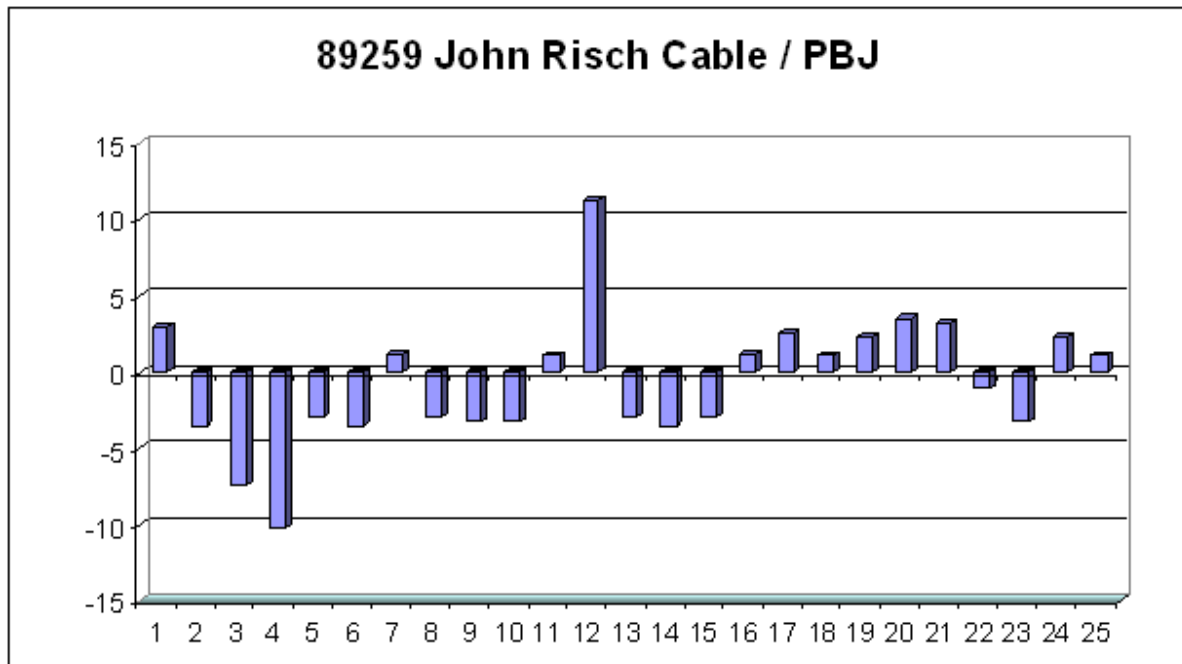
Cardas SE-9 with: Ratio 4 L/C Ratio & Ratio 12 Fr/L-C: changed to '0'.

The SE-9 cable's L/C of 177 is very low indicating that the Magnetic-Fields and Static-Fields are more proportionally 'equivalent'.

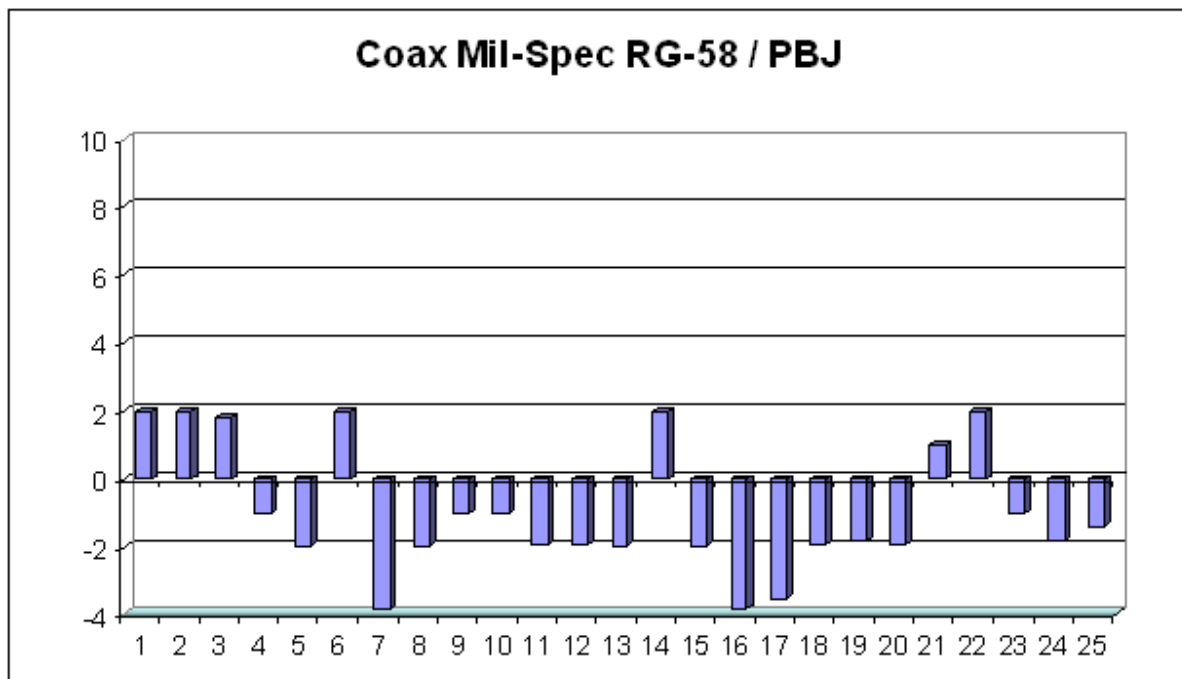
The PBJ L/C ratio is greater, having a larger proportion of inductance than capacitance. Comparatively, PBJ cable has more Inductance and less capacitance.

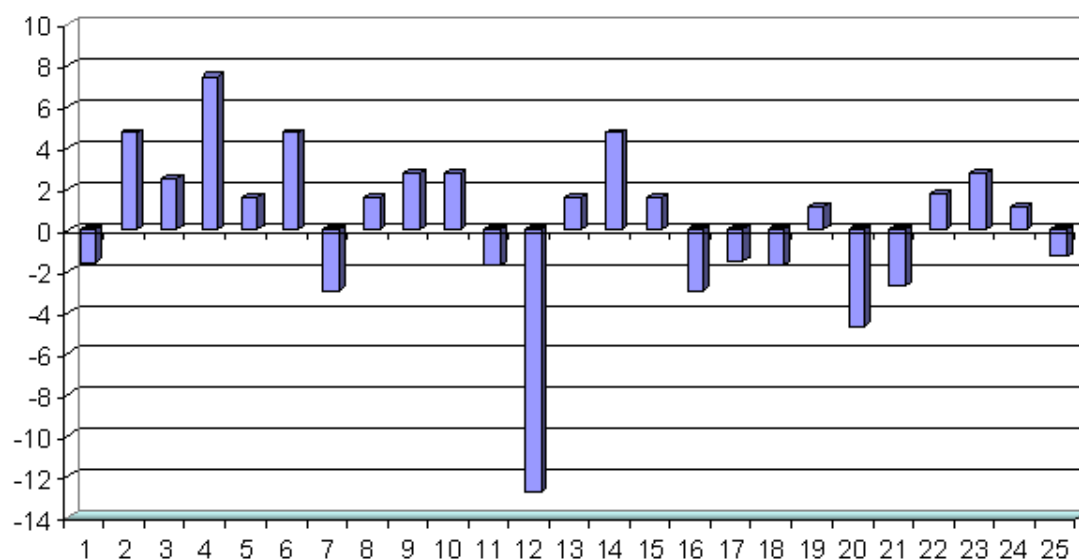
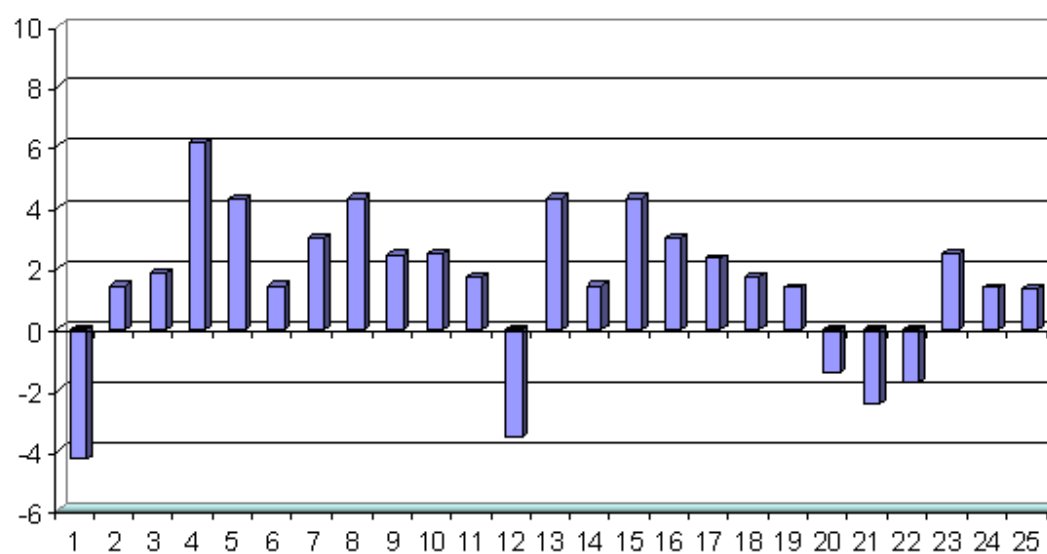
	F	L	ratio
PBJ	5.50E-11	7.70E-07	14,002
SE-9	2.83E-10	5.01E-08	177

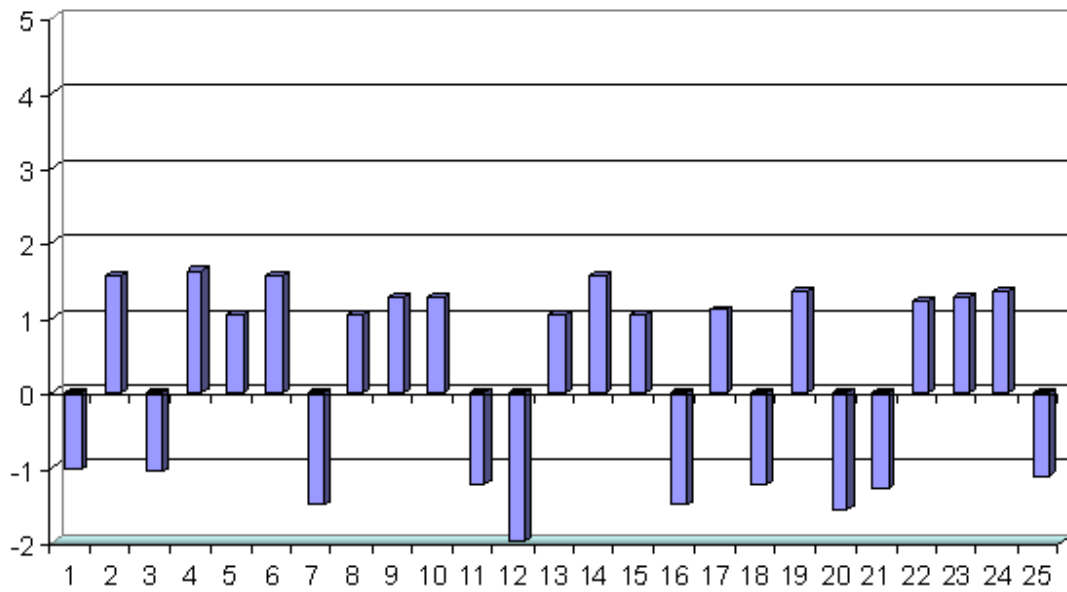
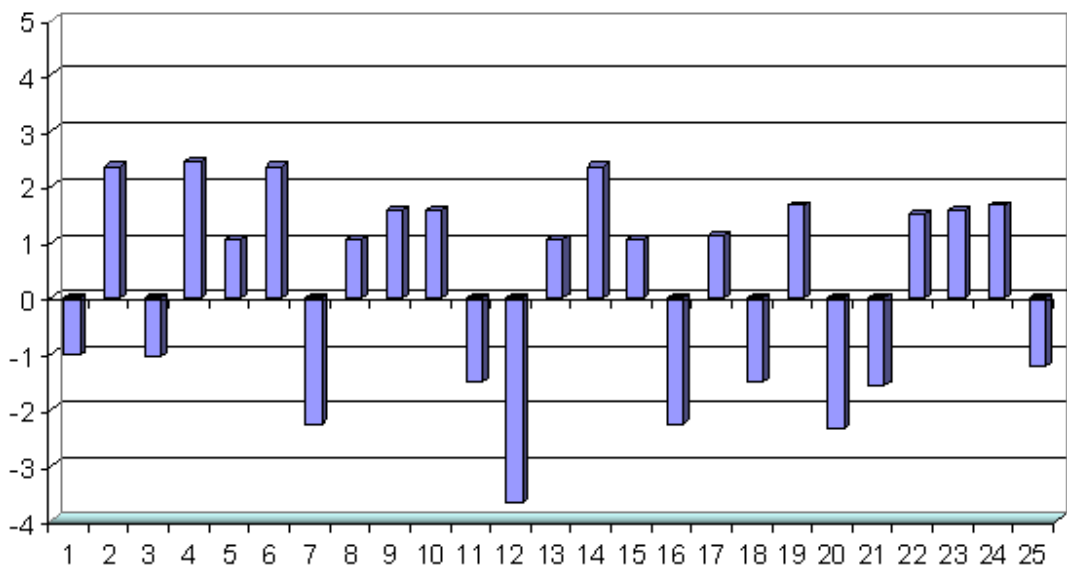


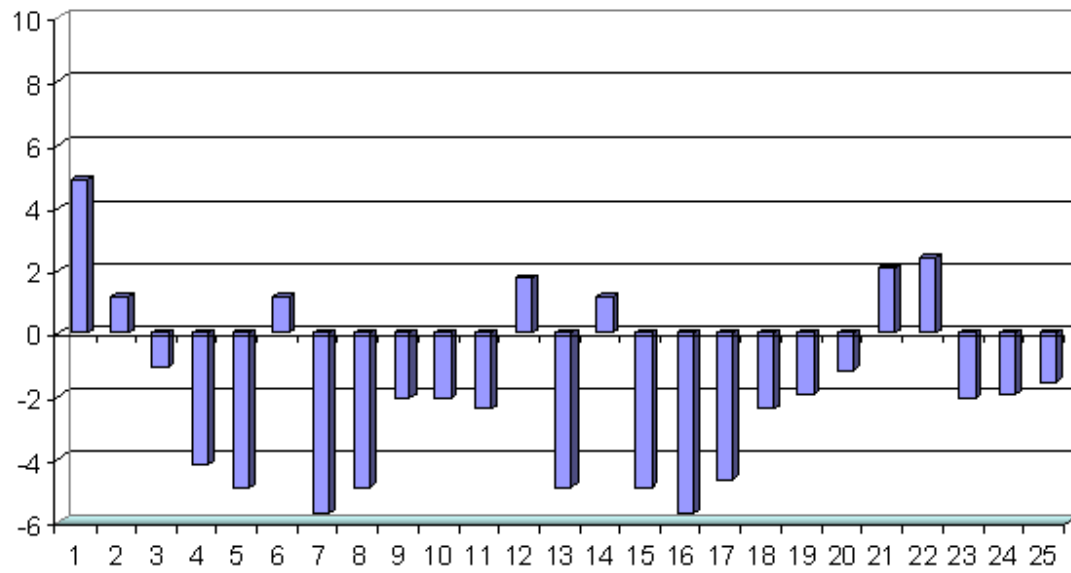
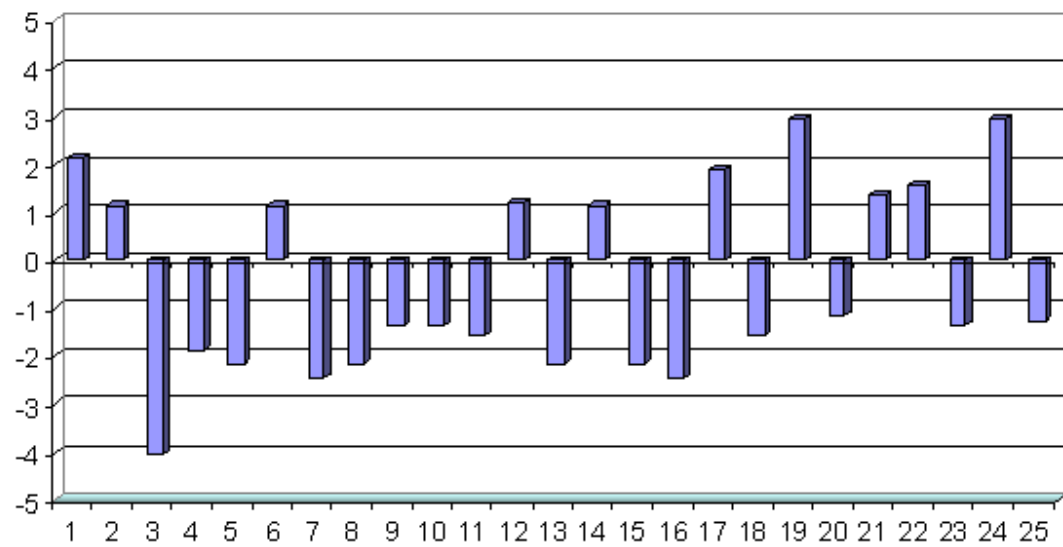


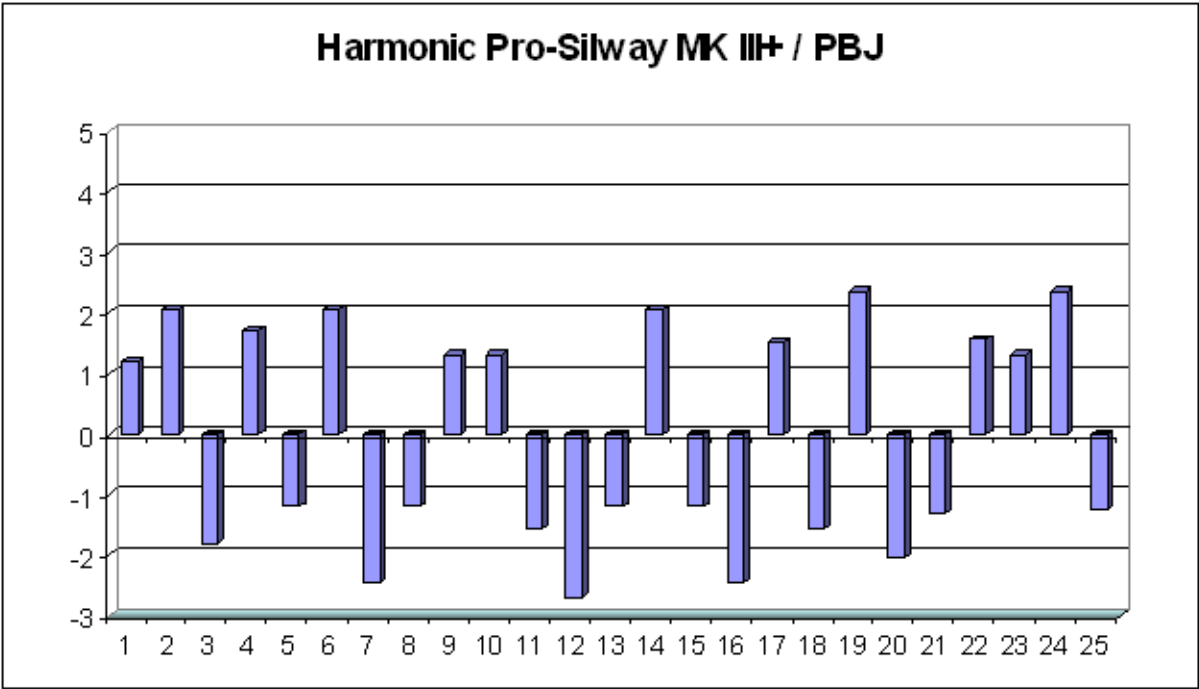
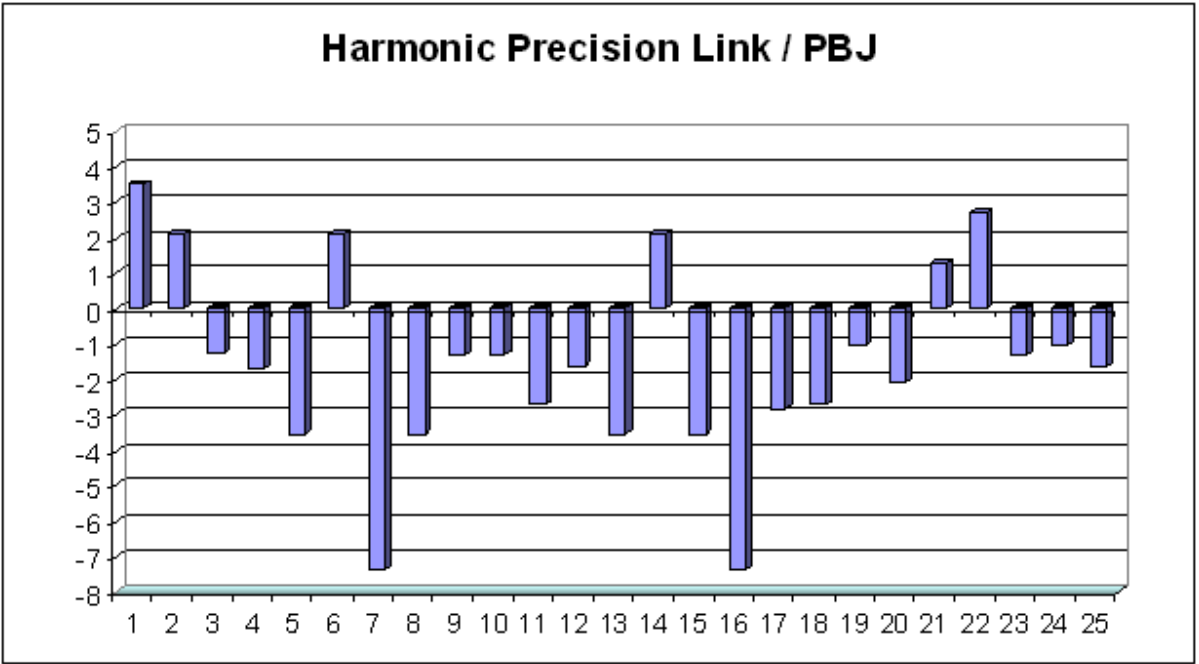
Round-Shielded Cable - Coax

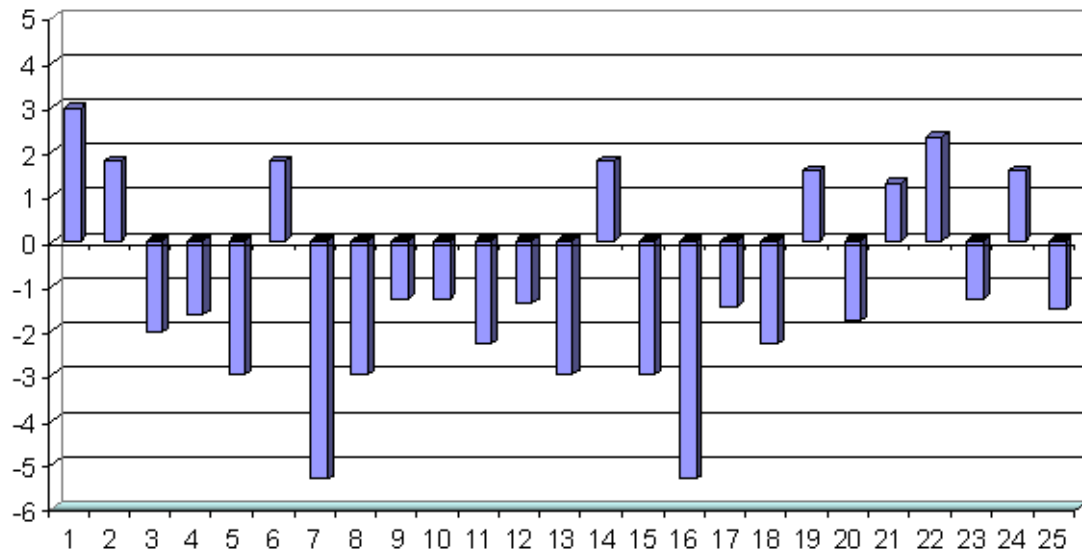
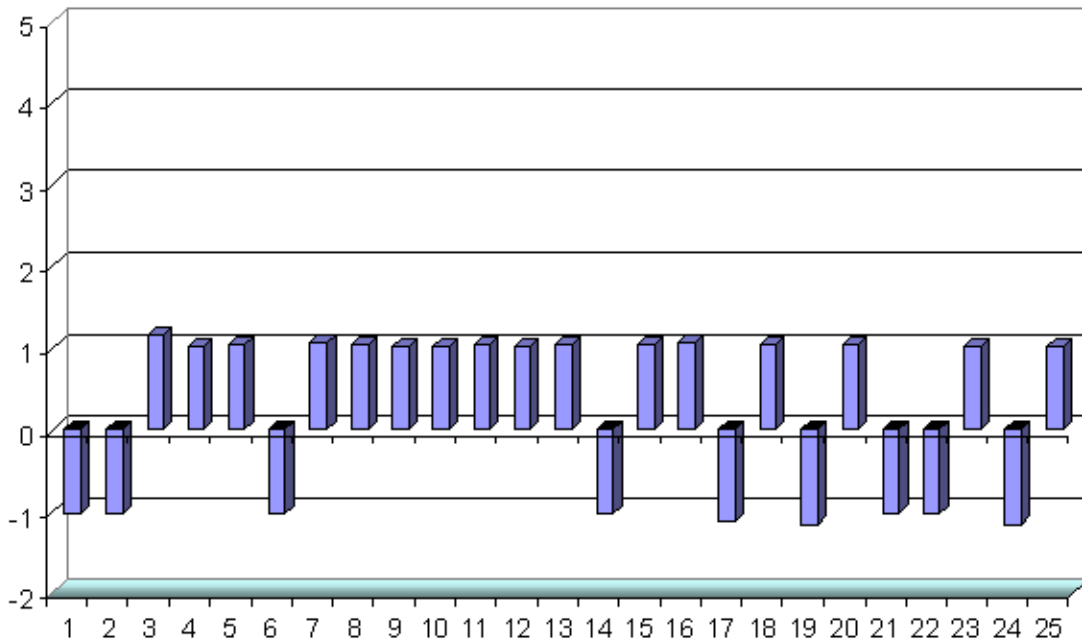


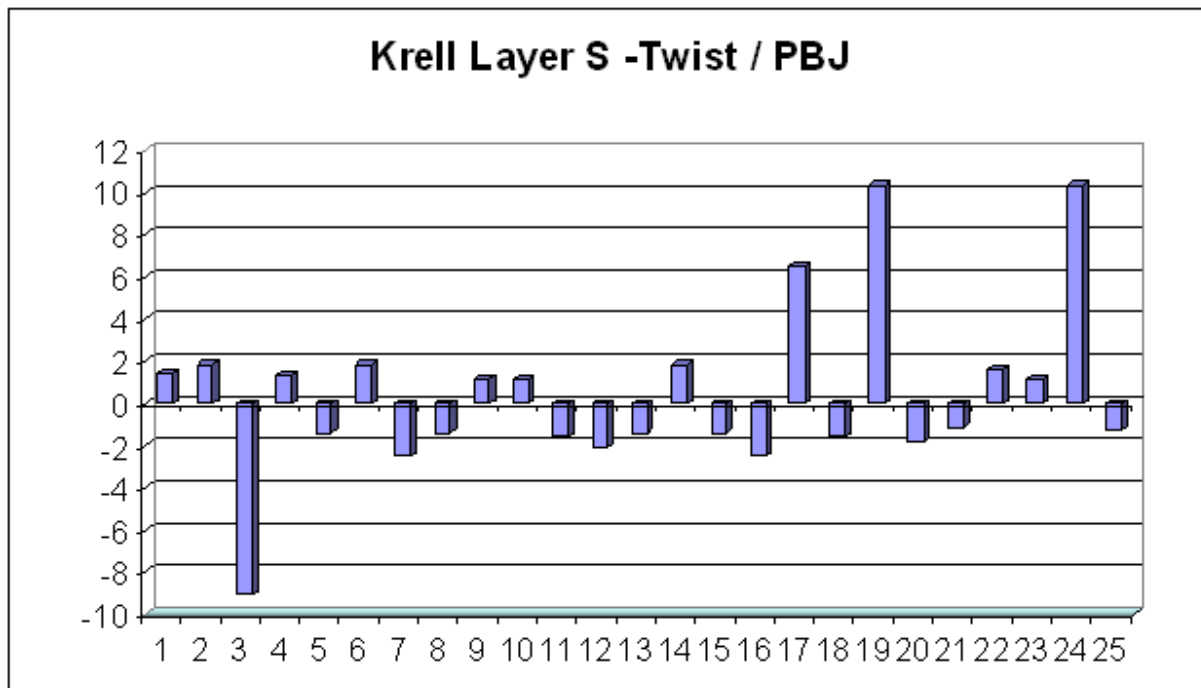
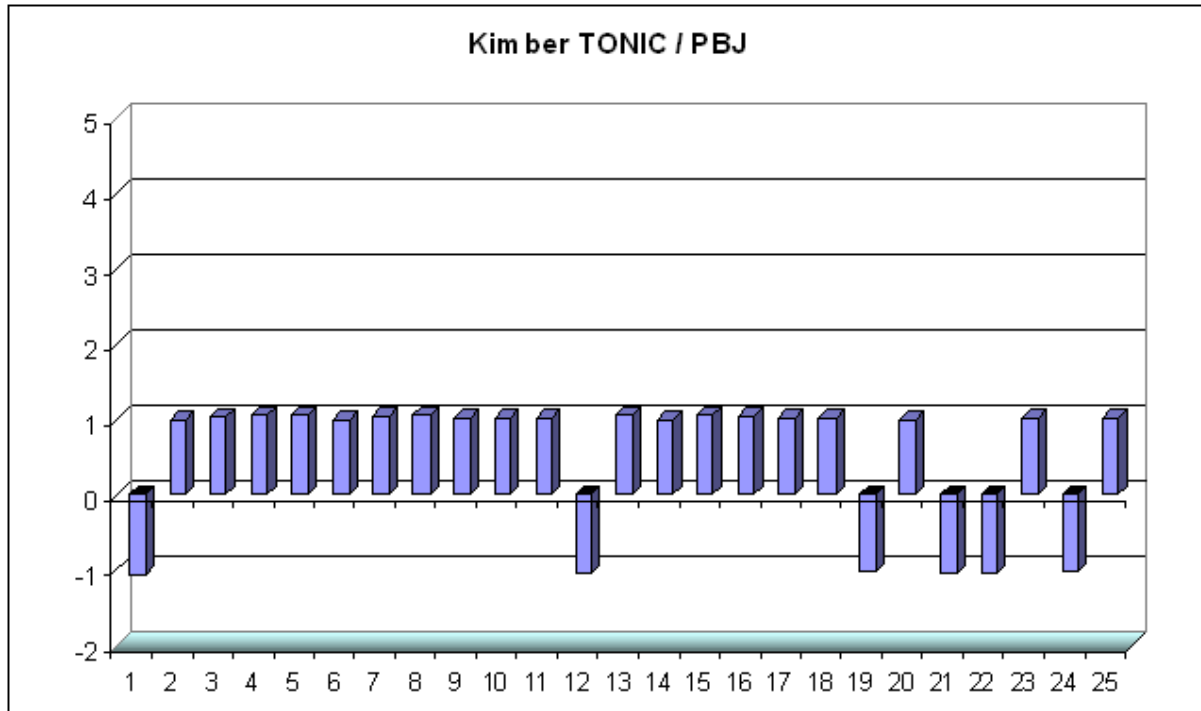
Empirical Audio Holophonic 2 SPC / PBJ**Empirical Audio Holophonic PC / PBJ**

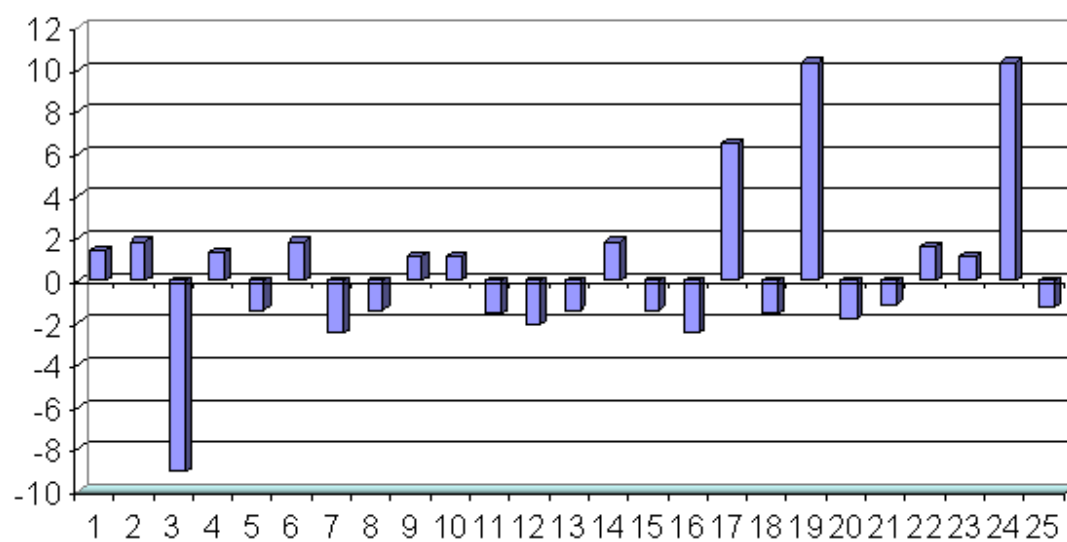
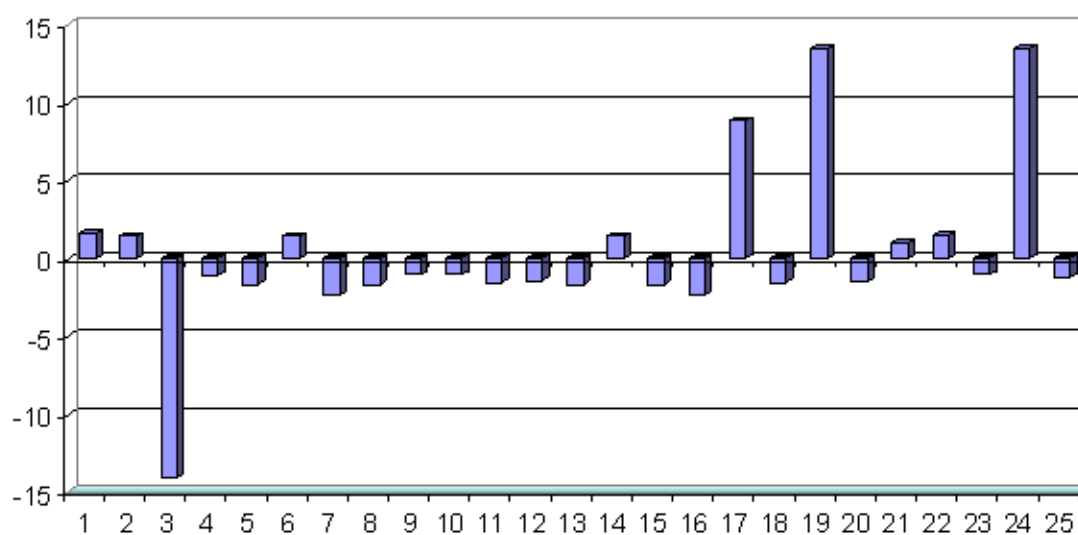
Granite Audio #470-12 / PBJ**Granite Audio #470-18 / PBJ**

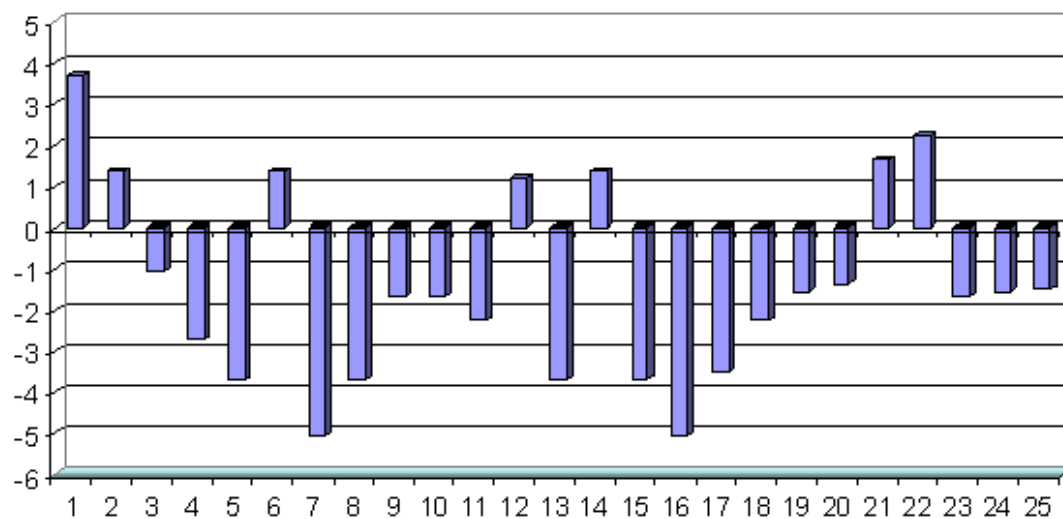
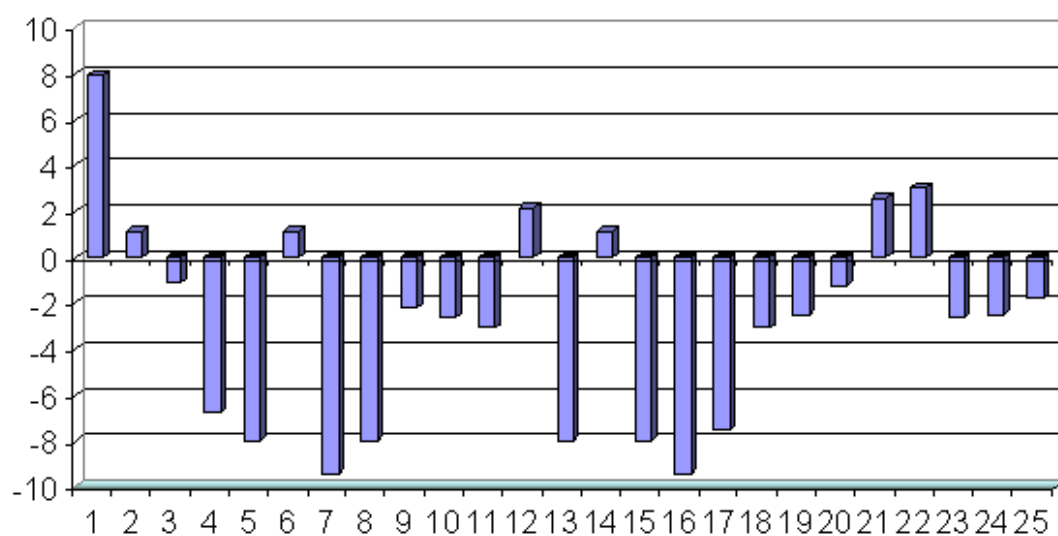
GutWire Chime OFC / PBJ**Harmonic Magic Link Two / PBJ**

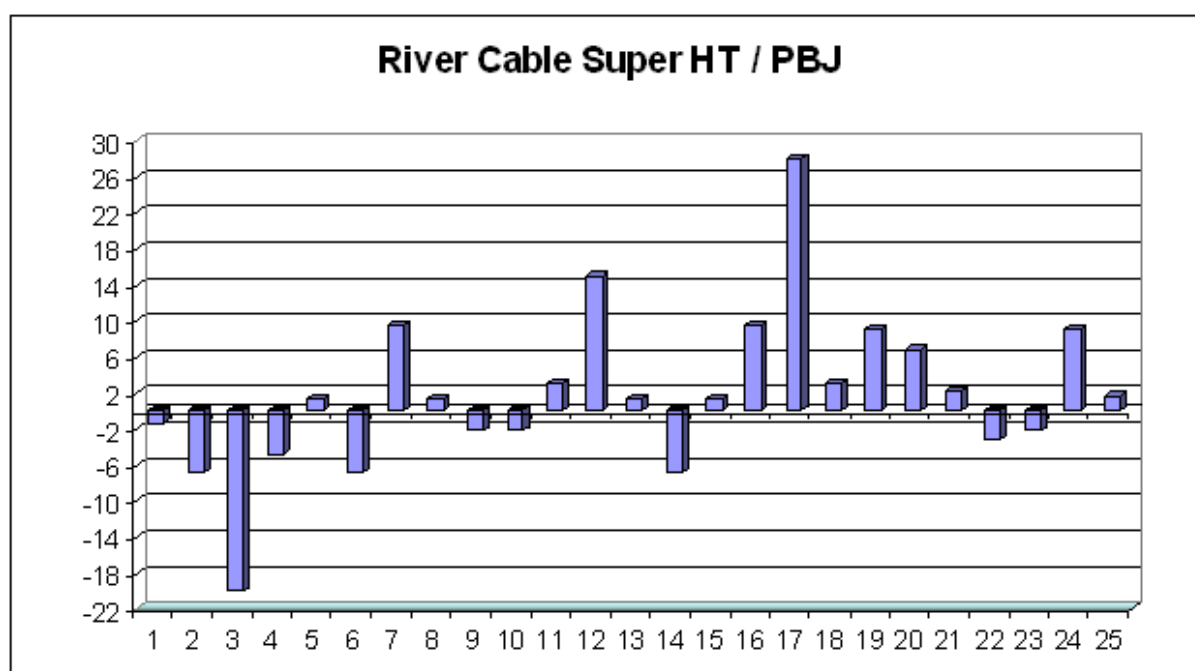
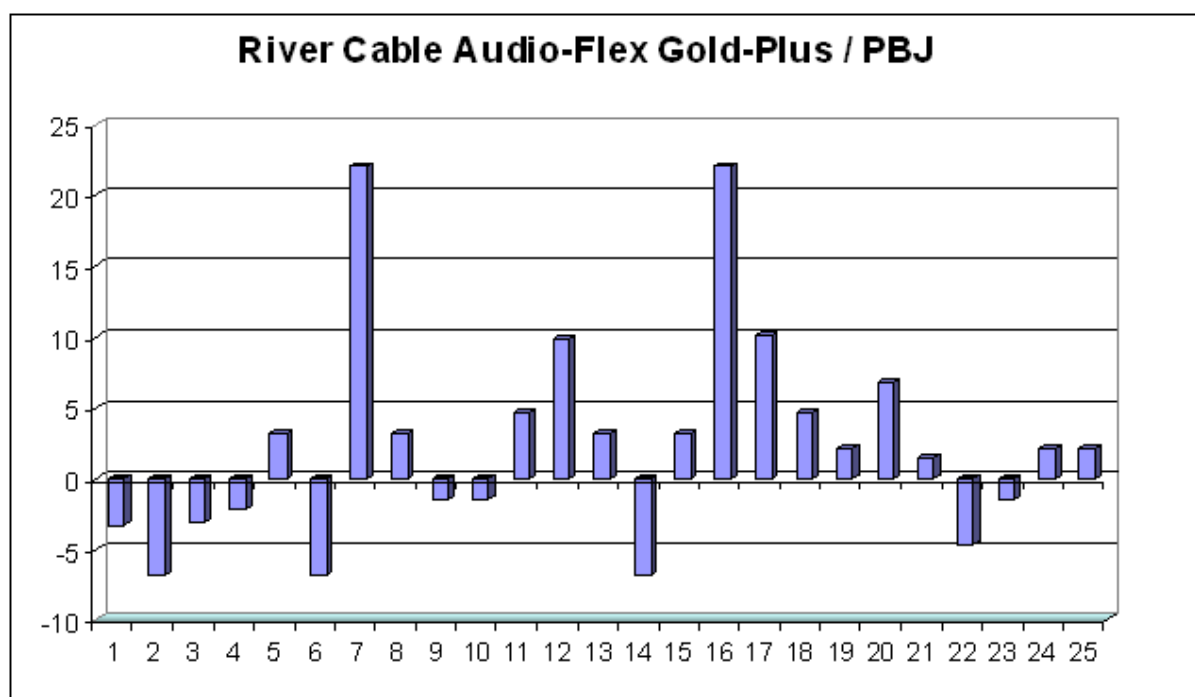


Harmonic Truth-Link / PBJ**Kimber Silver Streak / PBJ**



Krell Layer S -Twist / PBJ**Levinson HF 10C / PBJ**

Maple Audio Works Ambiance / PBJ**Purist Audio Proteus / PBJ**



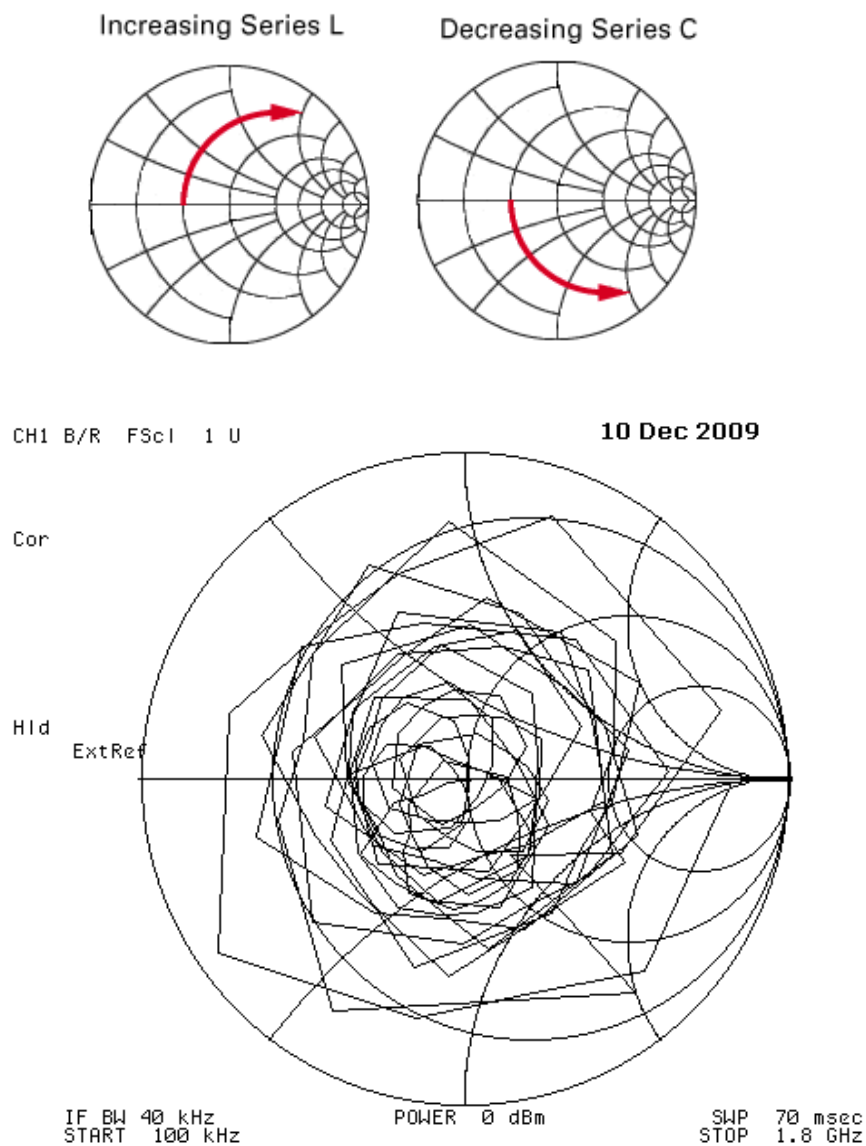
The previous graphs offer a simple process to compare cables using the published LCR specifications. To test your cables by using our RF Charting spread sheet program, just enter the L, C and R values into line **164** of the Spread Sheet called: **Cable-Tests-RF-Ratios.xls** in the - **CABLE CHARTS** folder. The **graph** below the 163, 164, 165 lines will automatically change as you type in the new manufactures L C R values. [Also see RosVeta web-site, Tech.-Papers-Cable-test]

Smith Charts

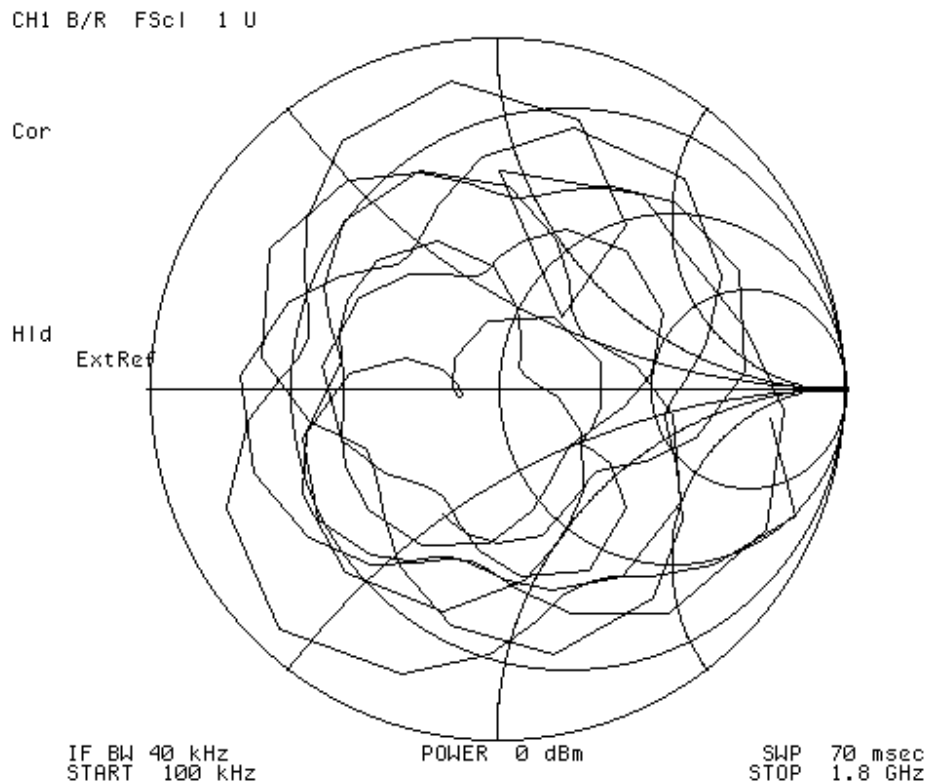
To conclude our cable test we will show a few RF Smith Charts.

Our RosVeta Fyra, a 2x2 cable, a manufactured 'interconnect' cable and a twisted-pair cable will be displayed. We did request a sample cable from several manufactures but they declined, which is ok we needed to finish this book.

The following charts indicate the RF characteristics of circuits as the frequency is changed from a low frequency to a pre-selected upper frequency. The circular chart is separated into three sections: top half Inductive and the lower half Capacitive and the horizontal-middle line represent the DC resistance value.



Zip-cord [6 Ft.]



Twisted Pair

As stated before, Zip cords and 'twisted-pairs' are always used for derision to say these styles work as well as 'snake-oil-cables'.

Here we present a scientific measurement of a few cables as compared to these 'Standard' cords - cables.

One simple interpretation of the previous charts is that the more the trace has quick-sharp changes the less uniform the RF characteristics are of a cable. Another point: notice how many times the trace makes 'circles', less the circles the better.

As you can see both of these standard cables have many sharp-edged changes, and many 'circles' as the frequency is swept through these *common* cables.

CH1 B/R FScI 1 U

Cor

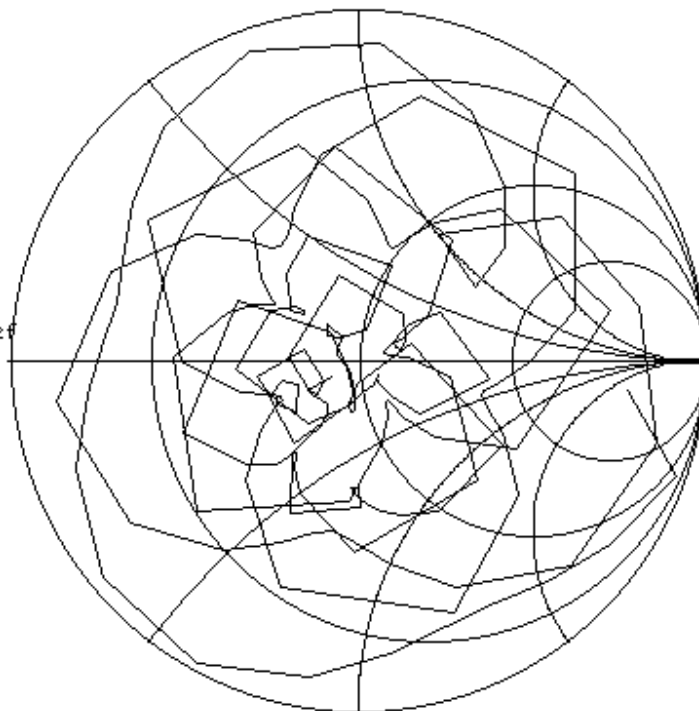
HId

ExtRef

IF BW 40 kHz
START 100 kHz

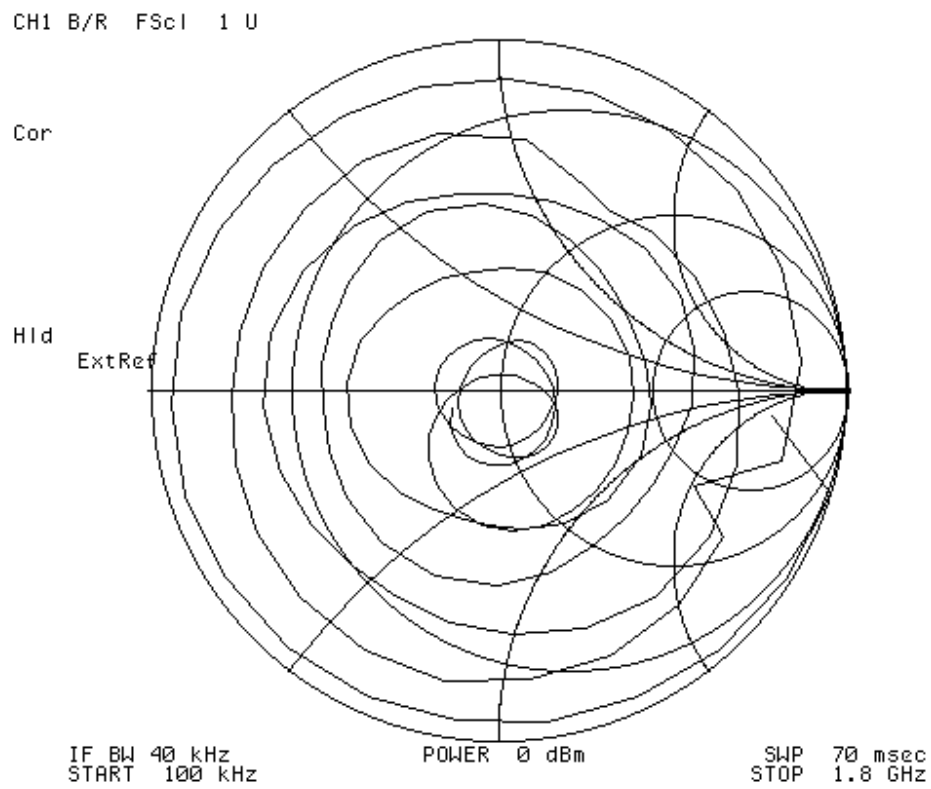
POWER 0 dBm

SWP 70 msec
STOP 1.8 GHz



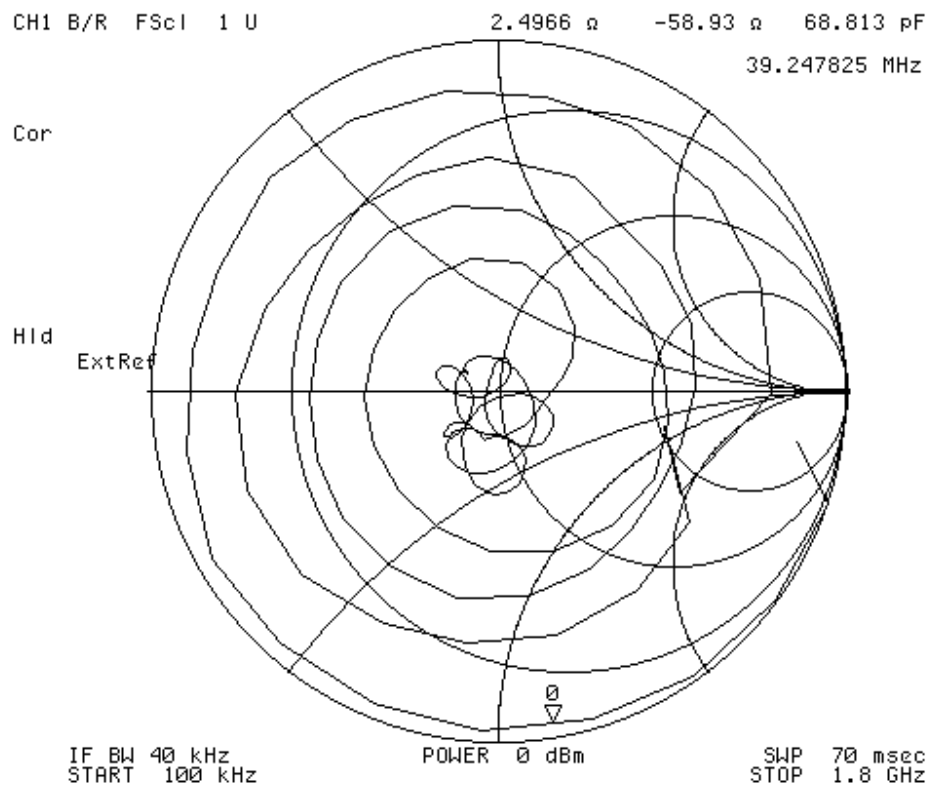
a home made three braid [1+, 2-]



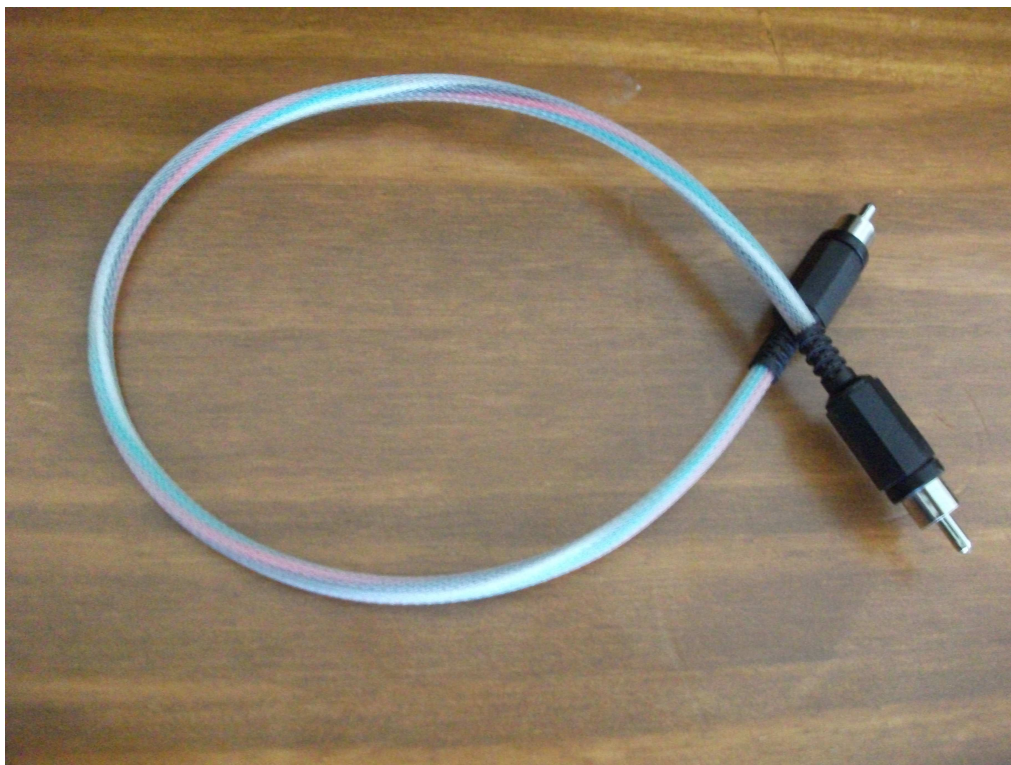


Pc Audio Electronics HIGH Resolution Signal Cable: [nice trace]





RosVeta Frya 2x2 Cable sample, 4-wire configuration - 16 Awg.



Which cable or inter-connect 'sounds' the best is a costly, hot-debate.
 Costly to the audiophile who buys the '*new*' cables and hot for the reviewers
 Who have to be careful not to offend the cable manufactures or sponsors.

Fortunately the audiophile can do many tests at home to test the various designs and styles of inter-connect. The audiophile can make and design his own cables and then test them out at home.

Cable testing will be more interesting and revealing when you replace your old - 'crossover'- circuits with the BRIICe circuits, or any circuit that does not have a '*crossover*' characteristic.

A-B Listening Tests

Since we have a very limited listening-memory, we suggest building up an inter-connect A-B test system. The switching time is fast enough to help reveal what differences there are between cable 'A' and Cable 'B'.

The BLIND-test process is traditional, but not needed here,
 because the differences are **not** minute and are very noticeable !

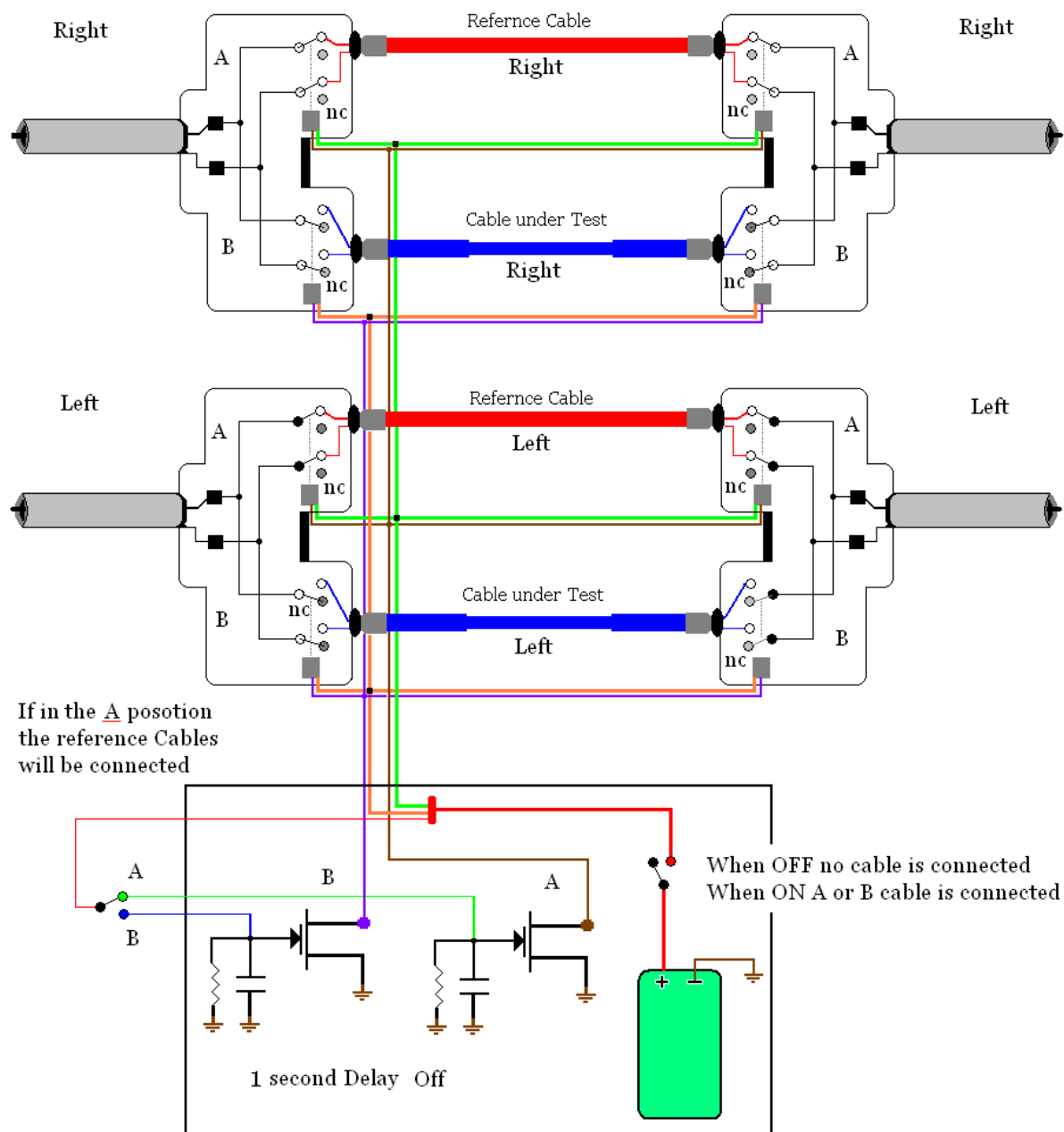
This switching scheme will reveal the differences in cables on any audio system. Greater differences will be heard if you do not use a 'crossover' in your speakers.

- - -

[ICTS-1] The following system uses any FET or Power FET and relays [8ea].
 The relays isolate the cables from each other and control the switching from cable A to cable B.

We use a delay of **One-second over lap** to avoid inducing Switching 'noise'.
 For our test set up the **A** relays are the Reference Cable control relays and the cables under test are connected to the **B** relays.

This IC-test system will greatly demonstrate the differences in the various cables. Making your own cables will be more exciting when you compare them to the PRO-audio cables on the market today, at home.



Inter-Connect Test System ICTS-1

The relays are a DPDT – double pole double throw – 5 to 9 volts, high resistance type. The Grey cables shown are 3-4 inches long.

Since cables affect the audio signal we then should seek a different way of Inter-Connecting our audio equipment.

We attempted to propose this system years before, but were dissuaded from trying.

WICs [no cables]

What if we did not use inter-connect cables and instead used a Wireless Inter-Connect system[s] ? -WICs-

The distance of some audio equipment components are either very close together or separated a great distance requiring a long inter-connect.

A non-cable system would be handy in these two situations.

We tried many of the traditional RF processes like; FM, AM, PM, PWM and Doppler.

FM, frequency modulation is insensitive to external random noise.

AM, amplitude modulation is susceptible to noise.

PM, phase modulation requires a reference signal.

PWM, pulse width modulation is like an FM process

Doppler, is a shift in time relationship with an original signal.

VLF or Static Field modulation or T-pulses, AM full-wave detection...

Other ideas include Very low frequency carrier, Full wave AM detection scheme, or Tesla-pulse system and un-filtered AM receiver.

The WICs has Four elements two transmitters and two receivers. The transmitters have Auto-turn-on and all four devices have a small rechargeable battery.

Well have fun testing cables...

- - -

Lets diverge a little as we address the Academic-Experts...

Now that you have seen or read the previous topics you can now better appreciate the following situation...

A 1 million \$ Paralogism

Few years ago a challenge was placed:

Calling BS on Snake Oil Cables

by Clint DeBoer — October 02, 2007

Reviews and News from Audioholics

This article was about the lack of SNAKE-OIL believers to take the challenge from **Mr. James Randi**:

'...who considers the art of cable science to be a form of **paranormal** belief...'
[not within the normal range or experience of explainable science]
 and

'... that pits \$1 million against anyone who can demonstrate
 the ability to discern a difference between these \$7,250
 cables and a set of Monster Cables.

To continue:

Mr. Dave Clarke, John Atkinson of Stereophile, and several others:
 Sylvia Browne, Dr. Brian Josephson, Uri Geller,
 Dennis Lee, John Edward, James Van Praagh,
 George Tice, and Ben Piazza;

were chided because they did not take up the challenge.
[as far as I know]

Mr. Clint DeBoer goes on to state that in his own research it was easy in some cases to tell the difference between **Esoteric**-cables and other cable models.

Also, in derision, that some Esoteric cables were poor and the best were almost the equivalent of a 12-gauge zip cord.

Adding, Mr. Clint DeBoer stated that the audio-listeners should 'demand' that the Esoteric 'heroes' should take Mr. James Randi's 'money'. Hopefully the heroes would have an excellent opportunity to wrap up this cable dilemma.

As is the case, this challenge is a *paralogism* because the opponents to Esoteric Cable designers are not themselves aware of the innate problem[s] in the proposed test[s].

As was pointed out earlier, the changes we made in our new-improved cables were concealed due to the improper inter-face circuits connecting the Audio equipment to the speakers.

To have an a correct trial of Golden-Ear Listeners **demonstrate** their ability to hear the delicate yet audible differences in the various Audio cables the Crossover circuits must be replaced with *non*-Crossover circuits. And when we use non-Crossover circuits *anyone* [especially the younger ones] will be able to not only hear differences in any cable, but will be able to design and test their own cables more readily !

Using any time delayed cable switcher, like the ICTS-1, easily substantiates if there is any audible differences in various audio cables.

-- --

To continue our discussion on cables:

To measure cables, inter-connects, power cords and speaker cables more accurately, we (the manufactures or designers of cables) have to add and use more sensitive testing processes[s] (as to the common cable tests) in order to achieve and establish a higher plane of Fidelity.

RF tests are, as previously shown in the Cable Graphs, applicable to audio cables.

The frequency spectrum of *20 Hz to 20 kHz* is far too limited in revealing significant differences in cables. For many of the same materials are used in the fancy cables made by the various cable manufactures.

Also, with the many simplistic changes that have been employed: gold-plating, purer-copper wires, OFC-Copper, better insulations, unique size and shapes of cables all claiming significant audio improvements; and that the ear is very sensitive to amplitude variances, frequency jitter, many Phase-variances; requires a 'higher-level' of testing systems of greater sensitivity and complexity.

And as shown, many of the 'traditionally' used testing processes cannot readily distinguish any significant differences in the various cables.

And much of this testing is seldom referenced to Fidelity.

The excuse that, "we can not measure Fidelity", is a poor one.

By analyzing parameters and characteristics that can be measured, we will learn what 'real' differences in cables correspond to reproducing true Fidelity.

Testing and measuring has to move to a higher level of sensitivity and correlation.

F-M40 : Frequency Magnification **Cable Testing**

Dr. Robert Meyers and I were hired to come up with new cable designs for a high-end cable manufacturer in early 1998 by 'accident'.

Dr. Robert Meyers (mathematics; Vermont University) was an ardent audiophile. Personally I am perfectly happy listening to: Rodger Whitaker, Dionne Warwick, or Yanni on a one-speaker boom box.

Dr. Meyers was strong on intuition and design of mathematical analyzing processes; (worked for Auto-Liv; air bag division); whereas, my background is R&D in magnetic-media (Iomega) and electronics; Electron Tubes through RF devices, Radar (Navy), and Metrology (USAF-F16); EET Weber State University.

Dr. Meyers would perform statistical analysis after we had tested the cables. After several months of boring 20-20 tests on different cable 'geometry's' we realized that 'traditional' testing at 20 Hz - 20 kHz was not helping us in determining any substantial differences in the 'new' cables; whereas, our golden-eared-listeners could hear 'differences'.

[Unfortunately, Dr. Meyers passed on, in June of 2000]

Our first endeavor was to test the golden-eared-listeners and to analyze if they really did hear differences, and how well. Only one golden-eared-listener passed our month long probing. Richard Diamond proved to be very exceptional in ascertaining differences and proved articulately honest in his efforts to clearly point out what he heard.

Next we had to find a way to relate to, or 'measure'; what Richard heard.

Unexpectedly another company wanted us to design a cable using a 'transformer' in their digital-cable to provide DC isolation.

(why, I do not know; except for the obvious, ?)

Digital signals being sets of higher order of [odd] frequencies we needed different equipment to do testing so we ended up using our HP 4194 to check for the 'band-pass' requirements.

Out of pure curiosity I suggested that we try and see what we could learn from testing cables at 'Low-RF' frequencies (MHz–R.F. levels). We were pleased to discover that at these higher frequencies, the gain and phase, showed us some measurable and repeatable differences in our cable geometry's.

From here on, we came up with a modest correlation process to 'analyze' the measurements with the help of many listeners.

The HP 4194; Impedance, Gain, Phase Analyzer (10 Hz to 100 MHz); was used to measure many more of our cable designs, but only gain and phase responses were used.

This 'new' process of using 'Low-RF' [1-40MHz] for audio is really just pushing the sand-box wall a little; for many others have been here before; nonetheless we refer to this type of testing as:

Frequency-Magnification (F-M40).

The tests done on cables using the 20-20 frequencies will provide many details of : L- X_L , C- X_C , Z, X; etc.; but are unable to differentiate any significant differences in cables; or 'show' any unique changes or characteristics. By using these higher frequencies the small changes and amplitude variances of X_L , X_C ; with resultant resonant-frequencies and Q-changes are 'magnified' about 2,000 times.

Based on the sensitivity of the human ear, we came upon the idea of 'seeing' how high up the RF-scale of frequencies could be related to any 'change' on the graphs and to what listeners could 'hear' or 'sense'.

It seems that many audio 'difference' that are 'seen', plotted or graphed, in the 1 MHz to 40 MHz range can be 'related' to some audible differences. Above a 42-45 MHz range the 'measurements' on the test equipment could not be related to what the listeners could hear or sense in the audio tests.

Mind you, the measurements shown in the graphs of gain and phase were 'compared' after the listeners recorded their responses on our correlation charts. The correlation charts were used to tract the listener's 'impressions' of a cable, and the listener's 'personality-of-listening'. We would look for 'visual' differences in the various graphs.

Eventually we broke down some of the 'differences-seen' on our graphs and were able to correlate and predict, to a modest level of accuracy, what the differences the listeners should or would hear.

For example; an old tri-wire cable made with 2-wires to the (-) and one-wire tied to the (+) had a frequency 'roll off' at 20-22 MHz (that is a change of more than 2 dB); and phase response of a certain slope of change.

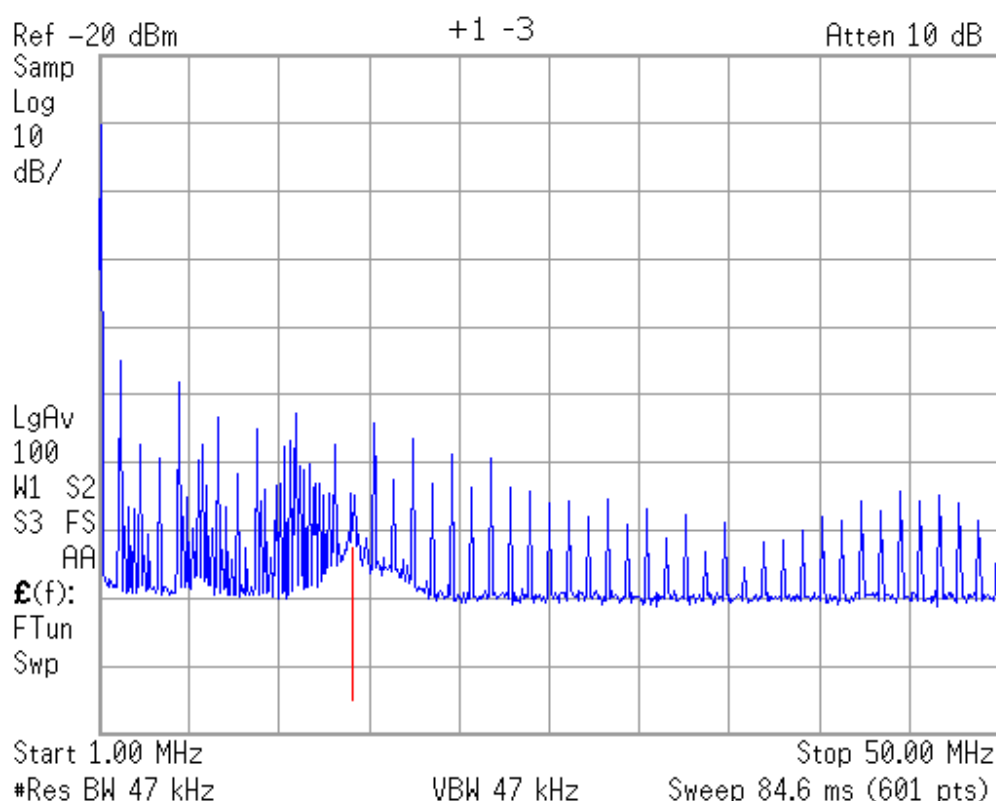
By re-connecting to: 2 wires (+) and one-wire (-) the freq. 'roll-off' extended to 28-32 MHz and the phase slope was a little less steep.

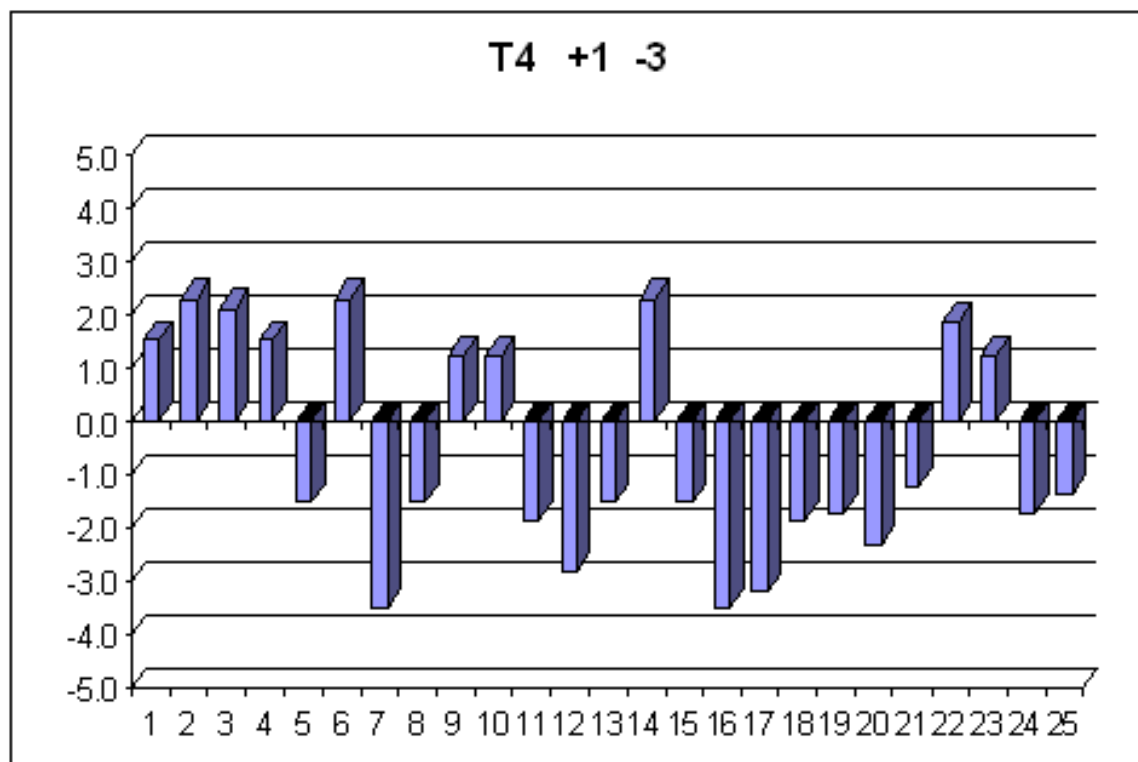
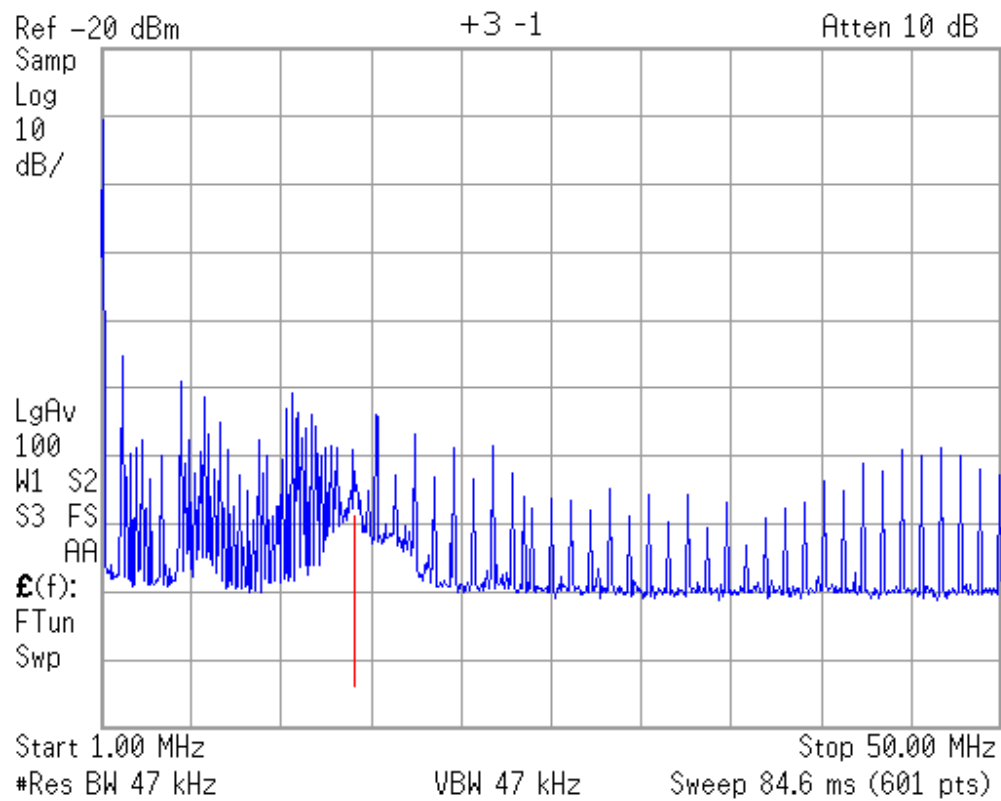
Nonetheless: with the 2(+) and 1(-) configuration; we secretly wrote down our predictions: that the sound stage would be 'fuller', more detail, etc.

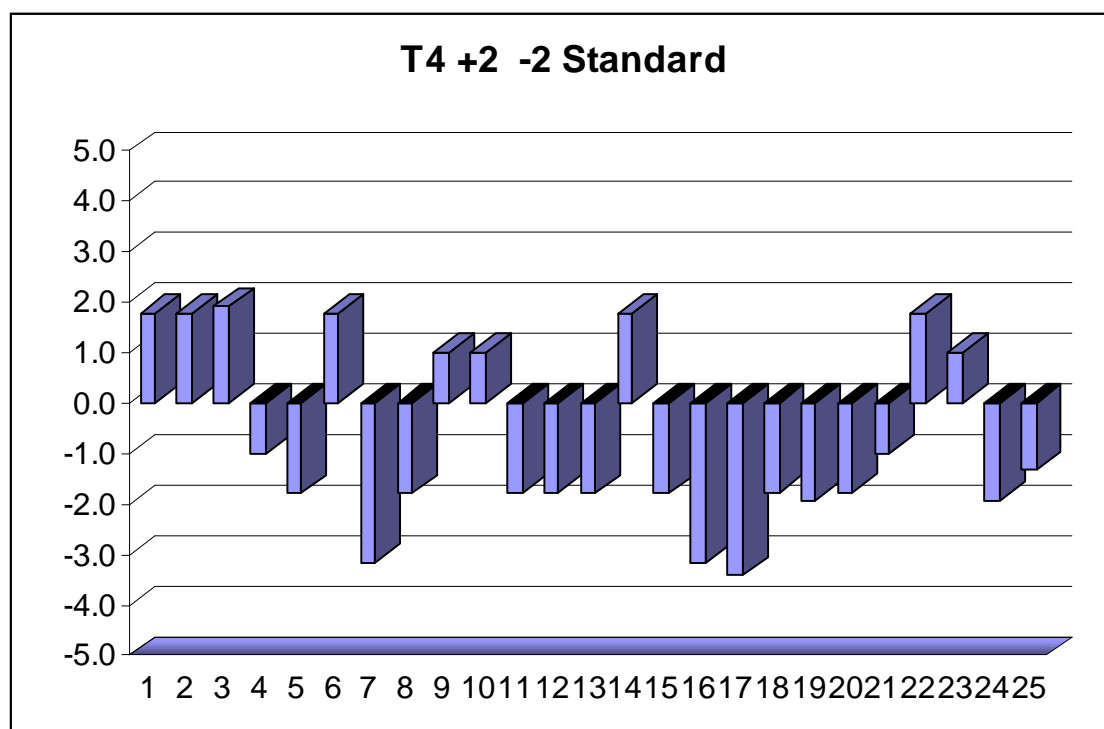
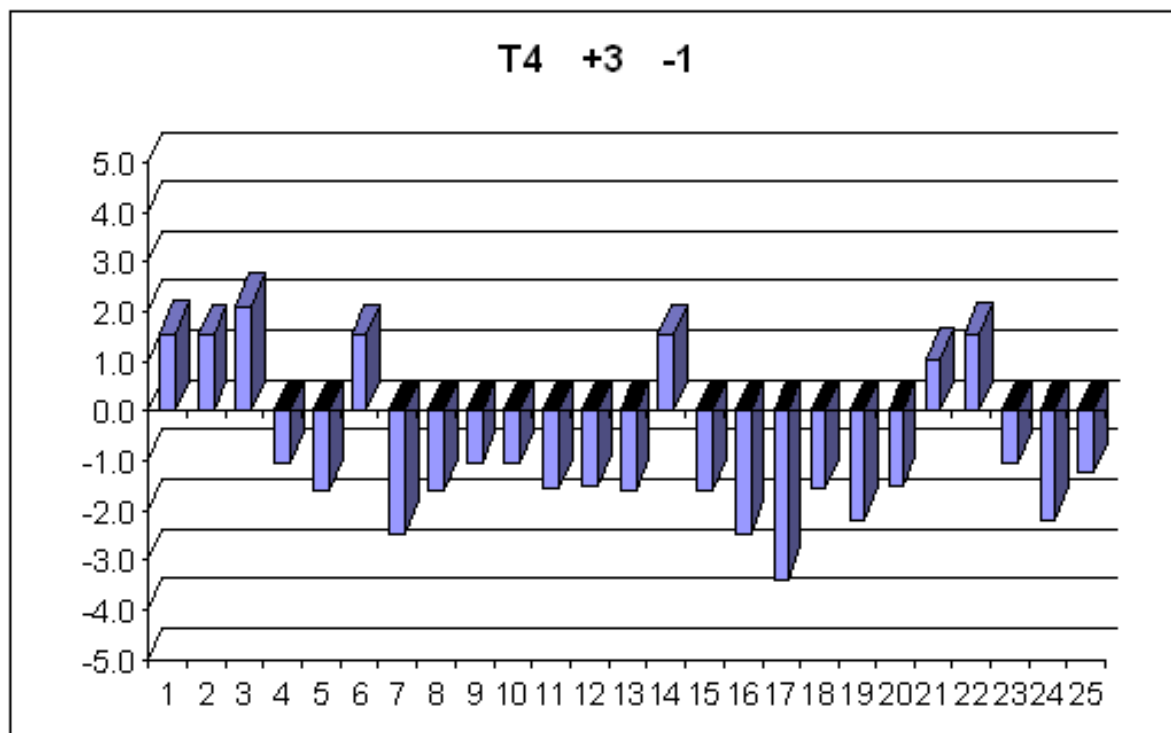
After Richard listened, we would let him report and then we would compare notes. We became quit confident in our cable testing using F-M40.

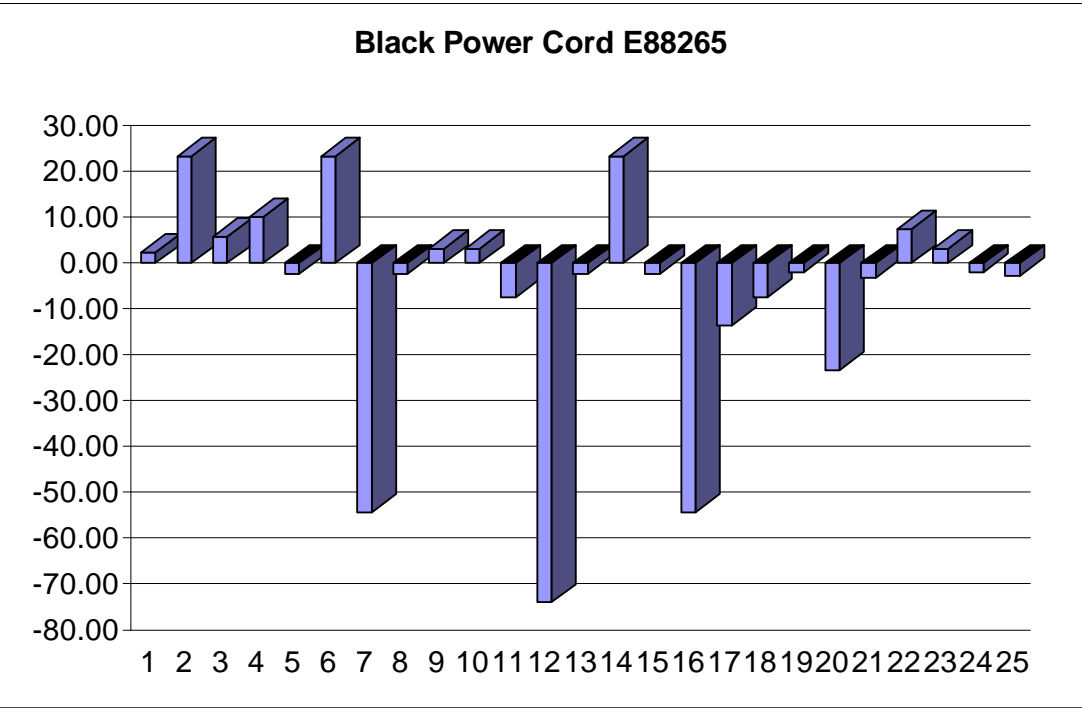
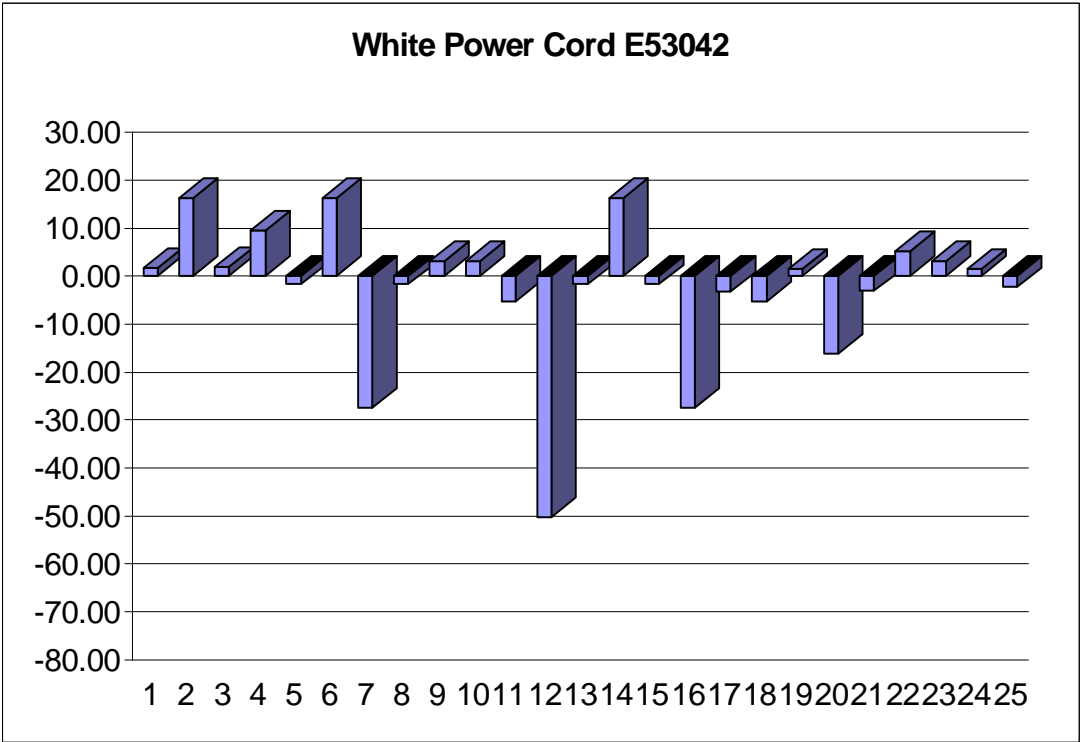
Cable Geometry

As described previously about the three wire cable and connecting two wires or one wire on the positive terminal, we decided to make up a RosVeta 2x2 test cable and test for differences in cable connections: +3 -1, or a +1 -3 configuration.









Later on we started using other 'low-RF' [1-50 MHz] measurements; Scatter-parameters; S-measurements [11, 12, 21, 22] SWR, Smith-Charts, Polar-Plots, Delay and etc, and then by pure curiosity we moved onto mastering:
POWER CORDS !

As cable manufactures we need to focus on watching for variances in our cables due to the various materials -in- and unique geometries -of- our cables which will require a more sophisticated testing processes.

After the cables are tested and analyzed, then the cables can be subjected to hearing tests for correlation with any cable changes made and with the graphed electronic tests.

Some cable test procedures have used as high as 100 kHz for cable testing, but even this 'low' frequency is not 'high' enough to reveal the many delicate and hidden cable characteristics.

After many more trials of testing cables we have found that the human ear can discern or sense changes or variances in cables, which were not easily seen by some electronic instruments.

These changes are easily seen in various S-parameter charts and graphs using frequencies up to about 40 to 45 MHz.

Our tests used a Network Analyzer furnished with the many types of Scatter or S-parameter displays and characteristic parameters like: group delay, Smith chart [Inductance, Capacitance, and Impedance]; polar plots and etc. over a very broad spectrum of upper frequencies.

By using F-M40, and two parameters in particular; SWR and Phase roll off vs. Frequency flatness plotted on a SMITH-Chart, we could predict which cable would sound better and many times - why.

That is, what changes or additions were made to a cable from the previous designs, are greatly 'magnified' and we could reasonably predict what the 'new' change would produce, i.e. timbre change, frequency differences, etc.

By using this F-M40 process we can see great differences in the many cables produced by various cable manufactures. Significant differences in cables have been graphed which has proved to be very interesting and easily correlated to what the human ear can discern!

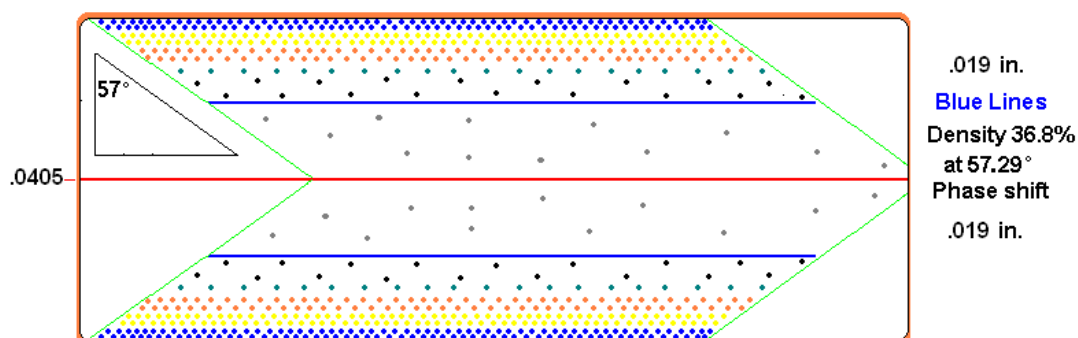
F-M40 process of testing will help in the development and use of correct materials and geometries to produce cables and inter-connects that better support Fidelity.

Let us now address another hot-topic

Skin-Effect !

12 Awg Copper Wire
Radius .0405 inches

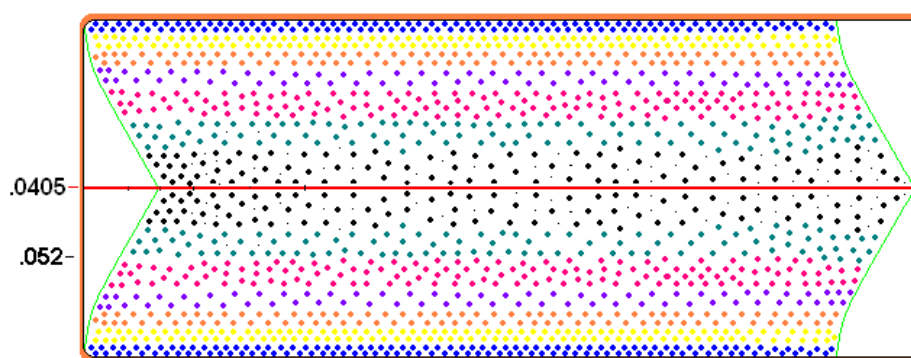
20 kHz SD = .019 in.



12 Awg Copper Wire
Radius .0405 inches

500 Hz SD = .083 in.

$.117 / .0405 = 2.89 \rightarrow$ more than $1/e$



$.0405 / .052 = .779$

Near Center of Wire calculated / ratio

Density 36.8 % x 2.89 = 106 %

Phase shift 57.29° x .346 = 19.83°

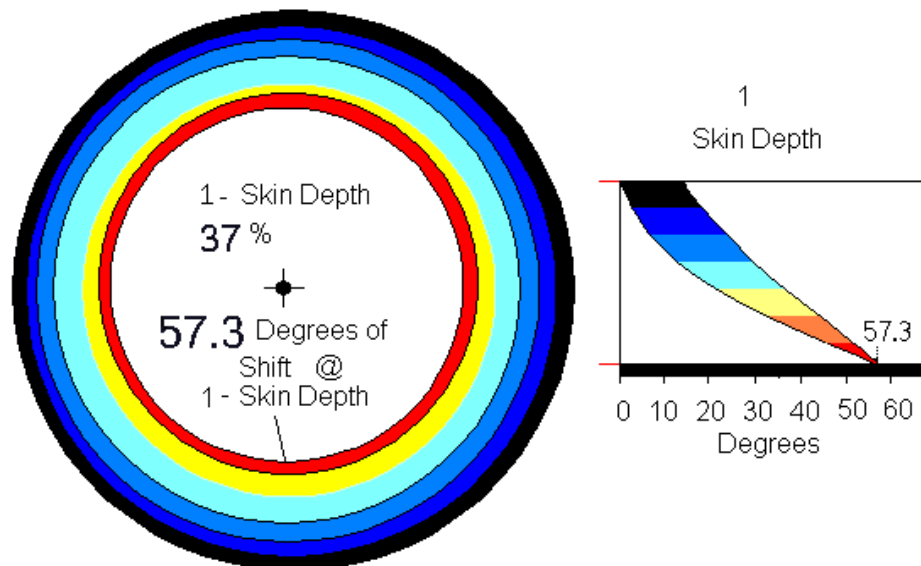
Of all the Audio topics that has been in great debate; the SKIN Effect phenomena has been a great topic separating the so called 'cable-soothsayers' from the Academicians [Academia / Esoterica]. Many well-known engineers have played down the idea that SKIN-effect contributes to any deleterious effects on the Fidelity of an Audio signal.

'Only very high frequencies [RF] are greatly affected by this conducting property', at low audio frequencies we can ignore it.'

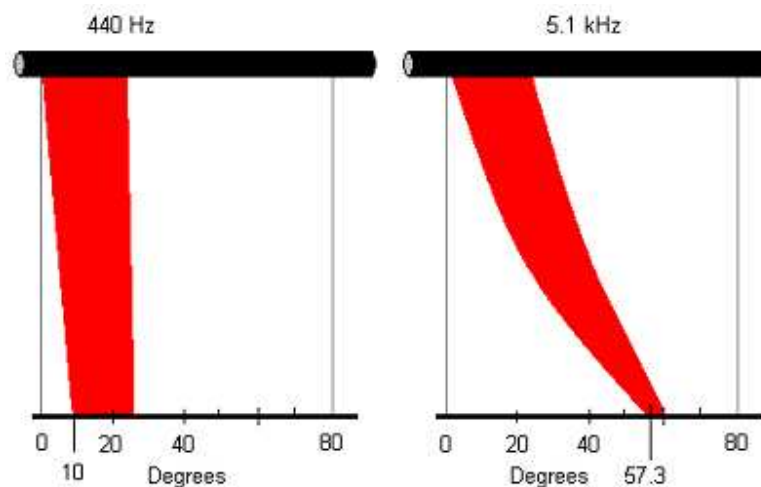
Using the following graphs we hope to clearly demonstrate the property of SKIN-Effect in a 'round' conductor.

Current Shifts in a Wire

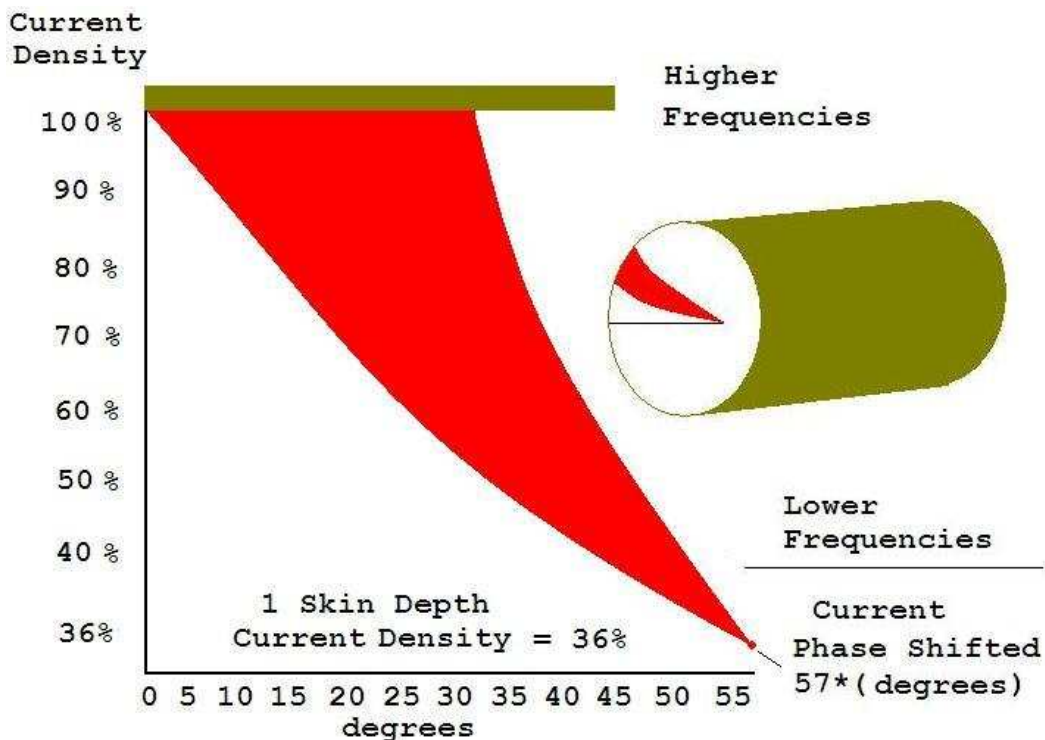
36.8 % of Maximum Current Density @ 1 Skin Depth
 ~ 1.6 Degrees of Shift per 1 % of Skin Depth



The main idea is to realize that not all of the complex Audio-signals composite frequencies are located, or move, in a wire at the same place or at the same 'time' and that the various frequencies are 'separated' from each other in a conductor. Inductance of a round wire is highest at the center and least at the outer surface of a conductor.



The upper frequencies [say: 15- 20 kHz] travel more towards the outer portion of a conductor while the lower frequencies [< 2 kHz] travel over most of the whole area of a conductor.



The absolute center of a round wire has very little current flow [or none] as compared to the rest of the conductor.

Skin Effect has some interesting properties;

1. Different Frequencies correspondingly penetrate the conductor at various depths.
2. Current density drops off [becomes less; exponentially] as the current moves closer towards the center of [in our case] a round wire.
3. The $1/e$ depth is where the inner current of a frequency is $\sim 36.8\%$ of the surface current.
4. The inner currents at $1/e$ are phase shifted ~ 57 degrees, lags – behind the surface current. [time-shifted]

5. The $1/e$ parameter: 36.8 % and 57 Degrees correspondence is only accurate when:

'...the radius of curvature of the conductor surface is at least *several times* the Skin-Depth, provided the effective thickness of the conductor is at the same time at least three or four skin depths.'

Electrical and Electronic Engineering Series

McGraw-Hill [1955] p23 paragraph 3.

Frederick Emmons Terman

[Library of Congress Catalog Card Number 55-6174]

6. And these parameters are highly influenced by the 'Proximity Effect': that is other 'conducts' that may be 'close-by'.

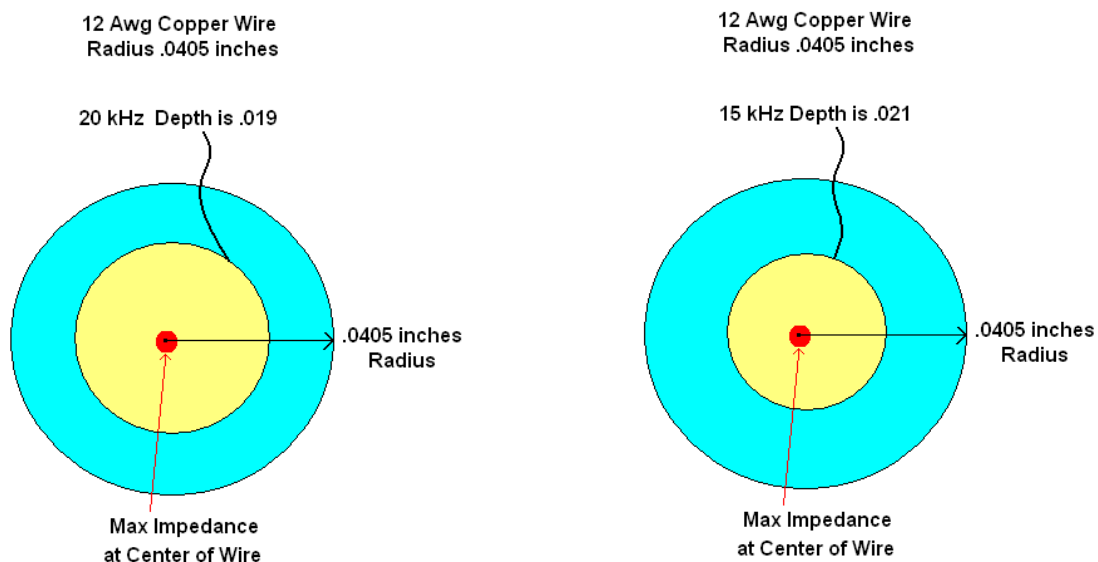
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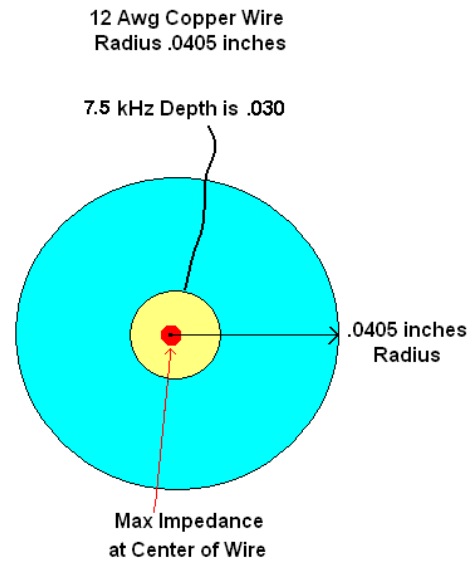
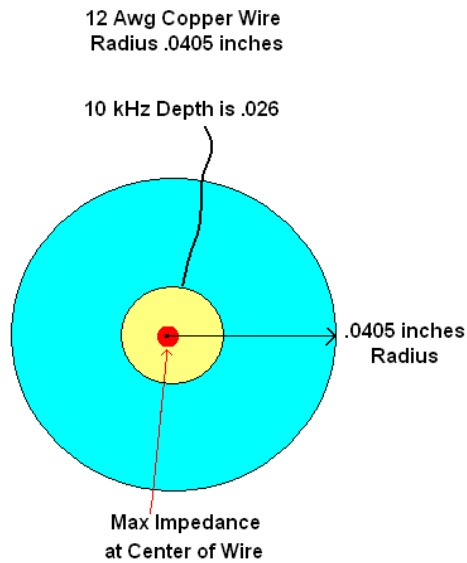
The following diagrams show the 'area' of travel-depth at different frequencies- 12 AWG wire.

Red maximum Impedance at center of wire...

Blue portion is the area of current flow to $1/e$.

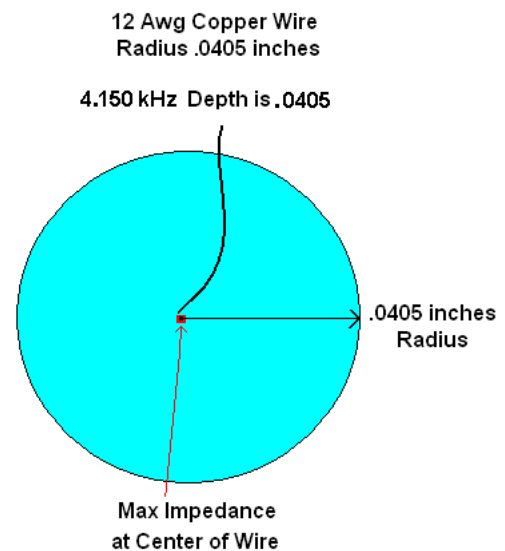
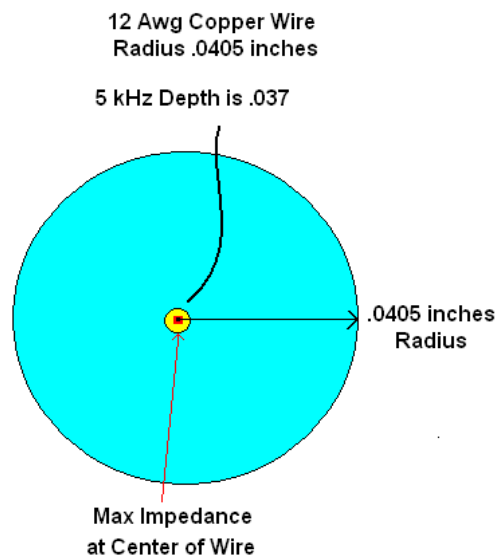
Yellow is the area of less than 36% current flow.





5 kHz 1/e is at .037 inches...

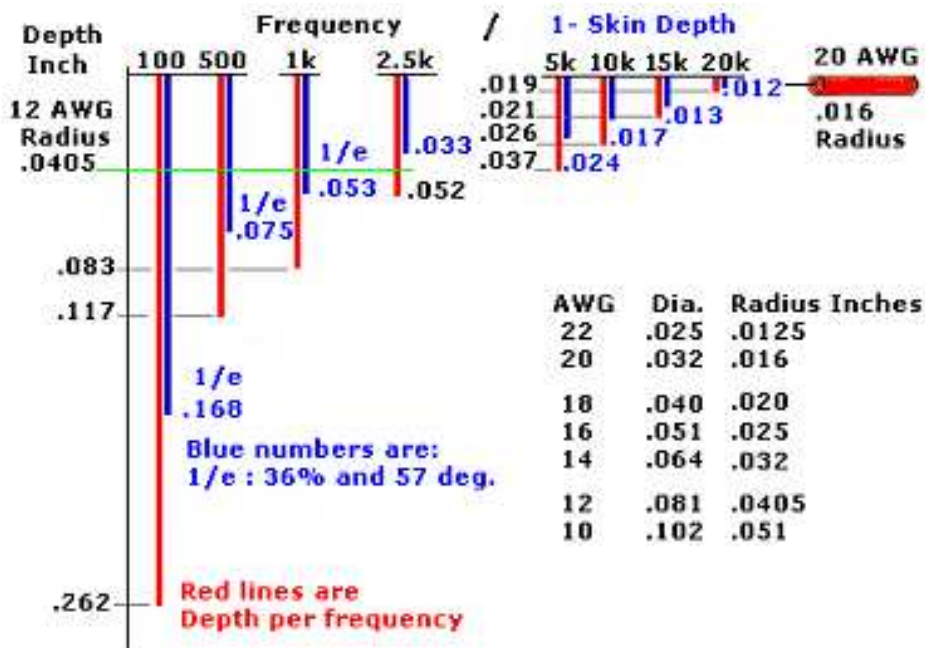
but at 4.15 kHz the 1/e Exceeds the radius of the 12 AWG conductor.



So any frequency below 4.15 kHz will experience a greater 'loss'.
The Academia experts treat this 'over flow' or deep penetration increase in electron-density as a DC property. That is, only the DC Ohmic-properties of the conductor are of any concern.

But let us remember the current is an Alternating Current and that the $1/e$ parameter : 36% and 57 Degrees correspondence is only accurate when:
 'the radius of curvature of the conductor surface is at least several times the Skin-Depth, provided the effective thickness of the conductor is at the same time at least three or four skin depths.'

So the inner portion of the conductor will have a greater affect on the lower frequencies more than one might expect.

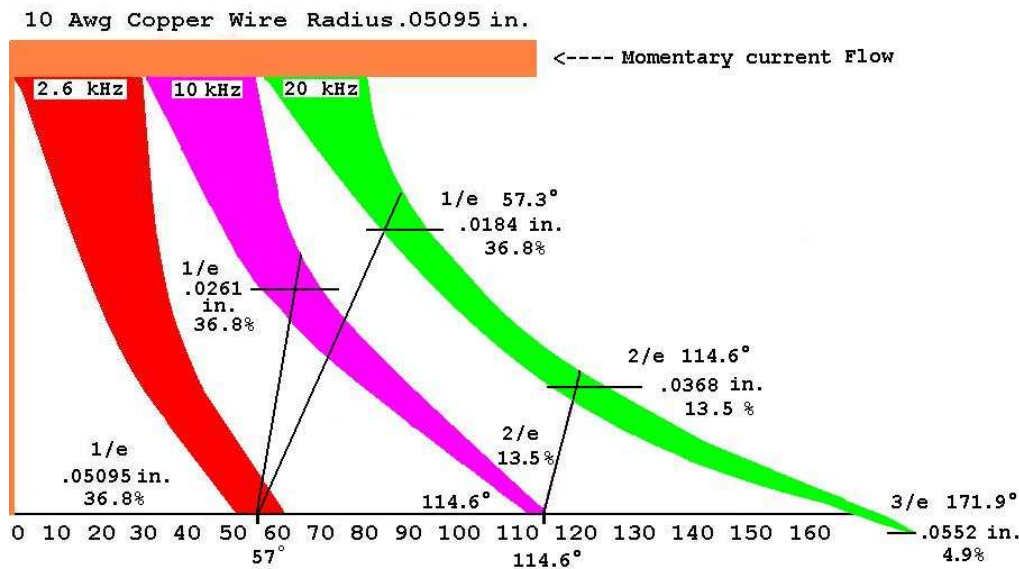


This simple chart shows a 20 AWG wire as compared to the diagramed frequencies $1/e$.

As can be seen, the Frequencies below 20 kHz will greatly exceed the radius of a 20 AWG wire.

The following chart shows a larger wire of 10 AWG.

Even at almost 4 times larger in radius, frequencies below 2.6 kHz exceed this larger wire's radius.

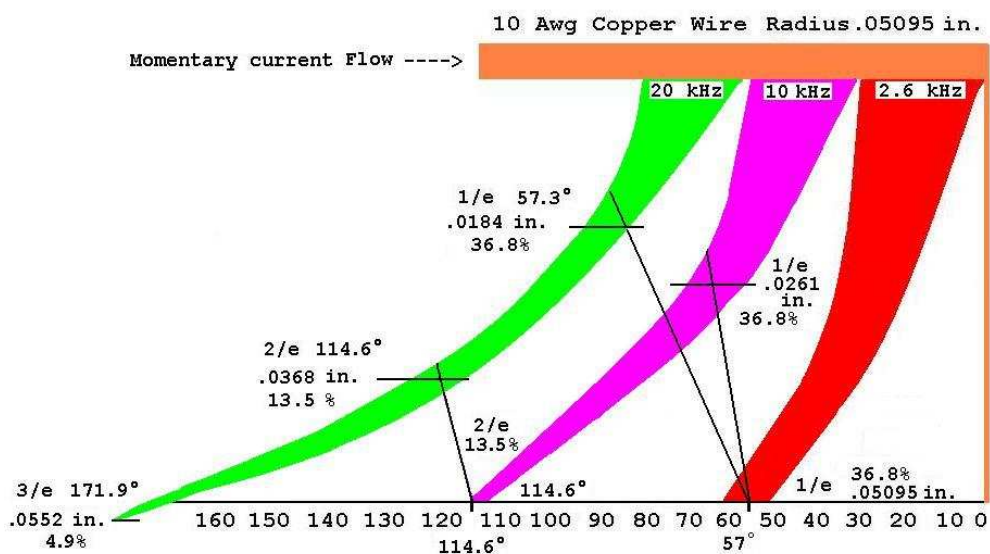


Large diameter wires smear the High's by introducing more time lag ...
The higher frequencies are able to be time shifted even more than in a thin gauged wire. [10 / 20 AWG]

For curiosity sake, let's examine how far an electron or a group of electrons will travel. Using the current density for copper wire, which is about 480 amps /cm², the distance traveled is about 3.6 x 10⁻² cm/sec, or 28 seconds to travel 1 cm.

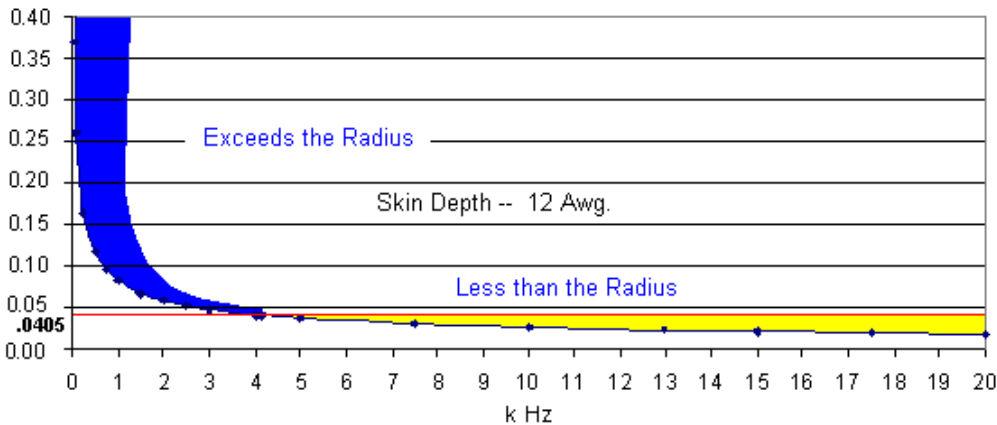
[*Physics for Students of Science and Engineering 3rd Edition 1963, p.681*]

So then, we realize the actual movement of *electrons* is very small. And with alternating signals, movement is more of a *vibration* than physically traveling.



This diagram shows various sized wires and their relationship to some frequencies. You will notice that 10 AWG radius is .051 and any frequency below ~ 2 kHz has a 1/e that exceeds .051 inch.

12 AWG wire .0405 [red-line] will affect frequencies below 4 kHz.



Phase Shift	Copper Wire 8 to 40 AWG 1 m.							
	Degrees Shift 1SD – 57.3 deg							
	Skin Depth mm @ Frequency of: [in copper]							
	100 Hz	1 kHz	2.5 kHz	5 kHz	7.5 kHz	10 kHz	20 kHz	250 kHz
	6.619mm	2.093mm	1.324	.936	.746	.662	.468	.132
8 AWG 1.632 R	100 Hz 8.63°	1 kHz 27.3°	2.5 kHz 43.2°	5 kHz 61.1°	7.5 kHz 77°	10 kHz 86.3°	20 kHz 122°	250 kHz 433°
12 AWG 1.0265 R	100 Hz 5.4°	1 kHz 17.2°	2.5 kHz 27°	5 kHz 38.4°	7.5 kHz 48°	10 kHz 54.3°	20 kHz 77°	250 kHz 272°
30 AWG .1275 R	100 Hz .7°	1 kHz 2.2°	2.5 kHz 3.4°	5 kHz 4.8°	7.5 kHz 6°	10 kHz 6.7°	20 kHz 9.6°	250 kHz 34°
40 AWG .0395 R							3°	11°

The previous chart above displays four wire gauges and their respective Phase shift in each at various frequencies.

Remember a phase-shift greater than 6 degrees [light Blue] can be 'heard'.

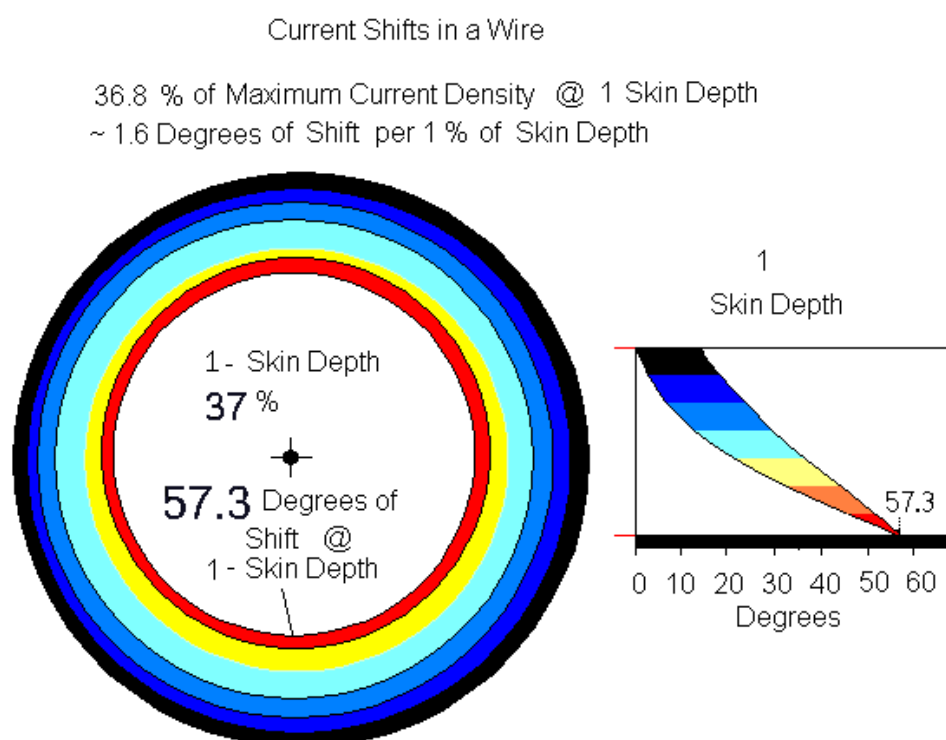
Even with large diameter wires the phase will be shifted well below 1 kHz. Some manufactures use small diameter wires trying to 'avoid' the Skin Effect.

The thought being that the lower frequencies will be dispersed across the whole of the wire's cross sectional area, or the lower frequencies will experience less Skin-effect.

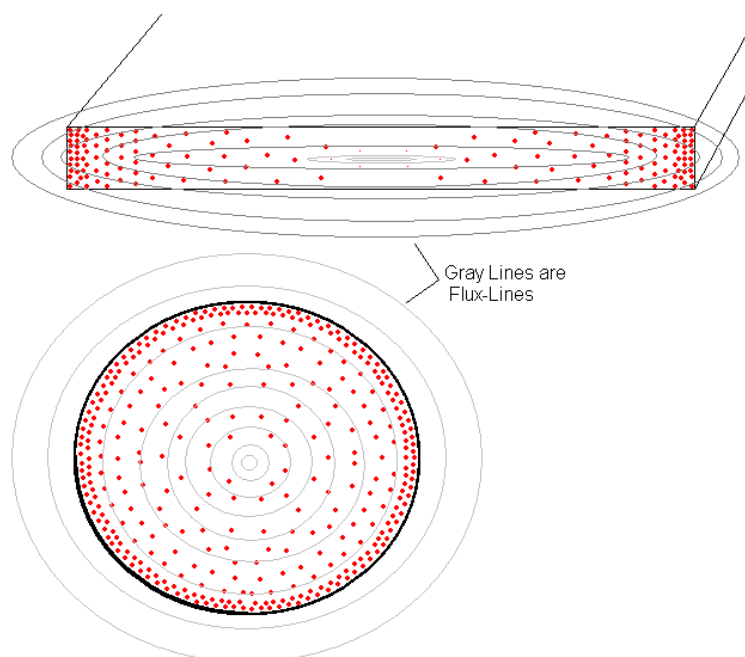
Well the *effect* is still there, the AC resistance will be increased for the lower frequencies and the small wires will still *impose* distortion upon the audio signal due to magnetic fields *impinging* upon the surrounding wires.

Also, the increased *impedance* on the lower frequencies will make the quality of the sound 'bright' due to the low frequency losses.

Seems to us, that a medium size of wire, gauges 12, 14, 16, 18 or 22; is a good compromise.



Flat Wires vs. Round Wires



Flat wire, as shown, has far less than the 3-4 times $1/e$ requirement.

Measured		Specifications		CLR	Reference		Freq 1kHz								
C - Farad	L - Henry	R - Ohms	X-C	X-L	Z-total	SWR-50	Zo	NAME-TYPE	AWG						
2.35E-09	1.55E-07	0.00878	67,725	0.00097	67,725	6.16	8.12	Spectra-Ribbon-064-flat	8						
2.05E-10	3.05E-07	0.00822	776,364	0.00192	776,364	1.30	38.57	Kimber-Weave-16-LPC	7						
1.05E-09	1.95E-07	0.02124	151,576	0.00123	151,576	3.67	13.63	Spectra-Ribbon-036-flat	15						
1.75E-10	2.85E-07	0.01605	909,455	0.00179	909,455	1.24	40.36	Kimber-Weave-4-PR	14						
3.45E-10	3.55E-07	0.00752	461,318	0.00223	461,318	1.56	32.08	Audio-Quest-Litz	6						
1.25E-10	5.15E-07	0.01515	1,273,237	0.00324	1,273,237	1.28	64.19	Kimber-Weave-8-LPC	10						

Flat Cables have least Inductance

Flat wire designs have least Total Impedance

Round Wire - Weave Design has Best SWR

Round Wire - Weave Zo is closest to '50 ohms'

Well then the big question is:

'Can we hear any differences in an Audio-signal due to Skin Effect ?'

The complex Audio signals will be affected by Skin-Effect, but what will be the results ?

Academia contends that there will be no 'noticeable' effect...

Fortunately a simple test can be done to see if Skin Effect causes any audible differences. For the audiophile, we offer the following tests to analyze this interesting topic of **Skin Effect**.

SKIN EFFECT TEST

115

Start by making up three cable-pairs using three different sized copper wires like: 12, 18 and 22 AWG of the same make or manufacture, to be used as interconnects.

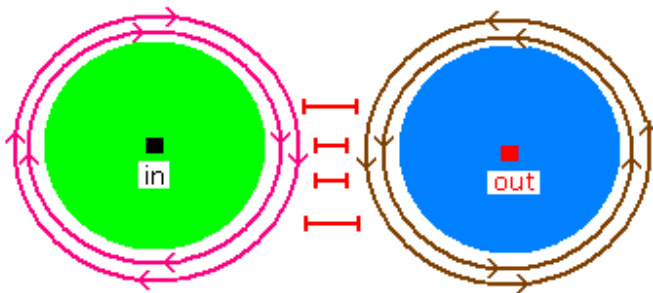
Another test could be done. Using one set of soft-covered [soft-plastic-clear] wires as compared to Teflon covered wires.

These three wire sizes have different Skin-effect characteristics, can you hear a difference?

We suggest two types of cable ‘designs’, the traditional twisted pair and a set of 4-parallel wires in Tech-Flex. The BRIICe Frya 2x2 is any twin wire cable placed together forming a four wire ‘square’ configuration.

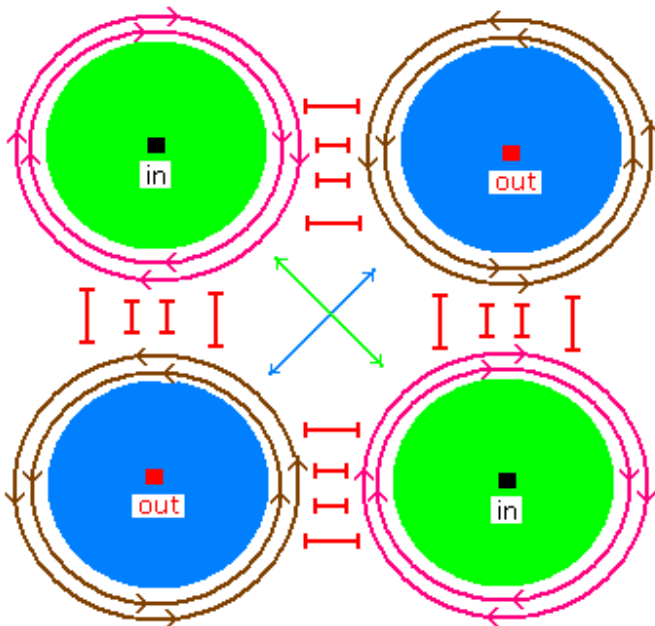
Connect opposite corners together.

Twin Lead

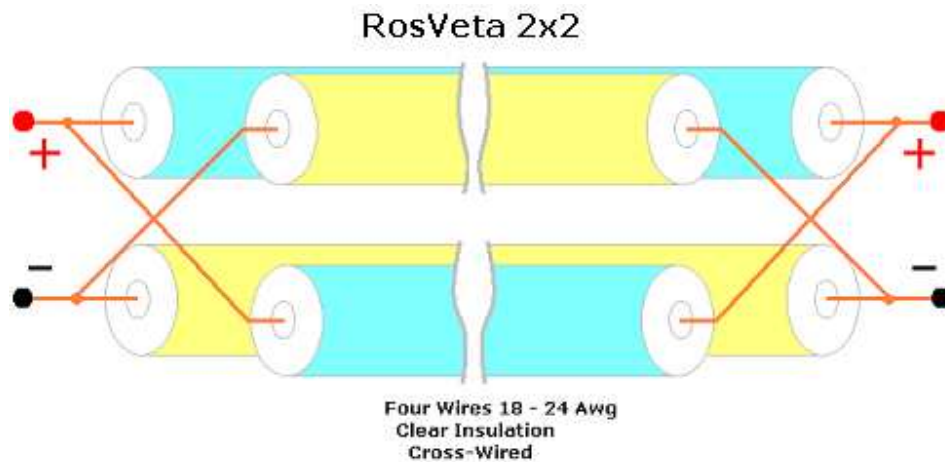


The Red-Bars represent the repulsion force between the individual wires.

RosVeta 2x2



The Green and Blue lines represent the weak attraction forces of the conductors carrying currents traveling in the same direction.



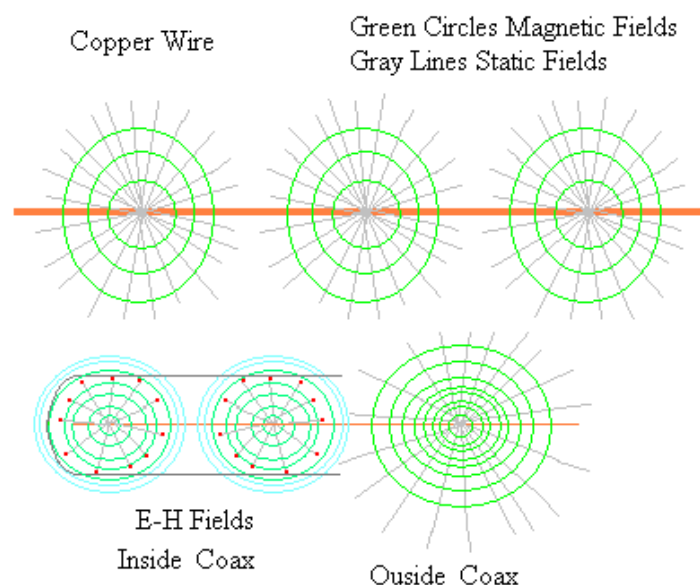
Use wires that are covered in a soft, clear-plastic insulation. Many colored wires use 'magnetic' materials for the pigmentation, which 'distorts' the wire's magnetic fields.

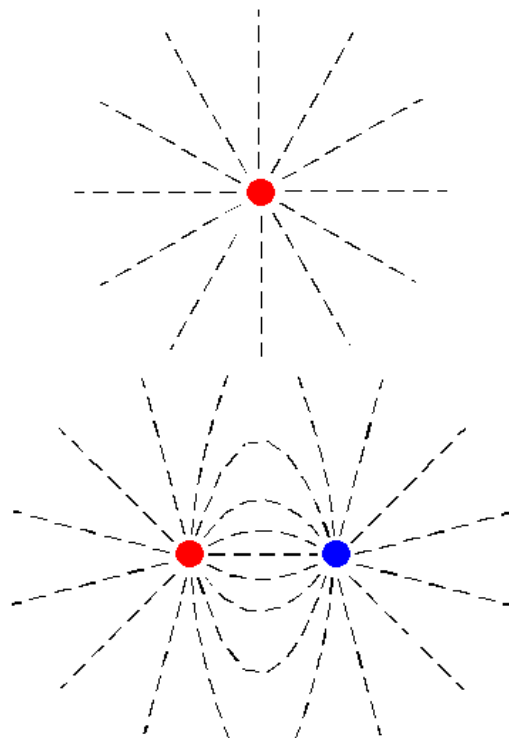
[The color 'distortion' is 'measurable' using the F-M40 process, that is: a clear cable compared to any colored cable.]

Also interesting is that insulations of higher dielectric constants help in 'sustaining' static fields of the propagating Audio-signal producing a better sound. These softer materials actually are a little 'slower' in velocity than the hard dielectrics - those having a lower dielectric constant.

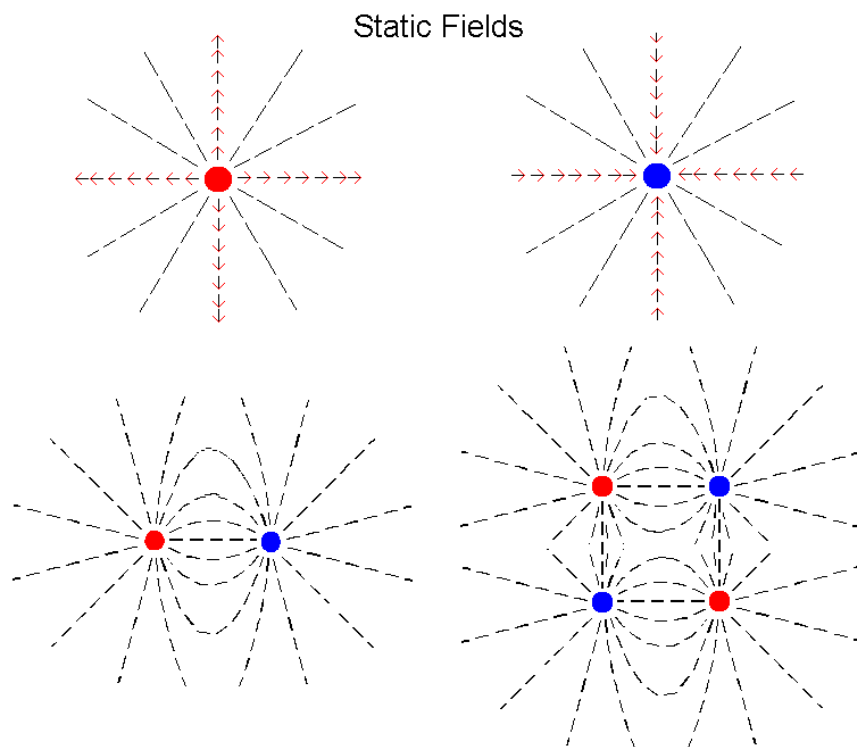
To test this idea of soft versus hard dielectrics try using wires covered with Teflon as an inter-connect and then compare them with wires covered with a material having a higher dielectric, like a clear, soft plastic cover.

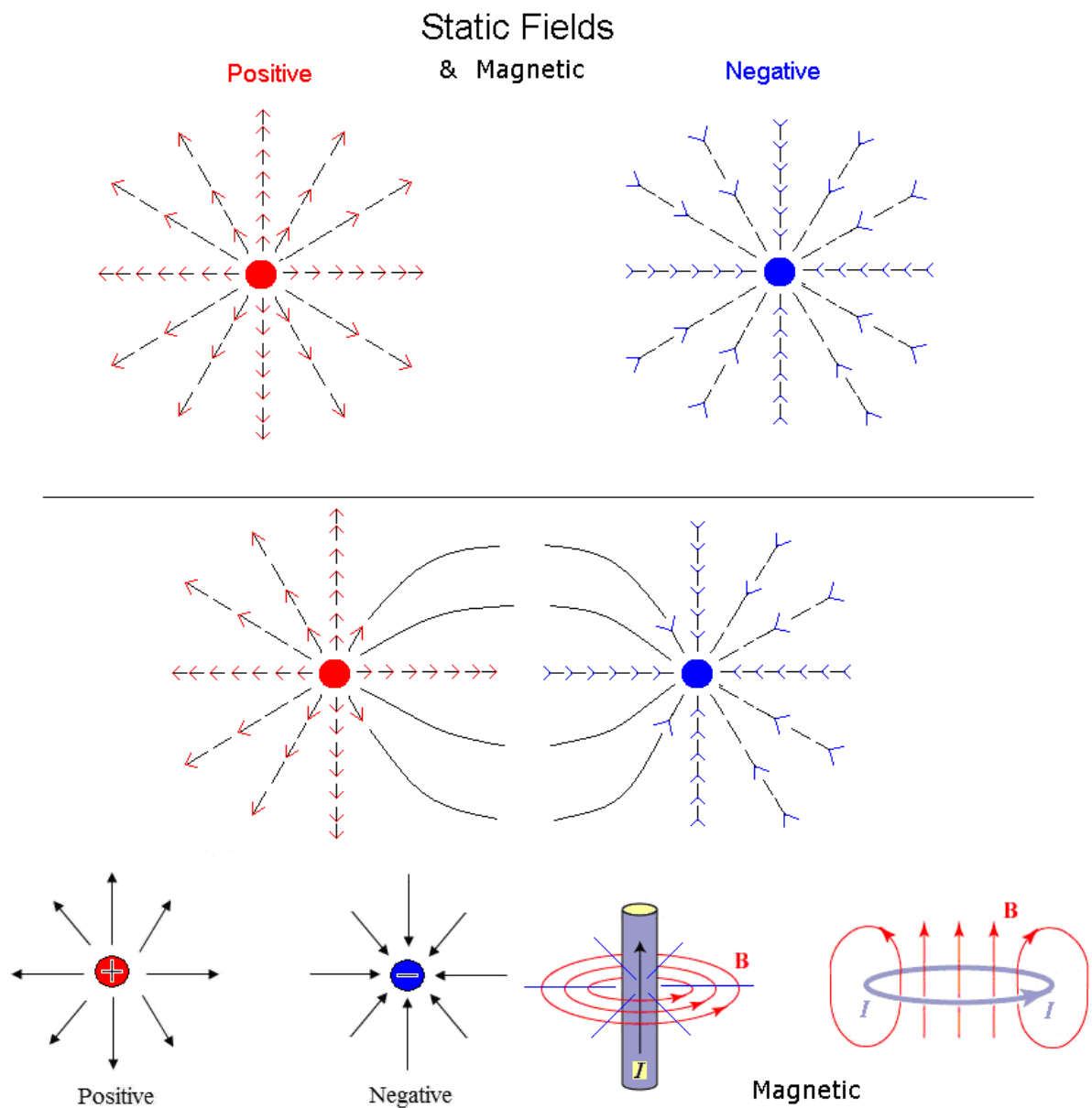
Make up a cable using coax vs. a 2x2 cable as suggested above and notice the great difference in what you hear, do not use coax for inter-connects!





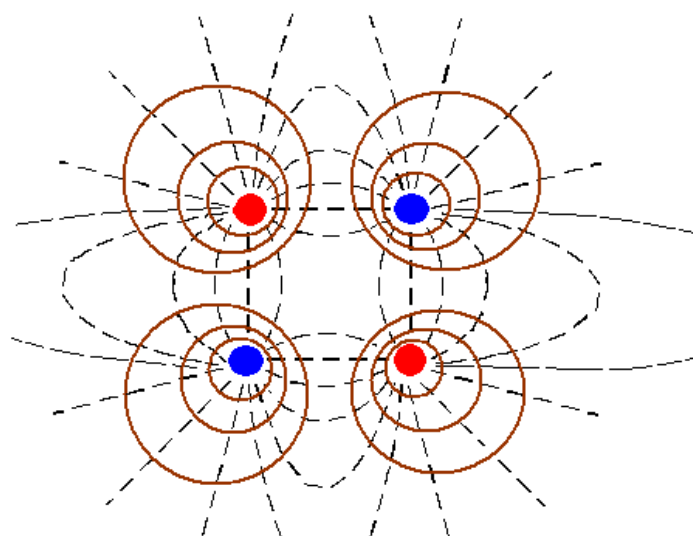
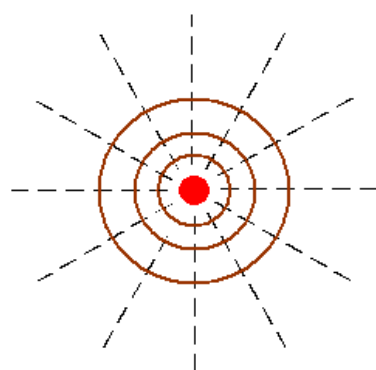
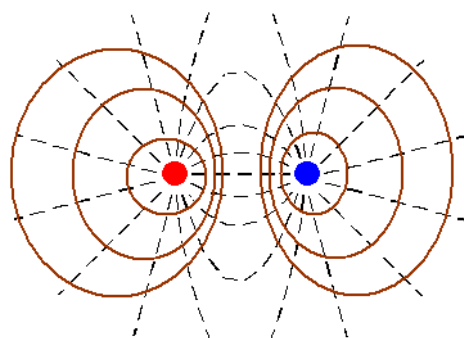
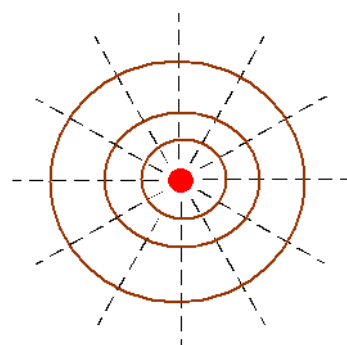
More diagrams of Static fields, twin lead configuration, then 2x2 design.





Adding the magnetic property and then show a twin lead and the 2x2 design.

The following diagrams demonstrate the self-shielding and the unique field-balancing of a 2x2 cable design.



Cable Burn-In & Directivity in Cables

While waiting for a new custom wire to be woven up, I decided to wonder around the plant to watch how the skilled employees put the many different cables and inter-connects together.

Fortunately [as it turns out] a delivery truck had just dropped off a new batch of custom-made wires. These large new spools of wire were taken to a cable rack and were placed in order of use for different cables. The large spools of wire were spooled off onto smaller spools, which were used when a new batch of cables or inter-connects were to be manufactured.

The wires were marked on the leading 'end' to indicate the direction of how the wires came off the spools. Then came the interesting part, before actual use, all wires were 'high-potted' to check for cracks, splits or flaws in the insulation.

If the wire had a flaw the High-Pot tester would sound an alarm and the operator would cut the flaw out, mark the end of the wire and re-start the '*high-pot*' testing. The wires were always marked and made up into a new cable with the wire's 'direction' in the same 'original' direction with all of the previous wires.

We asked the operator at what voltage-level were the wires being tested at, we were informed it depended upon what wire type was being tested, for the high-pot tester had two voltage settings: 2 kV or 10 kV !

Incidentally Richard and I had just been asked to investigate the 'notion' of 'cable-directivity', [of which I had never heard of before], for the new employer wondered if we could devise a test to check for 'Cable-Directivity'.

Our investigating of cable-directivity was started when Richard explained his experiences in listening for 'cable-directivity'. I was informed that Richard could hear some difference, but was unsure as to what he sensed, for it had been some time since he had listened for 'directivity' in a cable.

So by using several HP Analyzers, an LCR-bridge, LCR sweep analyzer and a Network analyzer; we eventually found, by using F-M40; a process to test for cable-directivity.

It seems, and is obvious now, that the high-pot testing was 'stressing' the wire's insulation.

The high voltage fields were at an 'angle' to wire's surface since the wire was rapidly spooled off from left to right [in respect to the operator] as the wire went through the high-pot tester.

Interestingly enough the notion of cable 'burn-in' was mentioned and the knowledge of the incidental 'high-voltage' stressing a wire became connected. So we had two cable sets made up.

One set was not High-potted [A] and the second set [B] was made up as usual. We had listening tests performed and several listeners could sense audible differences in the two 'different' cables.

The HP Network Analyzer, using F-M40 and Smith charts, showed visual differences in the *circular patterns* of the two test cables. We then had the cable set [A] 'high potted' [at 10kV] and listened to again in comparison to cable set [B]. Listening tests failed to notice or sense any differences in the two sets of cables.

We then turned to the idea of warming up, or burn-in cable set [A] by using a 8-Ohm resistor and a audio amplifier being feed with classical music. The idea is that the 'stressed' dielectric in the wire/cable could or would be 'un-stressed' by feeding a signal into cable set [A].

The amplifier was set to supply ~ 2 watts: 500 mA into the 8 Ohm load. The burn-in was done on cable set [A], which was for about 8 hours over a two day period.

[Since we were part time contractors, the time cable set [A] was 'off' was over night ~ 14 hours: Friday night to Saturday morning].

Again listening tests were performed that is:
A new [A] cable [set] was made up along with new [B] cables; both cable sets were Hi-Potted. Cables [A] was 'burned-in' and then compared to [B] cable. The listeners were able to notice some audible differences in the two cable sets.

Burn-In Tests

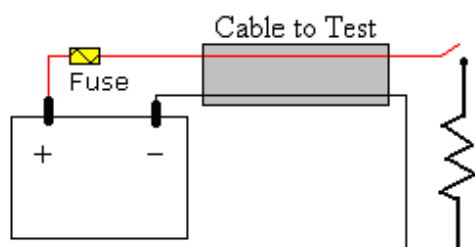
Be Careful

We do not assume any responsibility for your mistakes.

First set up a 9-Volt battery or 12 volt DC source, acquire a 16-20 Ohm resistor, two cable sets of the same type/manufacture. Connect one end of the cable(s) to one end of the load resistor.

For safety add a 2 Amp fuse in the 12 volt line.

Carefully connect the other end to the 12 Volt DC source, ensure the other end of the cable has an open, that is, the LOAD resistor is NOT touching both contacts of the cable(s) under test.



When ready touch the free end of the resistor to the other contact very briefly, several times for about one minute.

This process will induce:

- .75 amp surges with 16 Ohms: or
- .60 amp surges with 20 Ohms: into your test cable set.

This process will 'stress' your 'test' cable set [set A].

Remember to remove the load resistors before listening.
We do not assume any responsibility for your mistakes.

Now listen to your 'stressed' cable set [A] and compare it to your 'none stressed' cable set [B].

Now we can simulate 'burn-in' by using the same resistors as the load on the end of your 'stressed' test cable set [A].

We suggest 4 - 8 hours at low-medium level of audio [less than 90 SPL]. Then when you have 'burned-in' your test cables [A] listen and compare cable set [A] to cable set [B].

Directivity Testing

Directivity testing is harder to induce into a cable at home, so the easiest option is to make your own cables from new wires.

As pointed out above, as you un-spool the wire for your new cable, observe and mark the direction. Make one set [A] say left to right, that is place the wire spool

on your left and spool of to your right, and then make second set right to left by flipping the second cable set of wires in the opposite direction.

You will have to be very observant with this test so take notes and write down your first impressions. Listen to your opposite direction cable set [B] and write down your observation and impressions.

Unfortunately we suspect the cable will become the 'same' as the cables are incidentally 'burned in'.

Good Luck !

- - -

**We will now move onto the controversy of power cords
that is:**

Audio Grade Power Cords.

High Voltage

We do not assume any responsibility for your mistakes.

PREVENT being Shocked.

Never work alone with 120 Vac voltage.

Find a friend or a partner who knows how to handle and disconnect 120 Vac.

Electricians avoid being shocked by working with one hand
and keeping the other hand in a pocket.

Hook-up the meter or circuit before you turn on the power.

IN CASE OF ELECTROCUTION !

REMOVE THE POWER !

Turn off or disconnect the AC power.

If unable to reach a switch or plug, use an insulated tool to separate the victim
from the power source.

Check if the victim is conscious.

IF unconscious, check for breathing and pulse.

Administer Standard CPR if indicated.

Once consciousness is restored, check for burns.

Administer Standard First Aid for burns if indicated.

Warning

Ignoring this Warning can hurt you !

You could be hurt.

Do not attempt these experiments or projects unless
you fully understand and accept all risks involved.

We do not assume any responsibility for your mistakes.

Minors should not perform these Experiments in this BOOK
without supervision of a technician, parent or teacher.

BEFORE starting any experiment:

Everyone involved should know and completely understand these warnings...
and all warning labels on all materials and items used.

We do not assume any responsibility for your mistakes.

- - -

Audio-Grade Power Cords . . .



RosVeta Praxis Pyx - CD players
[Made of Selected Hardwoods]

We do not assume any responsibility for your mistakes.

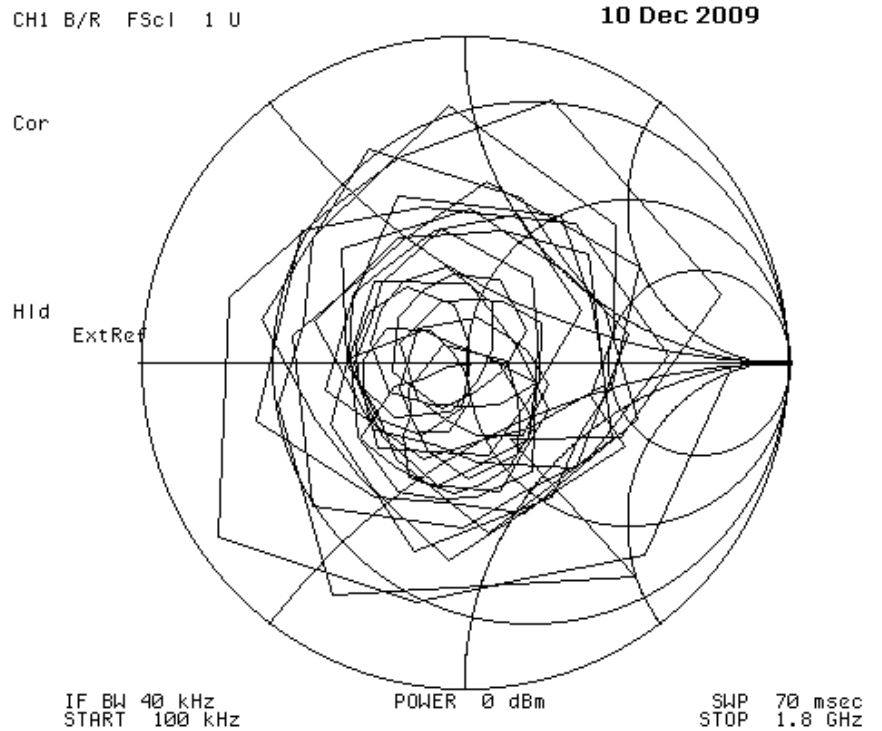
The follow graphs are of a common black-Zip Cord.

The jagged trace and many 'circles' in this Smith chart indicates non-uniform transmission properties of this black, six-foot Zip-cord.

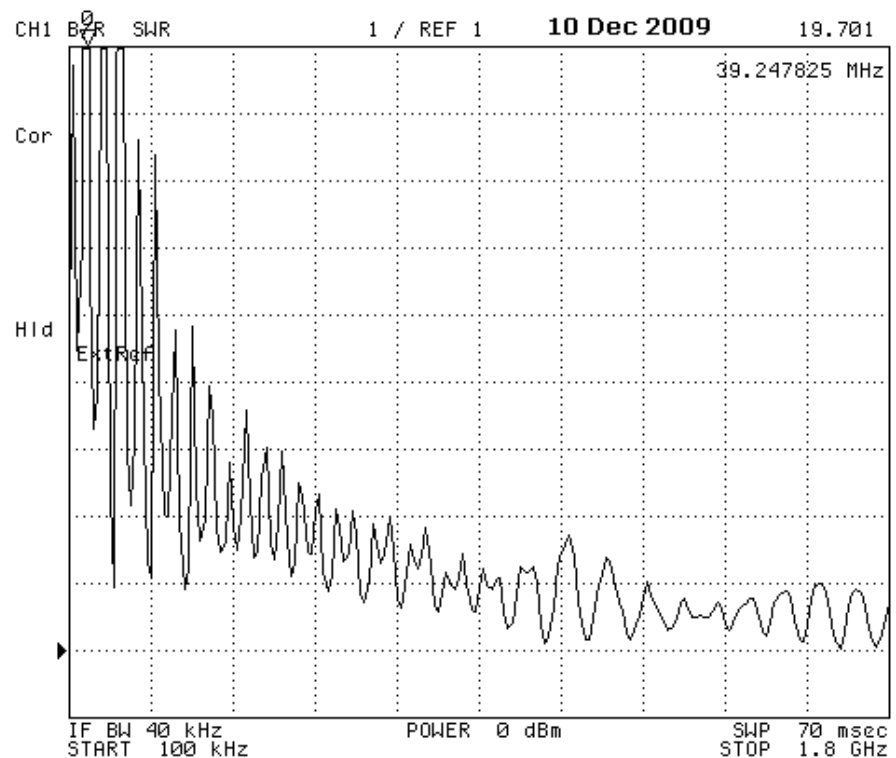


Zip Cord

Smith Chart



Zip cord's SWR Chart



The SWR response of this Zip-cord shows a marker at ~ 40 MHz. This cable was RF swept to 1.8 GHz. Horizontal spacing is 180 MHz per division. We notice that at 180-190 MHz the SWR drops off.

Several Power cables were tested using the new RosVeta F-M40 testing process.

The tests revealed many unique insights to power cords.

One insight was that the use of braided shielding is useless when making up Audio-Grade power Cords! Shielding, like in a Coax-cable, which is an un-balanced cable; distorts and suppresses the static lines

of force and adds un-wanted capacitance. These distorted lines of static force then influence the magnetic fields, which in turn cause 'Audible' distortions.



RosVeta Praxis-Rya - Amplifiers

[4 x 4 inches by 1-1/2 inch thick]

The debate was [due to lack of supporting tests - until now] how a power cord could influence the sound of a main power amplifier or any audio equipment.

Some manufactures have proposed that the SWR characteristic as the sole explanation of the source of the 'noise' source or interference.

Others assume that the 'noise' is from the 'power-lines' feeding into the amplifier's AC input connection.

Filtering of various types, large and small, are used and do provide some interesting changes in the sound of an Audio system.

If a 'noise' or an unknown 'noise-source' is the culprit influencing the audio system where is the source and is it measurable?

Noise is an interesting phenomenon and is a field of study in and of itself. Noise -in our case- being: any-unwanted random 'signals' affecting a circuit, or any audio equipment.

So then, how can a 'simple' AC power cord affect the audio signal ?

Pieces of the Puzzle...

By using the F-M40 process, we measured many different types of common commercial power cables.

We did not measure any of the many Competitors' Audio-Grade power cords, for we decided to make our own various versions.

Our first -Esoteric- power cord was called the Pelican, which had 8-9 inches of the cord's wires looped in the middle of a standard power cord.



A reconstructed 'Pelican' power cord – [not the original]

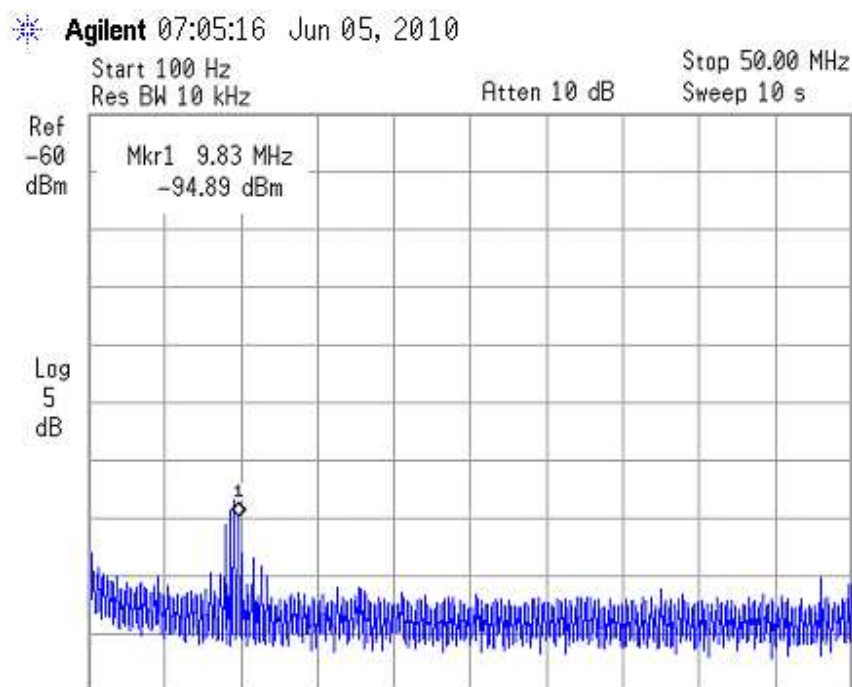
The Pelican power cord demonstrated that changes in the power cord's 'configuration' greatly affect the Audio signal. We used a High-End Audio power amplifier for our power cord tests and Richard would do the listening. Months later it was found that the power cord DID play a part in 'generating noise'.

The 'Noise-Generating-System'...

Two proto-type power cords [not shown] helped us realize that excess-energy of a high frequency content was being produced. And that the power cord's shape or 'configuration' changed what *noise* or frequency-band of 'noise'- was being 'produced'.

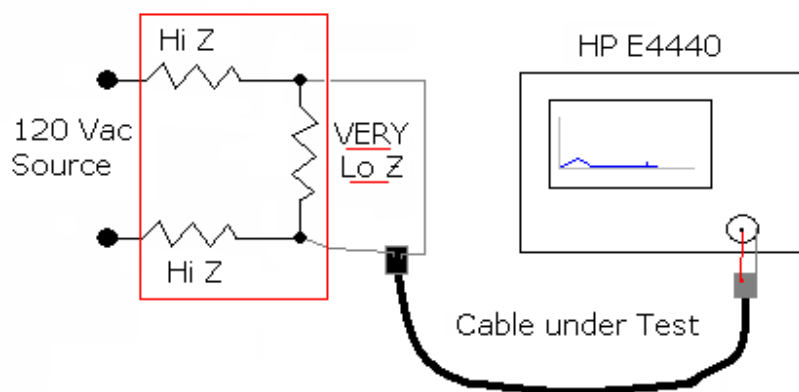
By using a HP E4440 Spectrum Analyzer and a balanced resistor attenuator network we measured the 'noise' of the following power cords.

The Power source was from a 120 Vac60 Hz [USA] wall socket.



White Power Cord - Electric Cord Westfield, Pa.
 E53042 LL30875 ICC Colors
 [9ft. 255 pf, 32 uH, .28 Ohms- loop-]

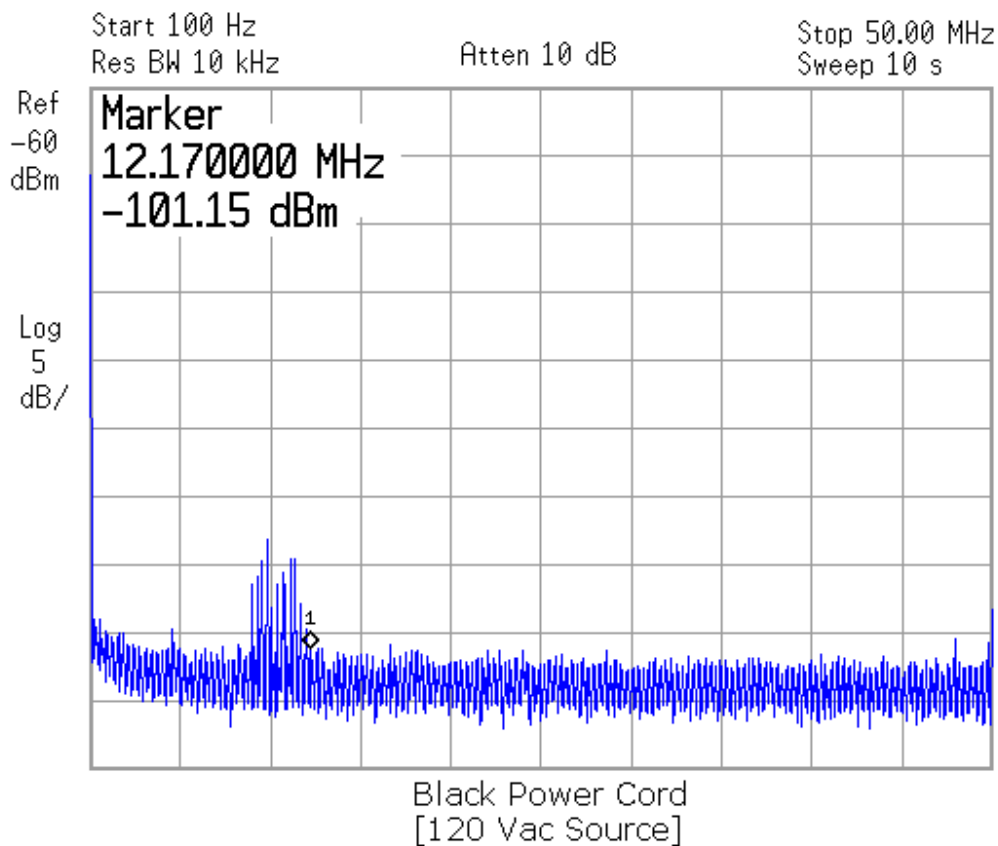
Noise Test - Attenuator - Analyzer



CAUTION: please do not duplicate this test set-up at home !!!

We do not assume any responsibility for your mistakes.

Agilent 07:05:16 Jun 15, 2010



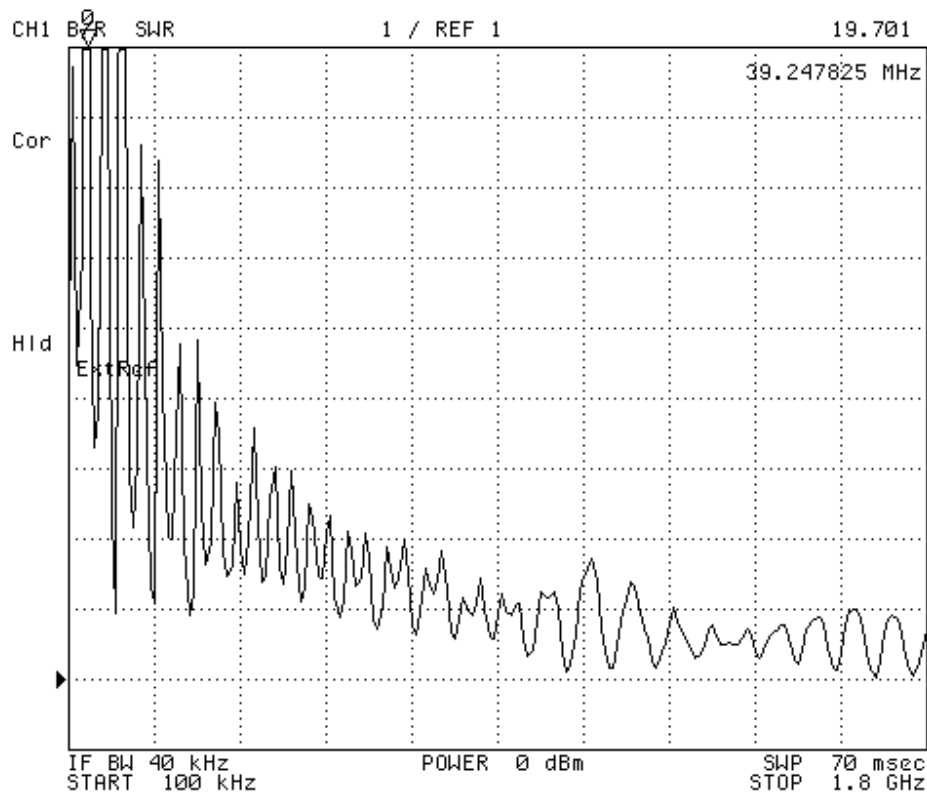
Black Power Cord - BELDEN CSA TYPE
E88265 LL81924 FT2 444027
[6ft. 235 pf, 33 uH, .565 Ohms- loop-]

CAUTION: please do not duplicate this test set-up at home !!!

We do not assume any responsibility for your mistakes.

As is well known 60 Hz is a very low frequency with a real long wavelength.

Yet the 120 pulses per second [of the 60 Hz power] play a significant part in developing the un-wanted 'noise'. As we see it, 'reflected energy' from the 'source' and 'load' impedance mismatch is part of the 'noise-source-generation-system'.



Simply put, the impedance ratio of the AC power - source - [Z-1] in conjunction with the amplifier's AC input to Transformer - load - [Z-2] is not the magic 1.1:1 ratio so then there has to be some reflected energy / 'noise'.

This then leads us to wonder what is the Impedance of a 120 voltage source of a typical wall-socket ? [U.S.A.]

WALL Socket Impedance

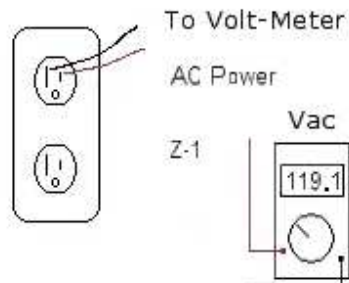
So how do we determine the impedance of a 120 outlet ?

Using the V1-V2 / load current principle we can come close to a useful value for the wall-socket's impedance.

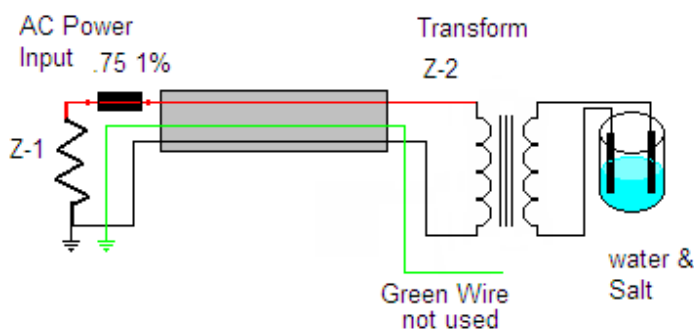
CAUTION: please do not duplicate this test set-up at home !!!

We do not assume any responsibility for your mistakes.

First let us measure the Wall socket's voltage with no load:
119.1 Vac [late at night, oven & dryer off].



Then we connect a - LOAD -
a heavy transformer with the Secondary connected to a Salt-water Load.



CAUTION: please do not duplicate this test set-up at home !!!
We do not assume any responsibility for your mistakes.

We then adjusted the current [V across the .75 - 1% resistor] to be about 8 amps by adding Salt to the water-load.

$$6.14 \text{ volts V-resistor} / .75 \text{ ohms} = 8.18 \text{ amps.}$$

At this load level we then measured the voltage at the wall socket:
117.1 Vac.

Source : Z1 : $119.1 - 117.1 = 2 \text{ Vac drop} / 8.18 \text{ amps} ==> .244 \text{ ohms}$

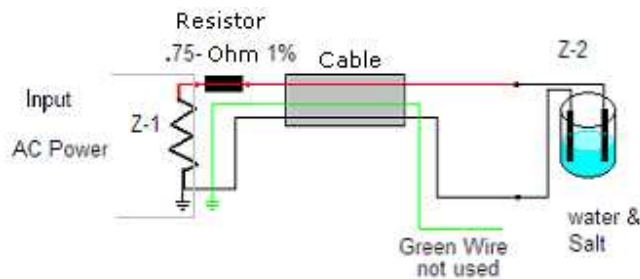
Load : Z2 : $117.1 / 8.18 = 14.3 \text{ Ohms}$

SWR : $14.3 / .244 ==> \mathbf{58:1}$ (a large mis-match)

Using only the Salt-Water load we repeated the Voltage-load-drop test.

Vac Source 119.1 Vac

Adjusted the Salt-water-load to 10 amps Ac / by slowly adding more salt,
then measured the voltage drop at the wall socket: 116.8 Vac



$$Z-1 : 119.1 - 116.8 = 2.3 \text{ Vac} / 10 \text{ amps} = .23$$

$$Z-2 : 116.8 / 10 \text{ amps} = 11.68 \text{ Ohms}$$

$$\text{SWR} : Z-2 / Z-1 : 11.68 / .23 \sim 50 : 1 \text{ (a large mis-match)}$$

CAUTION: please do not duplicate this test set-up at home!!!
We do not assume any responsibility for your mistakes.

Our house is wired with aluminum wire [of 1978] so we tested a wall socket
in my home office. Late at Night the results were:

Wall-Socket is 20 feet away from the power panel,
Open Voltage was: 119.8 Vac [late at night]

We then connected the Salt Water load, which was adjusted to a current flow
of 10 amps resulting in 114.6 Vac a difference of 5.2 Vac. [119.8 Vac – 114.6 Vac]
 $5.2 \text{ volts} / 10 \text{ amps} = .52 \text{ Ohms}$ [Z-1] Wall socket impedance.

Now determining the impedance of the Salt Water Load by:
 $114.6 \text{ Vac} / 10 \text{ Amps} = 11.46 \text{ Ohms}$ Zac [Z-2]

Then the SWR : Z-2 / Z-1: 11.46 Ohms of Load / .52 Ohms ~ SWR of 22:1

During the Day at 10-11:00 A.M., the load test revealed:

In house aluminum wire [same as above]

118.3 Vac open reading

113.8 with a 10 amp load

$118.3 - 113.8 = \text{difference of } 4.5 \text{ Vac} / 10 = .45 \text{ Ohms Impedance}$
for the wall socket.

Then $113.8 / 10 = 11.38$ Ohms impedance for the Water Load
 $11.38 / .45$ then a SWR of 25.29.

So we have .23 Ohms impedance for Copper wiring and a range of .45 to .52 Ohms impedance, for old aluminum wiring, depending on the time of the day.

SWR	Percent Reflected	This simplified table shows that at an SWR of 1.2 : 1 a good system will have .82 % of the Power reflected.
1.2	0.82	
1.5	4.00	
2.0	11.10	
3.0	25.00	
4.0	36.00	
5.0	44.40	
---	---	

At SWR ratio of 3 : 1 a system will have **25 %** of the Power reflected.

At SWR ratio of 5 : 1 a system will have **44 %** of the Power reflected.

At SWR ratio of 22 : 1 a system will reflect **82%** of the power, and at
 50 : 1 a system will reflect **92%** of the power.

So Now what ?

Power Resonance

Considering that the power cord is a long-shaped-capacitor that is in parallel with the primary 'coil' of the power transformer their relationship constitutes a resonant parallel tank circuit ! Reactive loads like transformers will have a greater level of noise in contrast with a pure resistive load.

By figuring out some of the possible resonant frequencies we can see if the frequencies are 60 Hz [120 pulses] resonant-related.

This Chart shows how close a Six-foot cable is to a quarter-wave of upper frequencies.

Frequency	Ft. 1/4 WL	6 Ft.
2 MHz	123	20-1/2
3 MHz	82	13-1/3
3.5	70.3	11.71
5 MHz	49.2	8.20
10 MHz	24.6	4.10
15 MHz	16.4	2.73
20 MHz	12.3	2.05
30 MHz	8.2	1.37

Harmonic	Ratios	
Frequency MHZ	60 Hz	120 pulses
1	16,667	8,333
2	33,333	16,667
3	50,000	25,000
4	66,667	33,333
5	83,333	41,667
6	100,000	50,000
7	116,667	58,333
8	133,333	66,667
9	150,000	75,000
10	166,667	83,333
11	183,333	91,667
12	200,000	100,000
13	216,667	108,333
14	233,333	116,667
15	250,000	125,000
16	266,667	133,333
17	283,333	141,667
18	300,000	150,000
19	316,667	158,333
20	333,333	166,667
21	350,000	175,000
22	366,667	183,333
23	383,333	191,667
24	400,000	200,000
25	416,667	208,333
26	433,333	216,667
27	450,000	225,000
28	466,667	233,333
29	483,333	241,667
30	500,000	250,000

Interesting to note that many of these upper frequencies are 'even' harmonics multiples of 60 Hz.

Using any power cord then will have many 'resonant' frequencies that are harmonics of the 60 Hz frequency or 120 pulses / second.

Some cables could be more 'resonant' than other power cords thereby producing more 'noise' at various frequencies.

So we see that the Power cord and the transformer's primary have many resonant frequencies, which are 'influenced' by the 60 Hz AC power.

These 60 Hz or 120 pulses-second can generate 'noise' due to some reflected energy, for there exists an Impedance-Mismatch; which causes reflections and is definitely a 'source' that can help set-up some unwanted high-frequency 'noise' as per harmonic resonance.

- - -

We then tested the previous white power cord for resonant frequencies using a sine-wave, a triangle-wave and a square-wave.

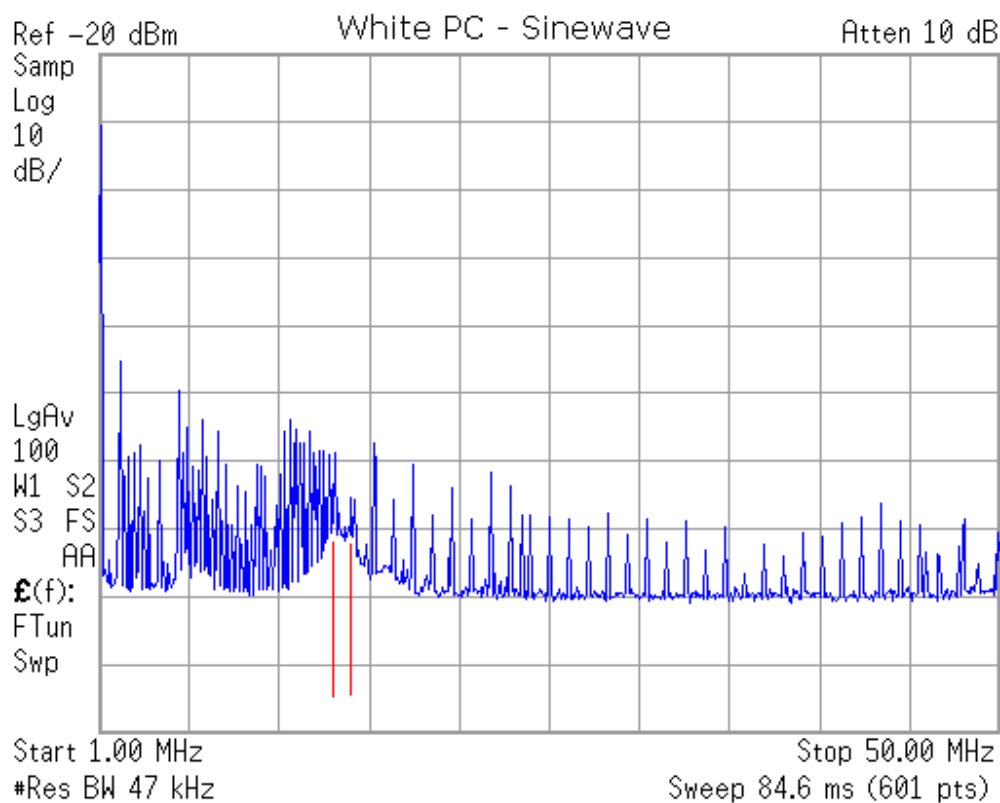
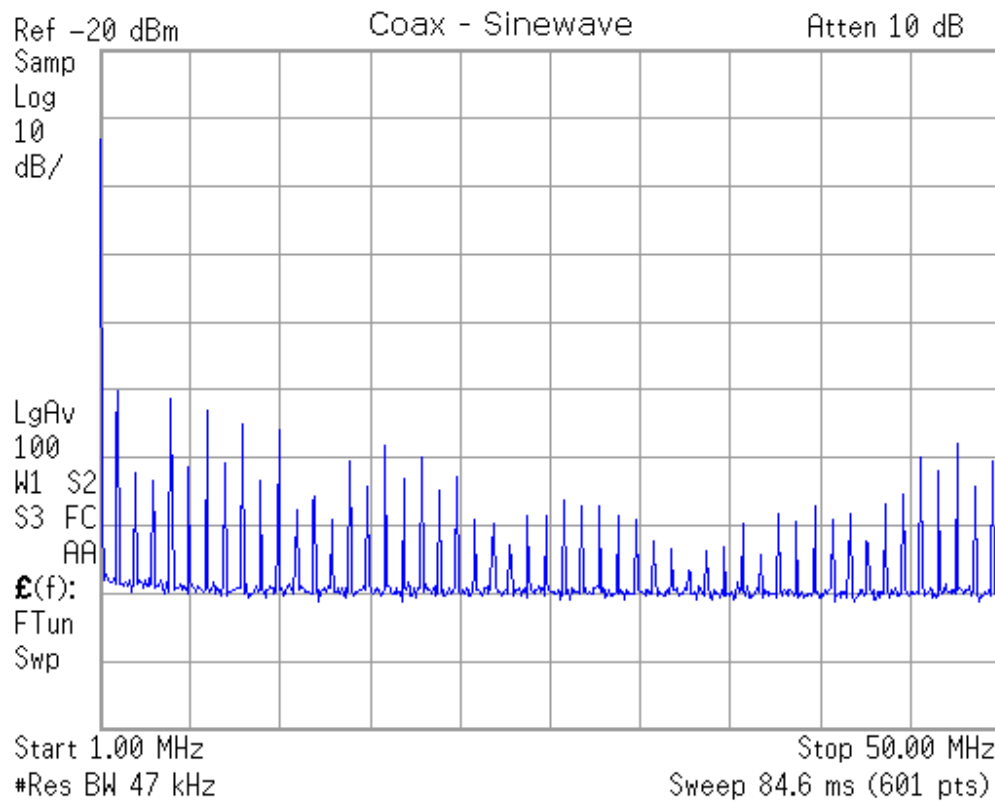
We first tested a common COAX CABLE in order to compare with the white power cord.

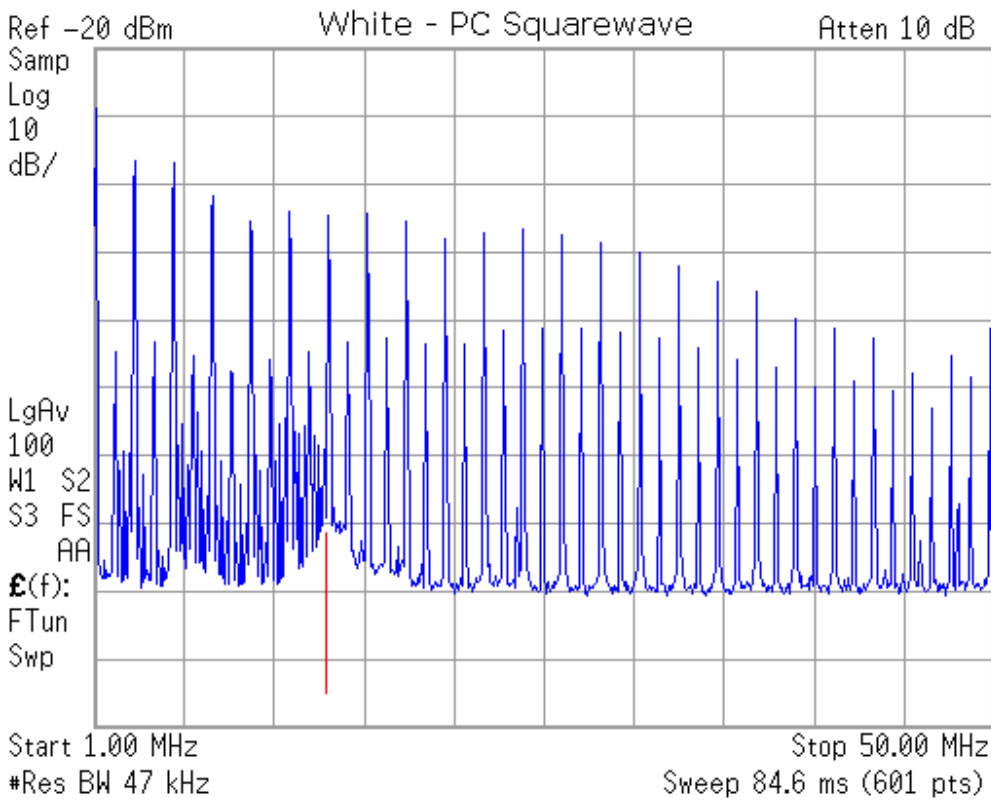
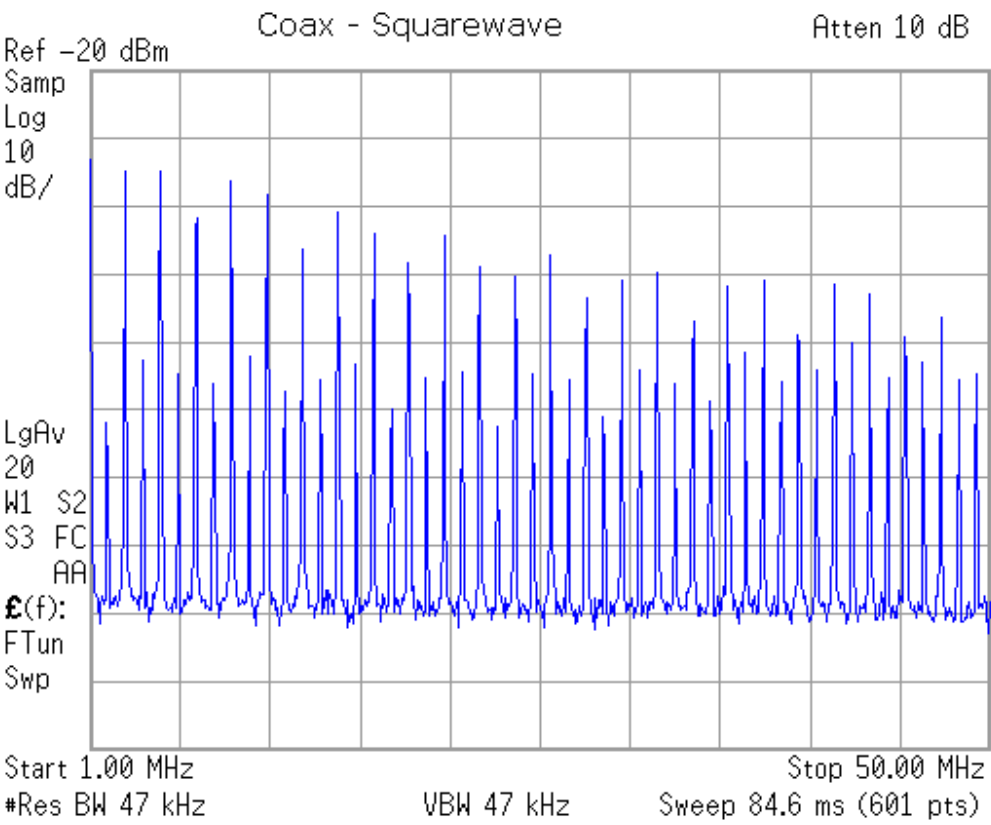
The tests were done by using a 1MHz signal and feed the signal in one end of the cable under test and connected the out-put end to the Spectrum-Analyzer.

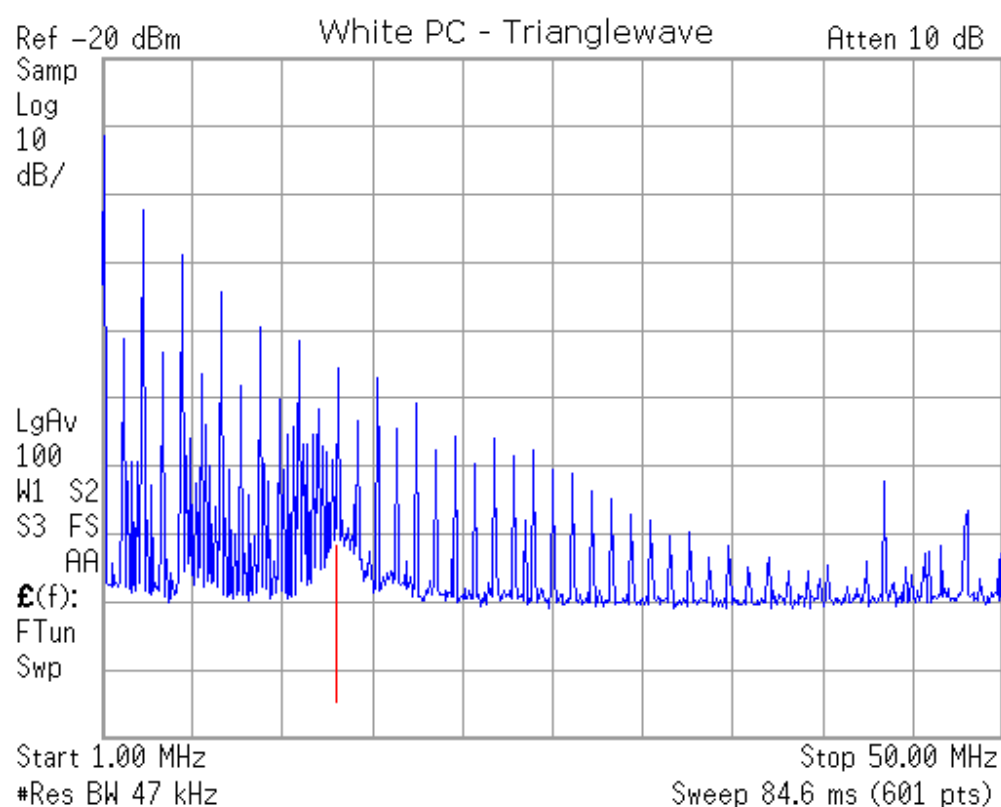
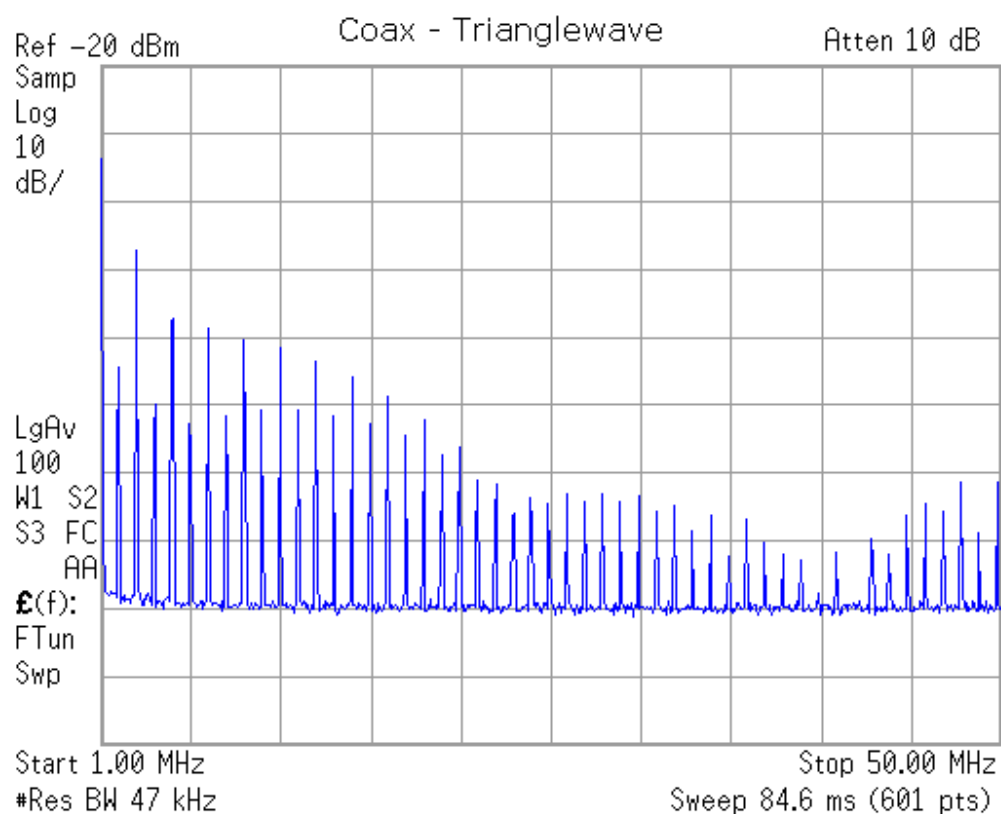
The three different signal types were plotted out:

- sine-wave
- triangle-wave
- square-wave ...

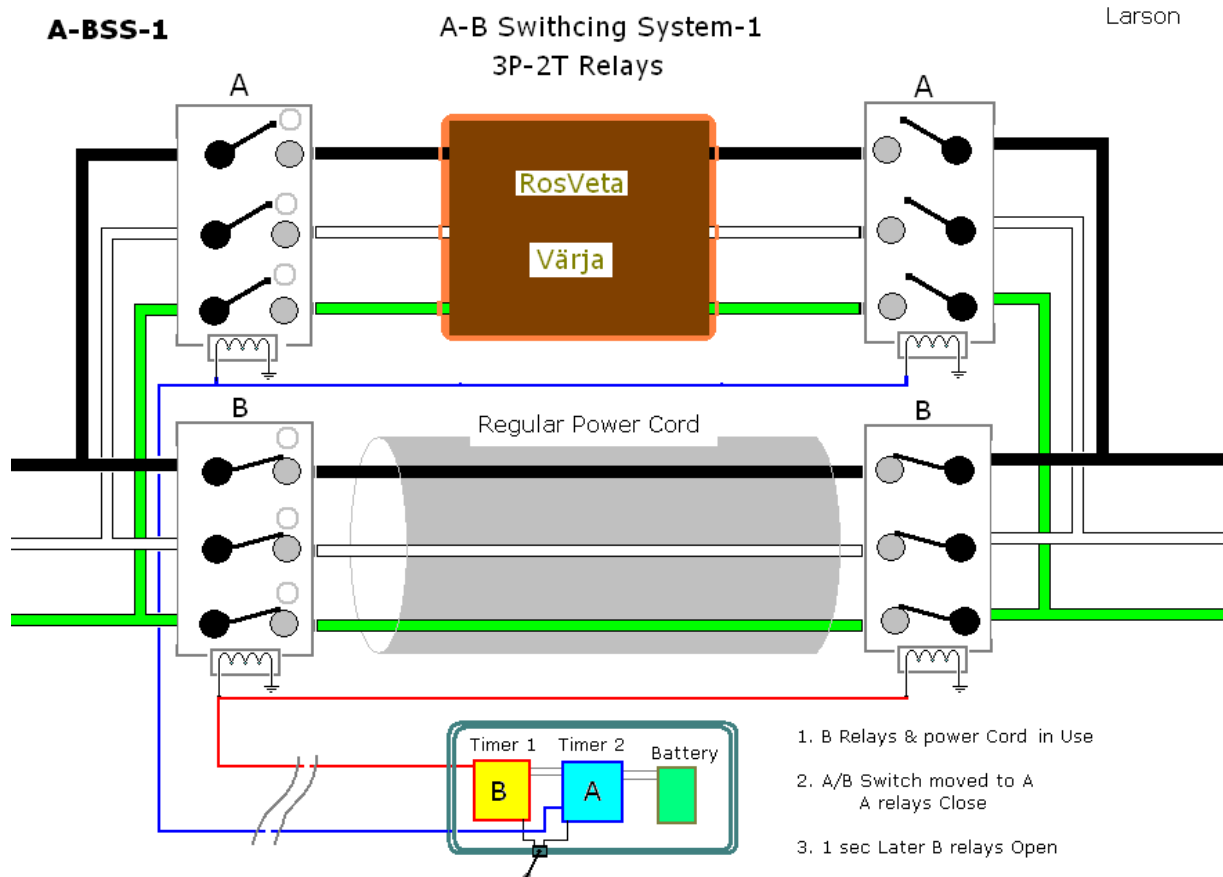
Notice that the red lines are in the 12, 13, 14 MHz range, nice 60 Hz harmonics.







For more accurate testing of power cords a quick change process is needed. This circuit allows for immediate and smooth changes from one cable to the next with no power glitches.



SWR Graphs

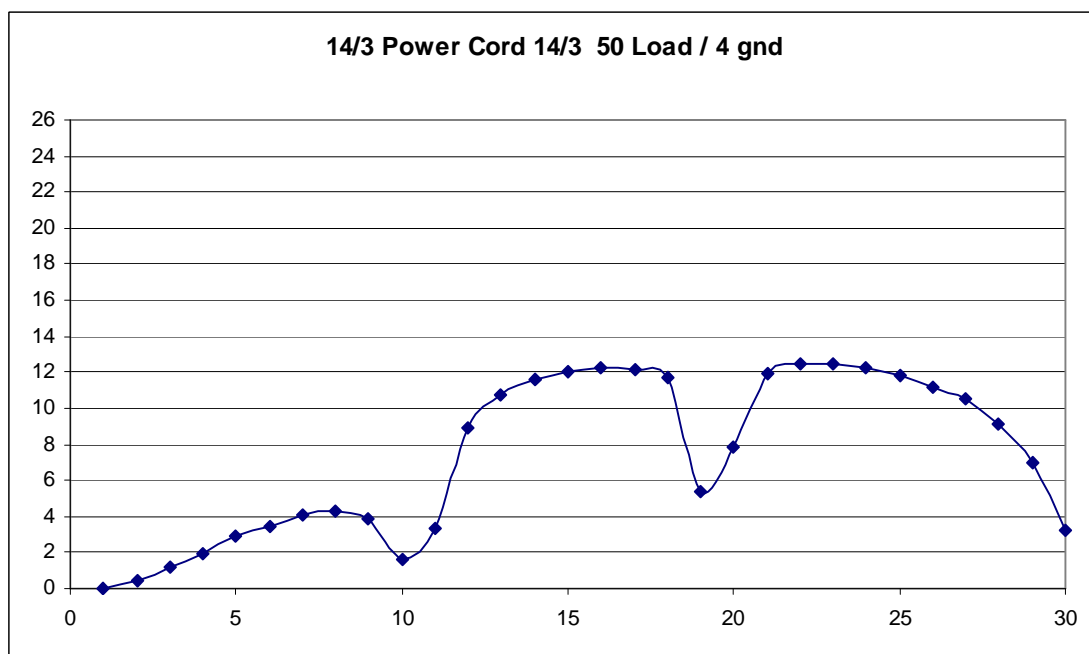
Now let us look at SWR graphs of various cable designs to visually realize what we are talking about.

We will first use a 97A50 SWR Auto Analyzer for the following SWR graphs.



These graphs are of common Zip cord, RG-58 Coax, various cables as noted on the Graphs. The vertical axis is in Vdc output as per SWR ratio.

The greater the voltage output the greater the SWR.



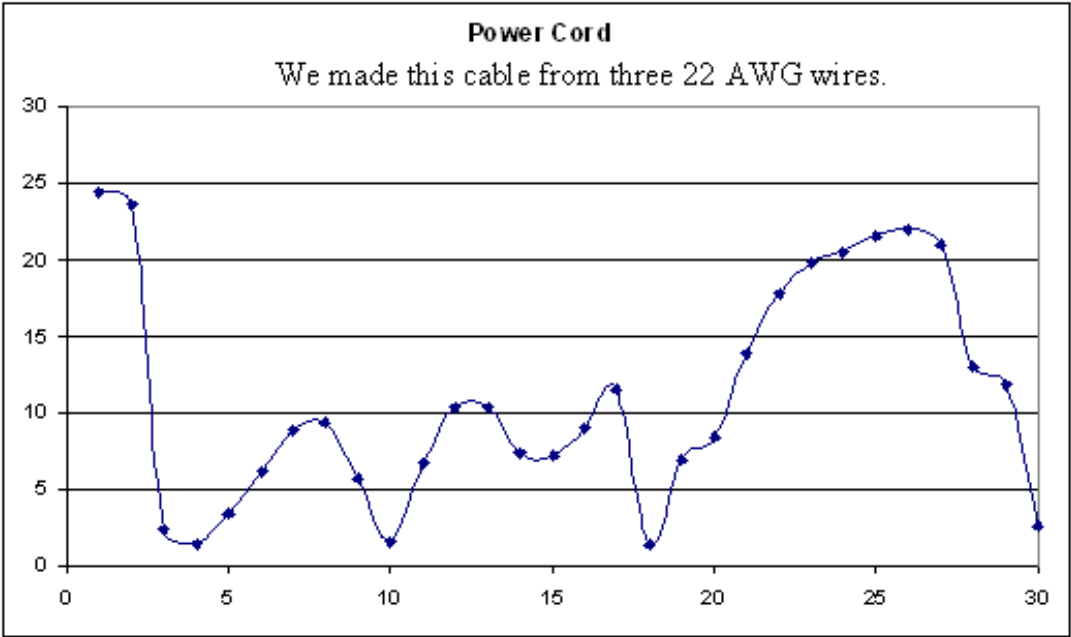
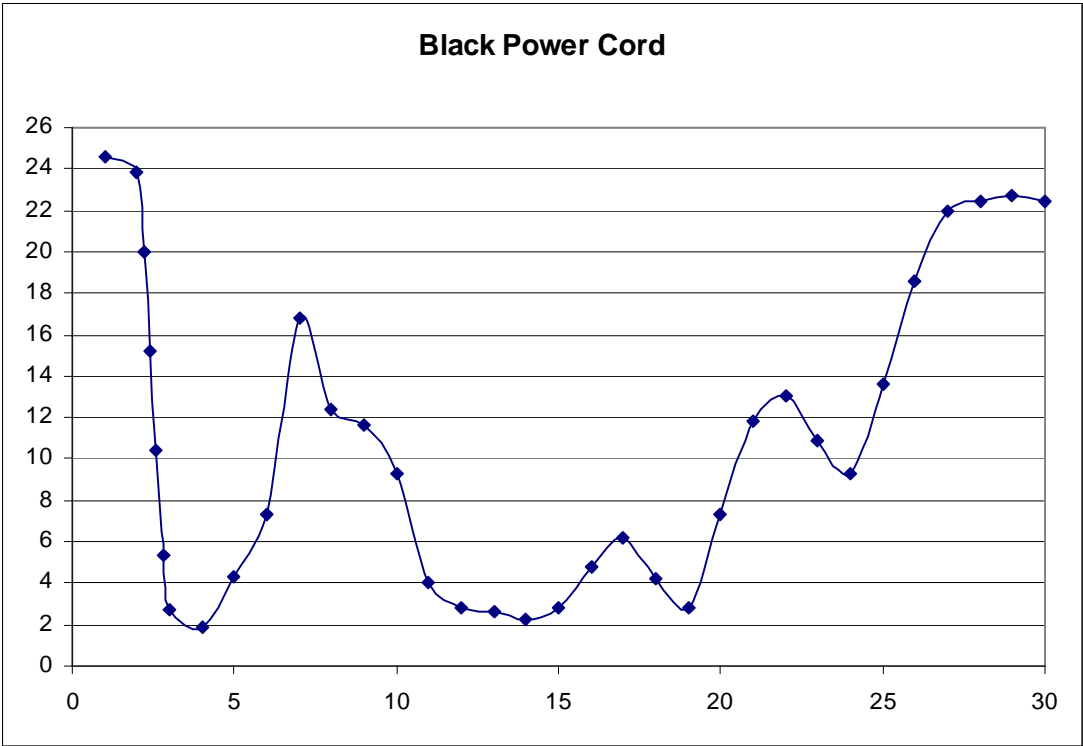
The round 14/3 Power cord was connected with a precision 50 Ohm load.
The input end's ground wire was connected to the neutral wire via 1-Ohm resistor.

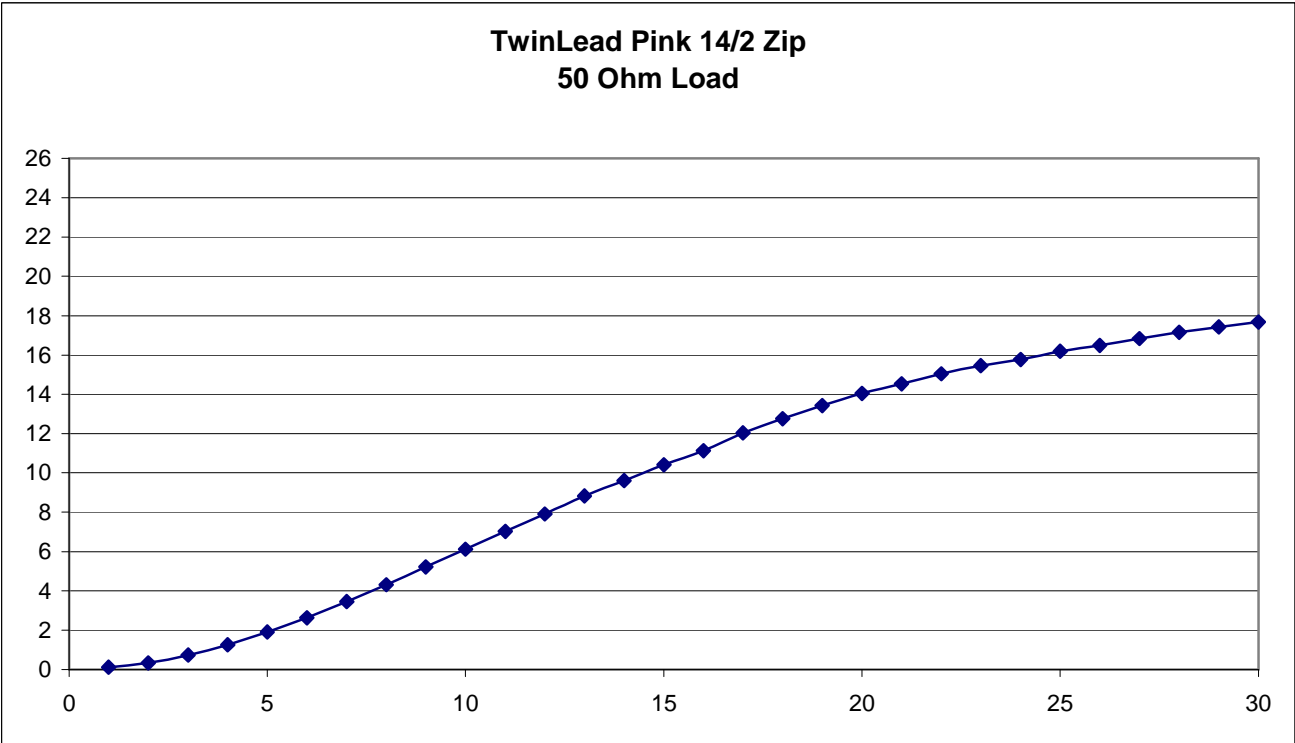
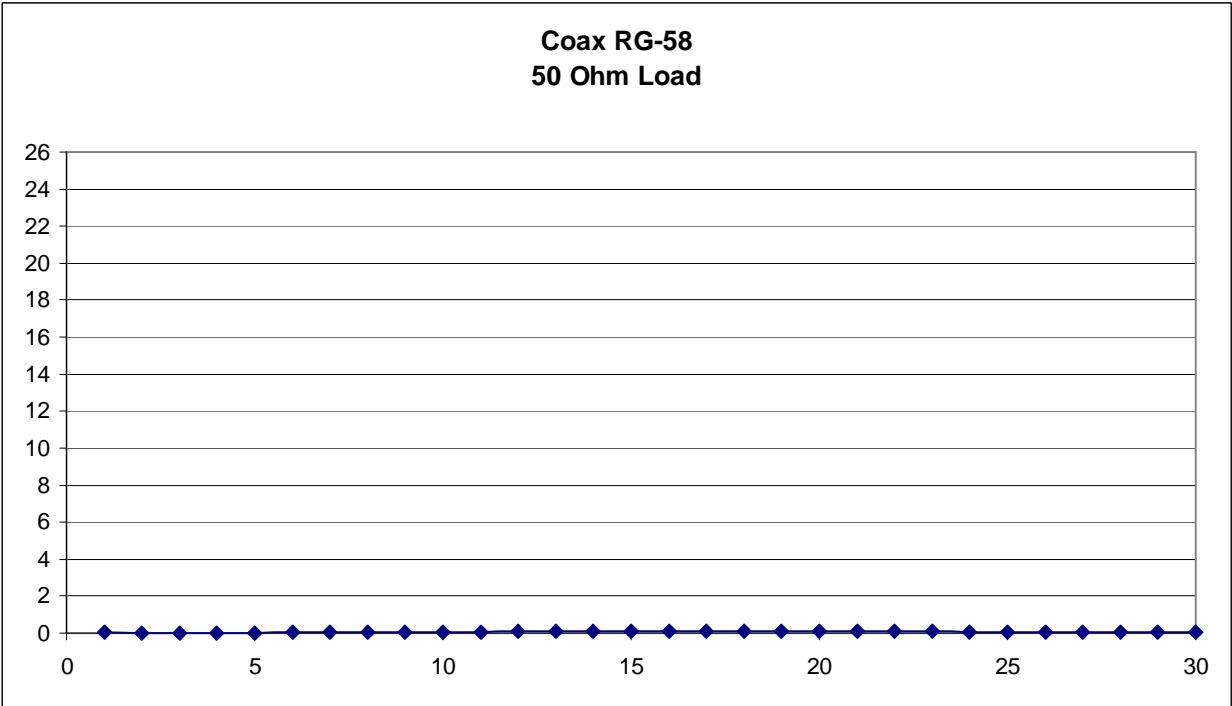
- - -

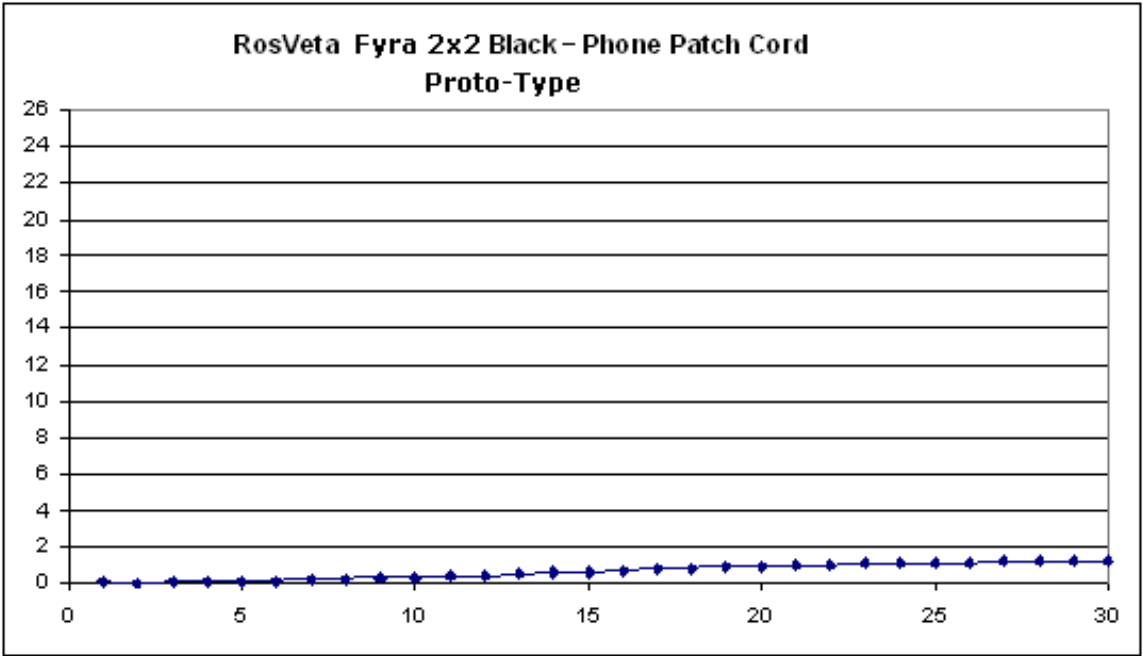
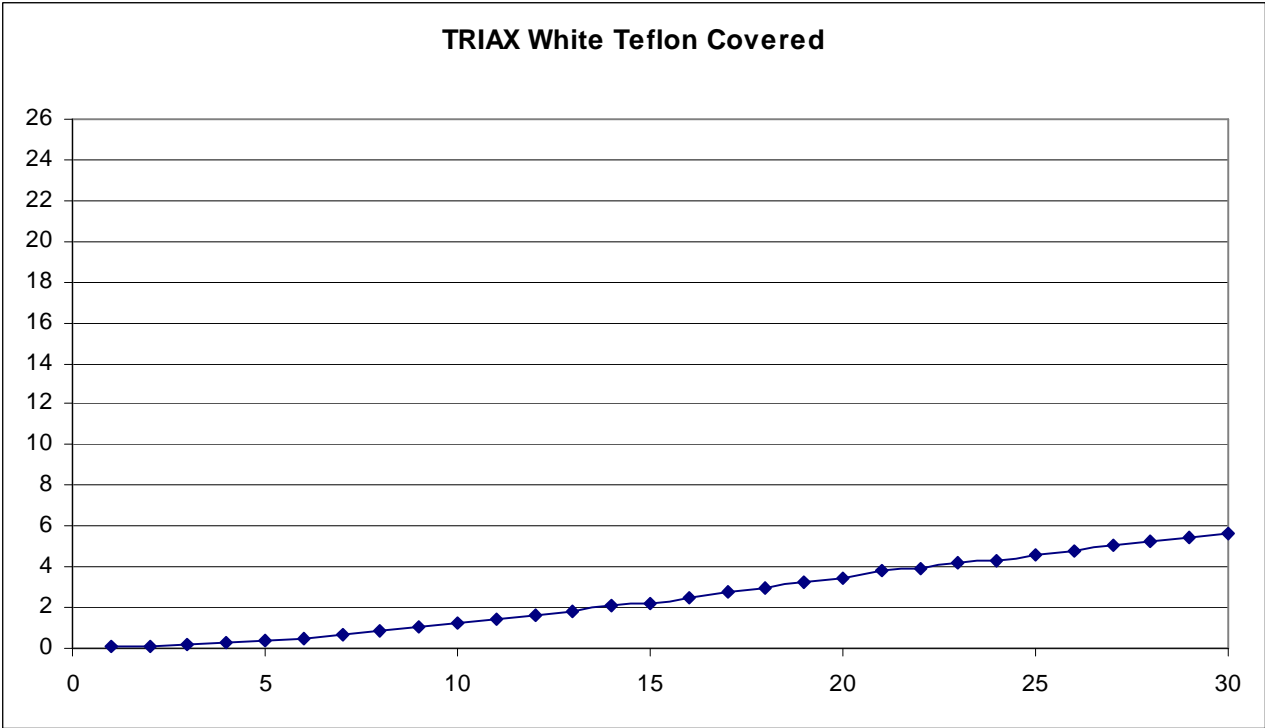
Standard Cable was Teflon covered Coax cable, Silver-plated.

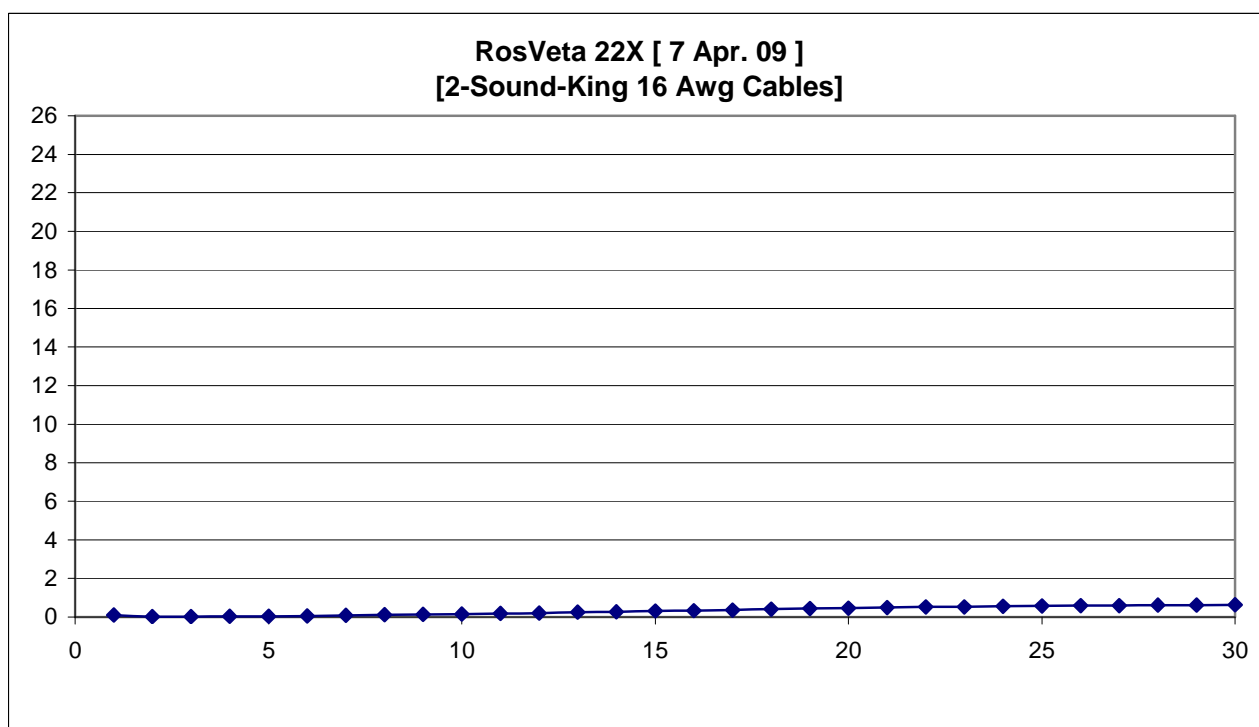


A Precision, non-inductive, 50-Ohm load as the common standard.









The previous graphs should clearly demonstrate that ‘geometry’ plays a critical role in cable design.

To continue:

To demonstrate this extreme low frequency to high frequency harmonic – response; we can all remember when we drove our car under a 60 Hz power line. [USA] The car’s radio would become ‘noisy’. And if our radio was tuned to a station near 600 [600 kHz] frequency and we all noticed that the 600 AM Radio station was more sympathetic with the 60 Hz power-line due to the increased ‘noise’.

So how does this help?

Let’s start with the quarter-wave of 60 Hz: = 4,100,000 ft. or 776 miles long! A cable of 6 feet is a very small length, about 1.46×10^{-6} of the $\frac{1}{4}$ wave of 60 Hz. Checking further let us look at the characteristics of a 92% reflection at 50:1 SWR as determined previously.

Looking at a Power amplifier system, for example, rated @ 480 Watts: that is 120 V drawing 4 amps and the 92% reflection @ SWR of 50:1 would be ~ 442 watts.

$442 \text{ W} / 1.146^6 [6 \text{ ft. of cable}] = 303 \text{ mW}$; reflected energy

$.000303 / 50 \text{ ohms} = [I^2, \text{SQR } I^2] \sim .00246 \text{ amps}$

then: $.00246 * 50 = 123 \text{ mV}$. This voltage is increased due to harmonic resonances as is shown in the following pictures. We will use the 123 mV as the reflected *noise* from the 120 pulses upon the 'Noise-system' of the Power cord and transformer.

Now, can this reflected 'energy' affect the audio circuits of the Power amplifier?

If the audio system power supply is 10 volts we can analyze how much 'noise' would become significant to affect the amplifier circuits.

$.123 \text{ volts} / 10 = -38 \text{ dB}$ is the noise level being impressed upon the amplifier system. [123 mV on the 10 Volt system]

The Power amplifier's voltage rails are fairly 'noise' free due to today's power regulators and fancy circuitry, which can filter some high frequency noise.

How and where will this 'noise' be induced into the amplifier's circuitry?

- - -

A typically good power cord has three wires: [usually]

one: Black - Hot side of the Ac power,

one: White - low side of the Ac power and

a green wire - ground [the 'earths' potential level].

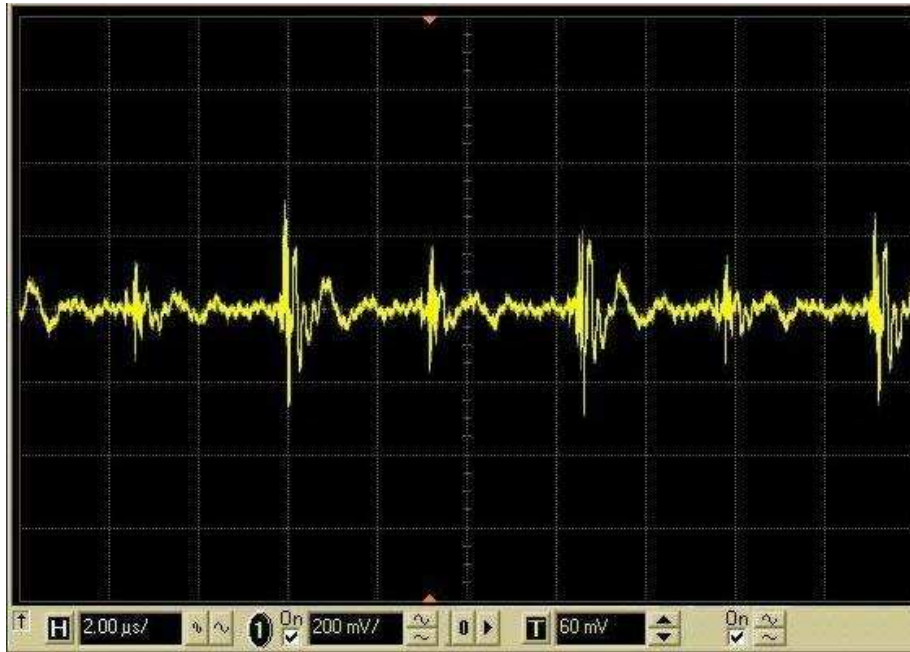
Many power cords can use various colors of insulation, but 'green' or green combinations are the ground-referenced wire. The green or 'ground' wire can actually develop AC noise potentials above 'earth-ground' as it branches out to the appliances in the home.

With the AC power off, of course, we can usually measure about 1-2 ohms between the white or low-side of the AC power and the green or 'ground' wire at the power socket, since these wires are tied together eventually at the power box via the common 'ground' bus. [USA]

The concept of 'ground' is far too many times thought of as a 'fix' for noise, a place where noise can be 'canceled', but the 'ground' plane can be a 'good' source of 'noise'.

This high-frequency 'noise' of the primary and the power cable can be coupled from the High-side of the AC power to the common-wire and the Ground wire and in turn be impressed upon the Ground-plane of the Power-amplifier or other audio equipment's ground planes. The 'natural' surrounding noise level is approximately -60 dB. That is, being isolated from nearby AC fields of lamps, power lines, etc.

This stored trace is 448 mV p-p, which is .0037 [.37 %] of 120 Vac.



Frequency of repetition [the time from one big ringing pulse to the next] is about 6.4 μ S. \Rightarrow 156 kHz. The ringing frequency is \Rightarrow 500 kHz.

By calculations this graph indicates this cable could have 5.6 pF/ Ft. or \sim 34 pF / 6 feet of capacitance with a transformer having 40 mH of inductance.

The 448 mV in reference to the 120 Vac is a -48 dB source of 'noise' on the power line.

Our calculated value: $.123 \text{ volts} / 10 = -38 \text{ dB}$ is the noise from the power cord and transformer, which is also being impressed upon the amplifier system.

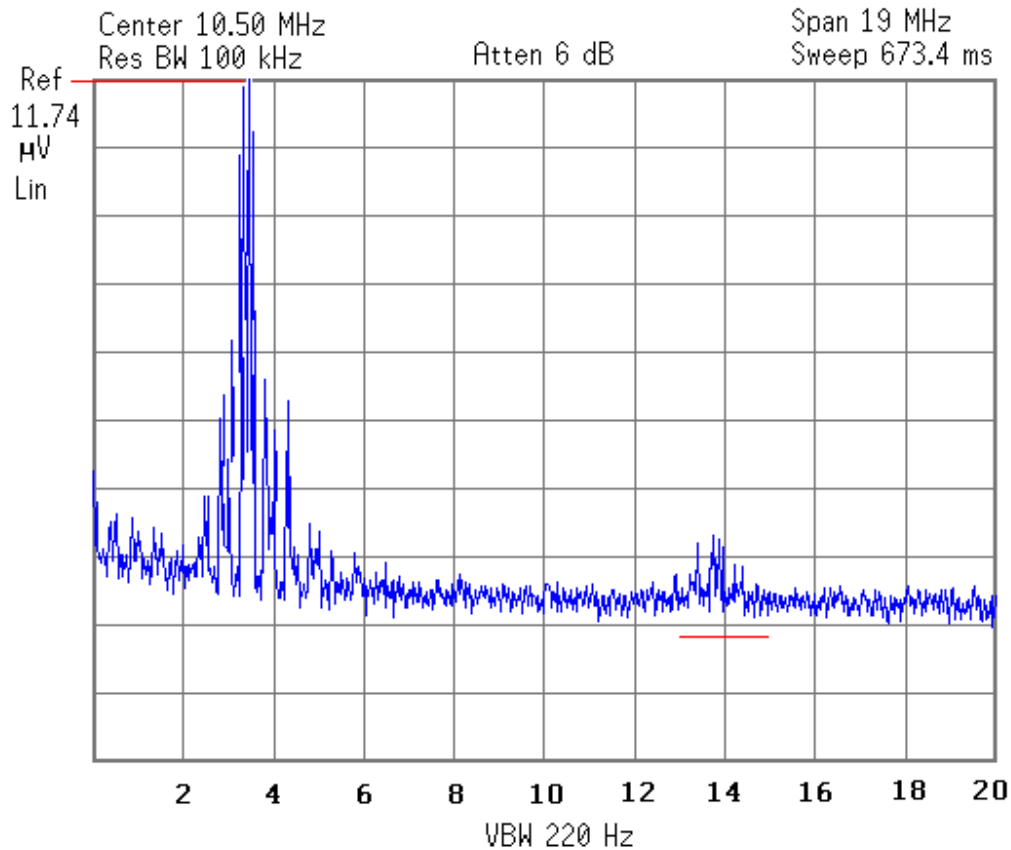
To actually capture the 'noise' on the 120 Vac we had to make up a test probe.

We built a Voltage attenuator, which feed a 70 MHz Differential Amplifier.

The attenuator is 240 / 1; the Diff-Amplifier is 1/1 with a 21/1-output attenuator.

The minimum Input Attenuation of the Agilent E4440-A Spectrum Analyzer is 6 dB or a attenuation of \sim 4. [3Hz – 26 GHz]

Agilent 07:07:16 Jun 25, 2010



240 Attenuation: $240 * 11.74 \text{ uV} \sim 2.82 \text{ mV}$.

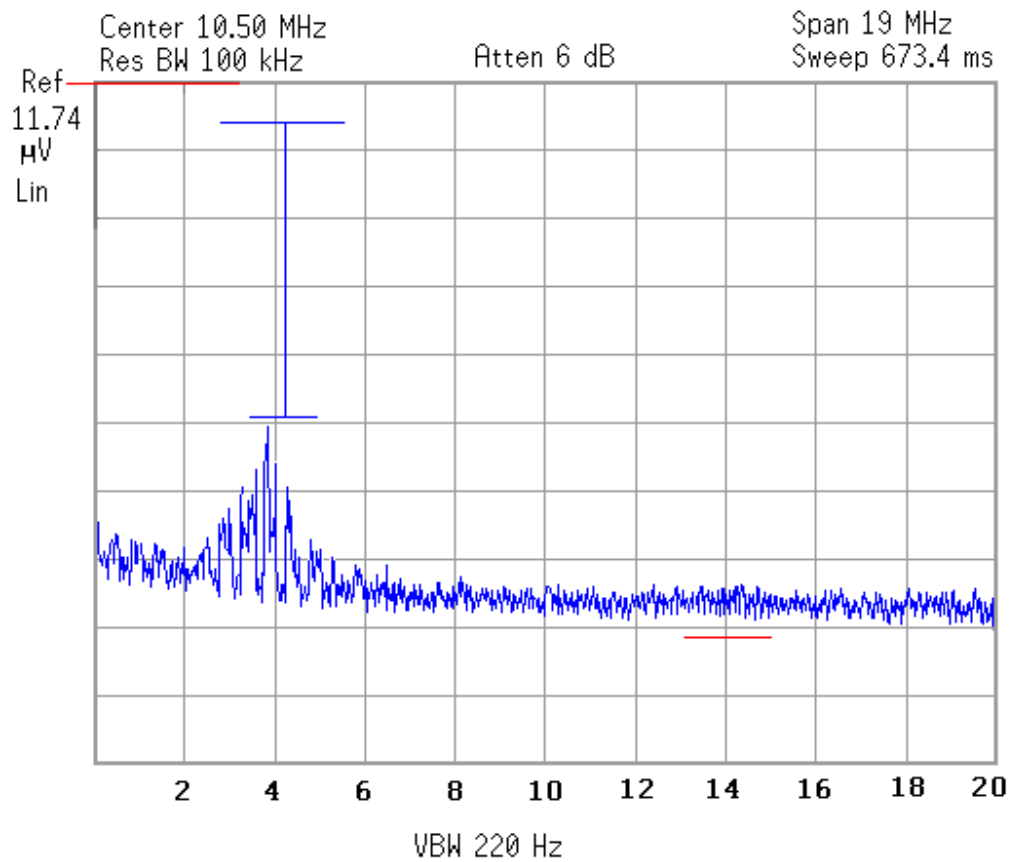
Then Output attenuated by 21 ~ 60 mV.

Then attenuated by 6 dB 4:1 ~ 48 60mV ~237 mV [total].

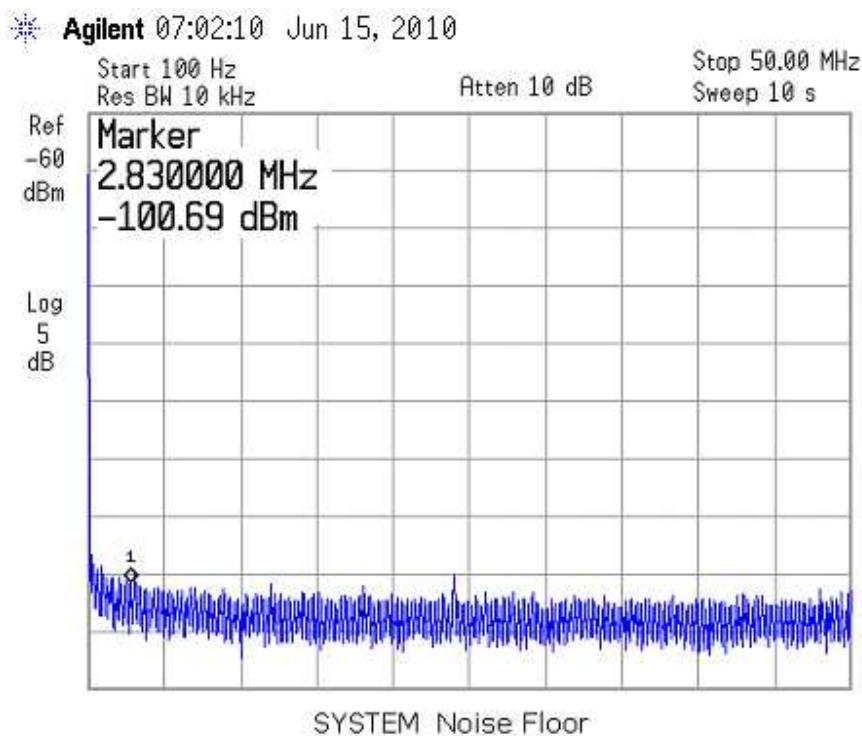
There are many ways to reduce the impressed noise,
but which process of reducing the noise has the best Fidelity ?

As can be intuitively 'seen' adding more wires or 'shields' [grounds] will only add to the noise-generating-process due to more available surface area[s]. Curiously too, a CD-player would be more susceptible to this 'ground- noise' since more of the CD-player's circuits are at low voltages level and referenced to 'ground'.

* Agilent 07:11:10 Jun 25, 2010



Applying our changes to the Power-Cable the NOISE reduces in 2-4 MHz range, and completely eliminates the 13-14.5 MHz NOISE. The blue line shows a drop of about 101 mV. in the 2 to 4 MHz range.
 (~1uv/div) [.000005 mV x 240 x 21 x 4 ~ 101 mV]
 [13-15 MHz as seen in the previous Graph]



System Level 'Noise' [no signal ~ 2uV.]

The ground connection of a power cord is tied to the chassis. This ground system is connected or tied to the various stages of the amplifier's circuits. Many of the amplifiers circuits are referenced to ground, in particular the transistors.

Transistor bias is from a low of 400 mV to about 600 mV. By including the addition of the transistors 'gain' and this *reflected-Noise* being impressed upon the base-emitter input system; this 'small' induced noise is being **amplified**. The transistor has a limited amount of free electrons and any additional 'signal' will 'influence' the Audio signal.

Assuming a low level of 50 mVs of this high-frequency-noise being impressed upon the transistors this would be 8% of noise at 50 mVs per 600 mVs; [600 mVs being the bias level of a transistor], 75 mVs would be ~12 %.

Using the calculated 123 mV noise level would be [.6 Vdc] -13 dB or 20 % of the bias voltage!

We measured the Vac from the neutral to the Ground wire, which ranged From .128 to .168 Vac.

Then add the 237 mV Ac. that is a Power level of: $.237 / .6 = .395$:
 $\text{Log} [.395] = -.403 * 20 \sim -8.1 \text{ dB}$ or 40 % of the bias voltage.

This *noise* is from the *Ground* side of the Power cord as shown in the First graph !

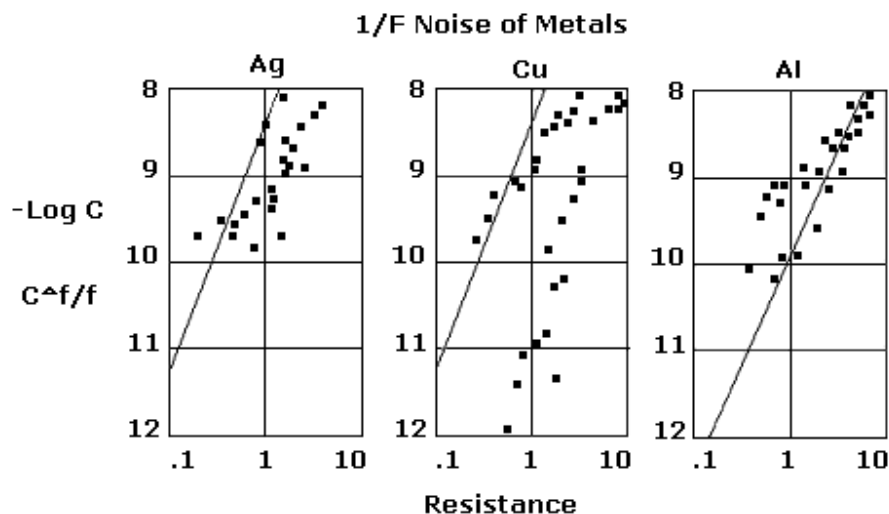
Now let us refer to some information on noise from older references.

Noise

Noise, for our discussion, is internal or random electrical noise - voltage or current deviating from an expected value, occurring in electronic devices or circuits.

W. Schottky [1918] pointed out that thermal 'fluctuations or 'noise' in occurred in passive conductors and is now known as 1/F bulk noise. [p.9c & p.168]

J.B. Johnson [p11 & p.168] reported thermal fluctuations in various metals: Silver, Copper, Aluminum, and various electrolytes.



1/f Noise of various metals

Electrical Noise: Fundamentals & Sources

Madhu S. Gupta / IEEE PRESS 1977 [pages-Cited]

“ It was also observed as the frequency decreases the $1/f$ noise increases. Further studies have shown that the 'noise' is current dependent not voltage or conduction dependant and if amplitude varies as $1/f$, then power varies as $1/F^2$.” [p.171]

“ In reference to audio it is interesting to note that transistors have a worse SNR at audio frequencies than tubes due to the physical structure of a transistor. Different materials and metals touching semi-metal conductor causes noise in a transistor. ” [p.59& p.237]

“ Transistors have five source of noise: shot-noise, thermal noise, partition noise, recombination-noise and flicker noise.” [p.237].

For an in-depth insight refer to:
Malcolm's PUBLICATIONS; http://www.essex.ac.uk/dces/research/audio_lab/malcolms_publications.html

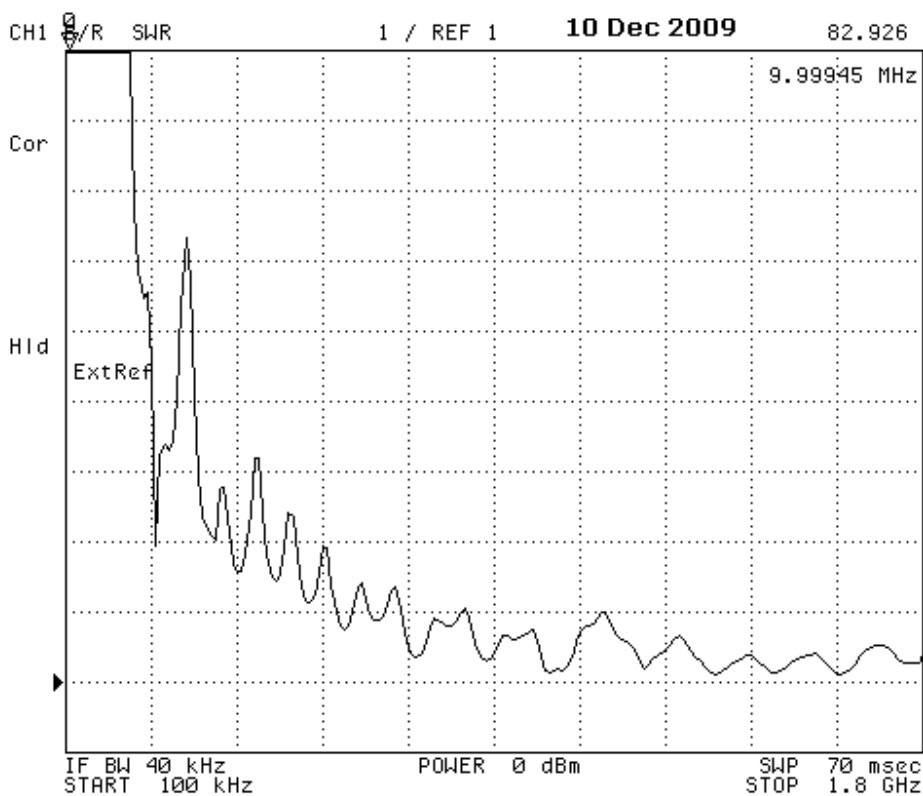
J7 FUZZY DISTORTION IN ANALOG AMPLIFIERS: A LIMIT TO INFORMATION TRANSMISSION?, M.O.J. Hawksford, JAES, vol.31, no.10, pp.745-754, October 1983

[http:// www.essex.ac.uk/dces/research/audio_lab/malcolmspubdocs/J7%20Fuzzy%20distortion.pdf](http://www.essex.ac.uk/dces/research/audio_lab/malcolmspubdocs/J7%20Fuzzy%20distortion.pdf)

- - -

By testing for SWR of the power cord on a Network Analyzer we graphed the difference between two power cables, one power cable was modified to help correlate the Spectrum Analyzer with what the Network Analyzer would indicate using the SWR parameter.

The Network analyzer plotted out the following charts:



The previous chart shows that the generated noise is in the frequency band of 1-20 MHz [10 MHz]. Then the modified power cord was tested and is shown in the following chart, which shows a significant drop in SWR - *random noise*.



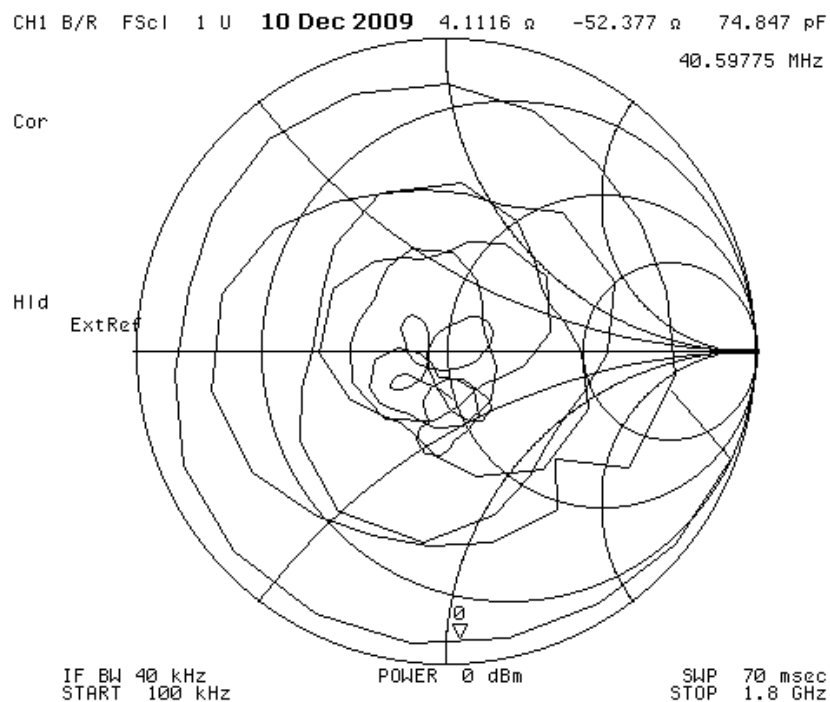
To wrap up this test we present the following Smith-Charts for demonstration.

By 'modifying' power cords the 'noise generating-system', due to reflected noise from the impedance miss-match of the transformer and the power input source, can be significantly reduced.

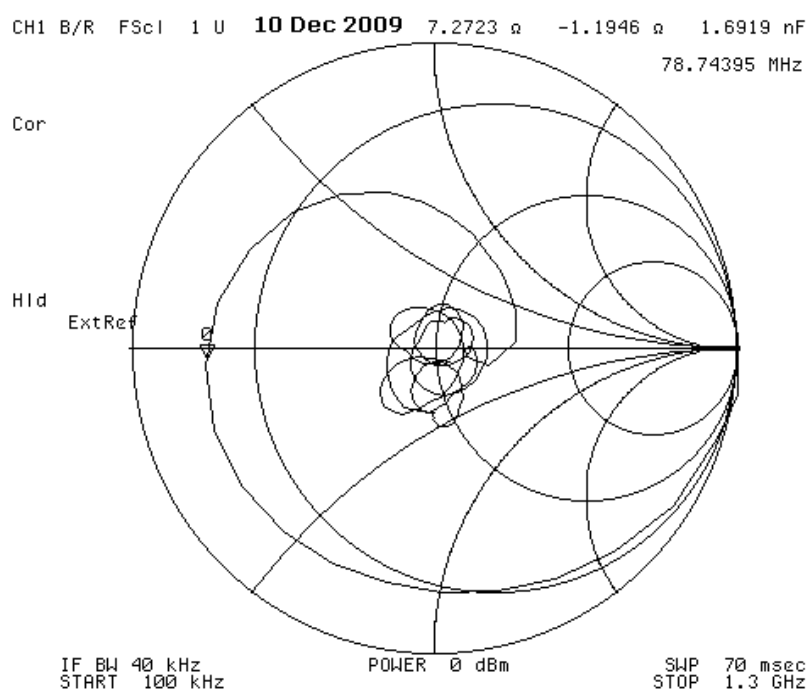
Of the following charts, the first Smith-Chart shows the characteristic jagged edges of 'reflection-points' of change.

The second Smith-Chart shows the *smoother* response of a cable when cable impedances are more closely 'balanced'.

Un-modified three-Conductor Power Cord



Modified three-Conductor Power Cord



We then were able to compare these two measuring systems to isolate the 'noise source' and 'measure' it subjectively.

We did extensive listening tests to the audio differences in these two power cords.

The main difference I noticed was how significant the change was in the Sound stage !

- - -

POWER CORD TESTS

To demonstrate and substantiate this interesting situation of a high-frequency-noise being produced or supported by power cords and the transformer primary windings; a test can be performed by you, the audiophile, at home.

So the following proposed tests can demonstrate how power cords audibly influences the sound of a Power Amplifier or CD-player. The following tests will also demonstrate how various materials used in a Power cord affect the sound of an audio system.

BE CARFULL, get assistance to prepare the power cord.

We do not assume any responsibility for your mistakes.

High Voltage

PREVENT being Shocked.

Never work alone with 120 Vac power.

Find a friend or a partner who knows how to handle and disconnect 120 Vac.

Electricians avoid being shocked by working with one hand
and keep the other hand in a pocket.

Hook-up the meter or circuit before you turn on the power.

IN CASE OF ELECTROCUTION

REMOVE THE POWER !

Turn off or disconnect the AC power.

If unable to reach a switch or plug, use an insulated tool to separate the victim
from the power source.

Check if the victim is conscious.

IF unconscious, check for breathing and pulse.

Administer Standard CPR if indicated.

Once consciousness is restored, check for burns.

Administer Standard First Aid for burns if indicated.

Warning

We do not assume any responsibility for your mistakes.

Ignoring this Warning can hurt you !

You could be hurt.

Do not attempt these experiments or projects unless
you fully understand and accept all risks involved.

Minors should not perform these Experiments in this BOOK
without supervision of a technician, parent or teacher.

BEFORE starting any experiment:

Everyone involved should know and completely understand these warnings...
and all warning labels on all materials and items used.

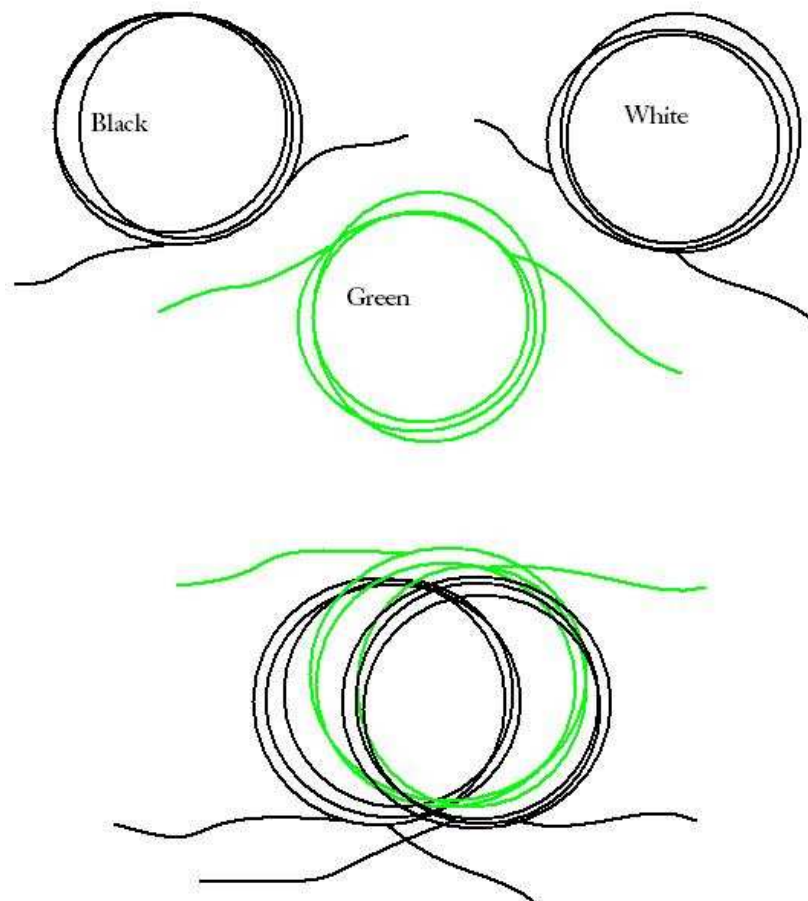
You will need to know how to use a Volt-Ohm meter !

Get help if you do not own a Volt-meter or know how to use one !

We do not assume any responsibility for your mistakes.

To move on, you will be surprised by how many of the effects are plainly discernable. My favorite part of these tests is how the Sound stage changes when you use plastic, or aluminum and or copper in the coil's center.

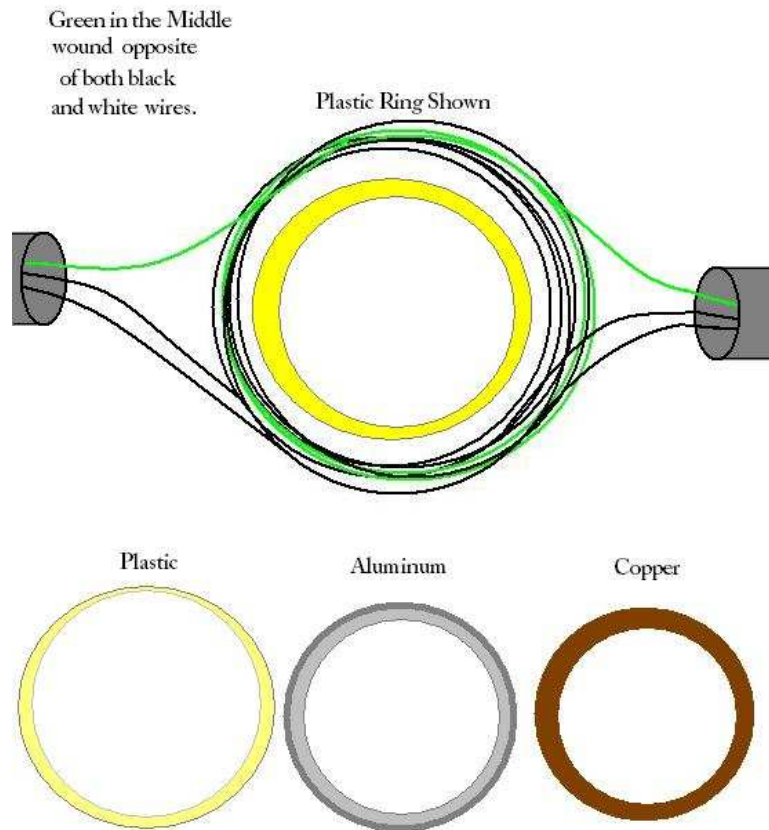
[Do not cut the coils off from the power cord, this diagram is for illustration purposes only]



This diagram shows the Green ground wire opposite-wound and inserted between the other two conductors. Size is about 3 inches in diameter and measured inductance about 5-7uH.

**[Do not cut the coils off from the power cord,
this diagram is for illustration purposes only]**

**We do not assume any responsibility for your mistakes.
DO NOT connect the Power cord to the receptacle.**



Cut a spare 3-wire power Cable to expose 12 to 13-inches of the three inner conductors, while still being attached to the cable proper.

By bending the cable, a butter-knife will help split the cable's outer jacket. The use of butter-knife will avoid damaging the inner cable's insulation.

For ease of use bare the cable in its middle and be careful not to cut or 'nick' the wire's insulation or expose the copper conductors!

Pre-Test the cable before use, check for OPENS between the three wires of the cable !

No shorts !

Form and wrap the three wires into ~ 3 inch circles as shown above. Take the green 'coil' or the 'ground' conductor and invert it in respect to the black and white 'coils', [some cables use different colors].

We do not assume any responsibility for your mistakes.

DO NOT connect the Power cord to the receptacle [power].

It is NOT necessary to determine or test for the HOT WIRE.
Just be sure that the 'ground conductor' is flipped **opposite** of the other two conductors and placed in between the other two conductors.

After placing the green [ground] 'coil' in between the black and white coils [OR OTHER COLORED WIRES, blue, brown or green with a brown strip etc.],

Tie all three coils together with white thread. [Tape or wire ties]
Add or connect power plug connectors if needed.

**Pre-Test the cable before use, check for OPENS between
the three wires of the cable with an Ohm-Meter!
GET HELP IF IN DOUBT.**

Now connect the Power cord to your audio system.



We do not assume any responsibility for your mistakes.
Unplug the POWER CORD before doing any
Modifications to the POWER CORD.

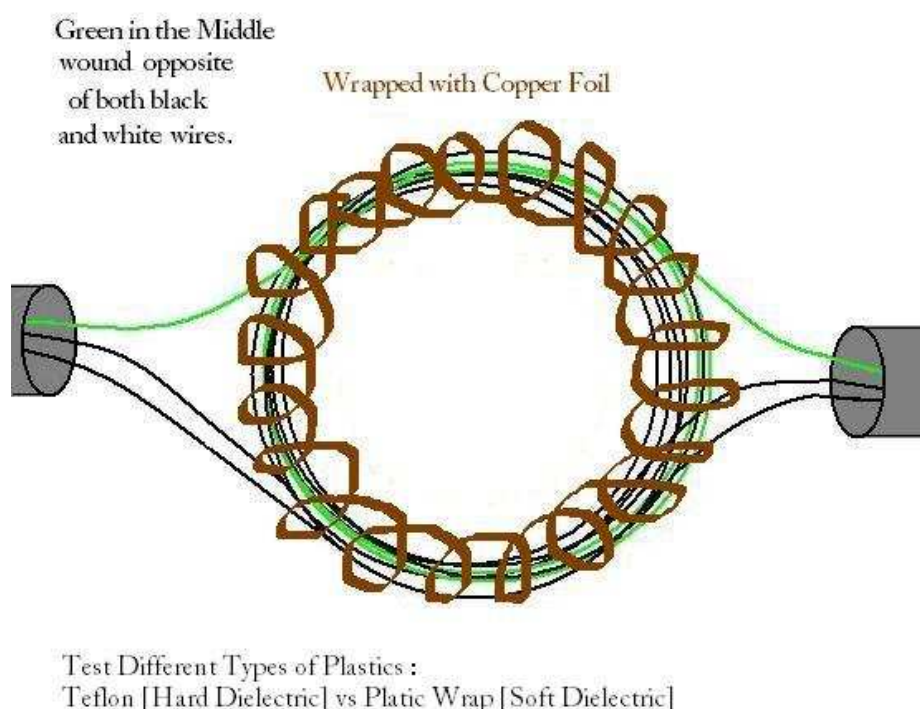


Figure - 3
Copper Foil

Then again;

Pre-Test the cable before each use, check for OPENS between the three wires of the cable with an Ohm-Meter !
GET HELP IF IN DOUBT.

Try wrapping the modified power cord with a hard 'plastic' like Teflon and compare it with various other plastics like a 'soft' material - like plastic wrap. Dielectrics make a difference in the audio sound.

The modified power cord can be connected to any audio component, CD-player, pre-amp, etc.; but the Power Amplifier is usually easier to experiment with. Of the many responses we have seen about Audio grade power cords the majority have reported that using the modified power cord made a more significant difference when connected to **CD-player**.

For a moment let us delve into the digital vs. analog conflict to see why a CD player would be improved by using an Audio grade power cord.

Digital and Analog signals

Vinyl records are an old analog format, having a few audiophiles keeping this 'hobby' alive. The analog tape world has died out; few reel to reel, fewer 8-track or cassette tapes; all have given way to the CD disc and all the newer recording devices.

Analog Tube amplifiers still are drawing a following of audiophiles due to the 'warmth' of the non-solid-state devices in contrast to the **gas**-device.

Digital electronics has taken over most of the electronic world and has brought many improvements to the analog world. Except for the obvious loss of vinyl record skipping and scratching noise, seems Fidelity has been colored a different timbre.

Has the change to CDs (digital) helped provide better Fidelity in our recordings?

Let us take a look at the basic process of digitizing an analog signal.

To process a musical signal, for example, which is an analog signal, a complex electronic circuit called an Analog to Digital Converter -ADC- processes the musical signal by changing it into a pattern of VOLTAGE-STEPS or -bits- that are representative of the original ANALOG signal[s].

These patterns of digitized-voltage or bit-patterns are recorded as required. Our main discussion, for brevity, will focus on the DAC: the Digital to Analog Converter. This electronic circuit is another complex device that reconverts these stored *bits* back into an *Analog* signal.

The generated noise as was presented above will be induced upon the DACs ground planes. A DAC has several ground planes an: Analog ground [AGND], a Digital ground plane [DGND] and the lower-side of the circuits designated Vss.

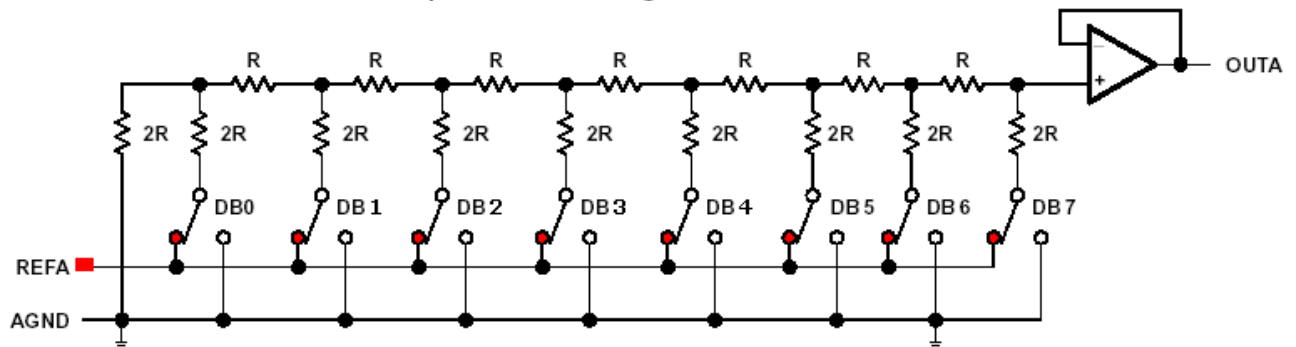
The designation **REFA** depicts the reference voltage input that is used in reconvert the bits back into an Analog signal. The recorded bits are 'read' unto the **DB0 to DB7** [8 lines of input - 8 bits] digital bits that are converted to a single voltage-level.

For this discussion this DAC has a Voltage REFA of 10 volts DC.

8 lines of input means we will divide 10 volts into 2^8 or 256 pieces or *bits*. The smallest piece or least significant *bit* [LSB] will have a voltage level of $\sim .039$ volts or 39 mV. The 2nd *bit* will be 2×39 mV or ~ 78 mV, the 3rd *bit* will have a voltage level of ~ 117 mV and so on according to the digitized input.

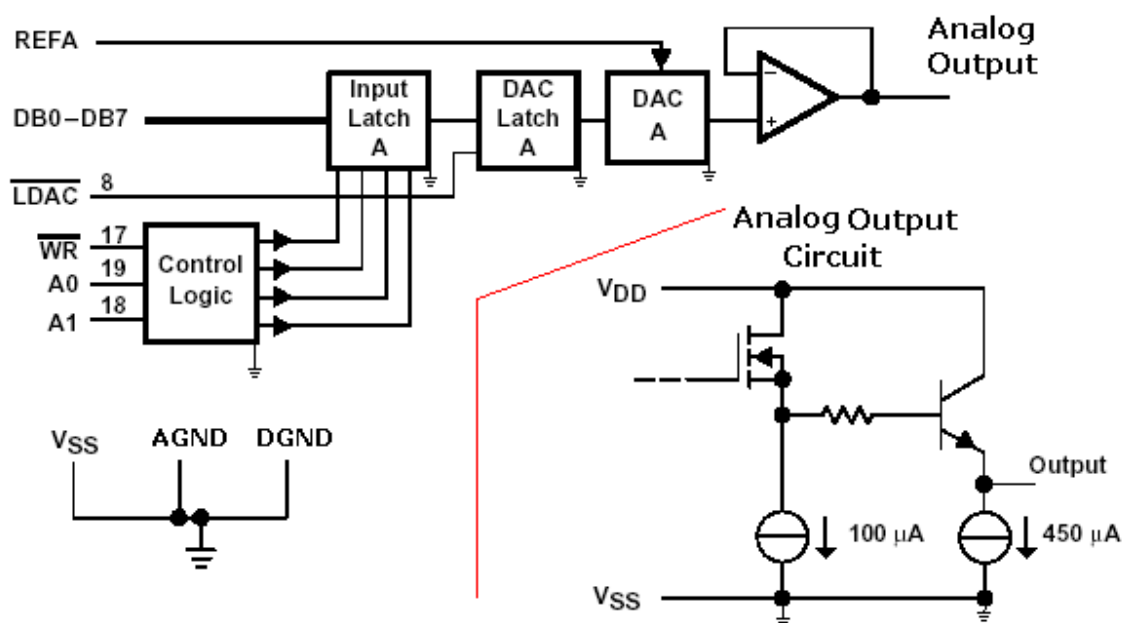
These voltages are presented to the OUTA, which represents the Analog output.

DAC Simplified-Circuit Diagram



Input Impedance is from ~ 1.5 k Ohms to an Open.

Partial Functional Block Diagram



Now let us compare the 1, 2, 3, 4, 5 & 6th Bits with the generated noise of 123 mV to 237 mV due to 'SWR' noise. We notice that the noise has the same or greater voltage magnitude as these lower 6 bits.

Bit 1 ~ 39 mV, Bit 2 ~ 78 mV, Bit 3 ~ 156 mV,

Bit 4 ~ 156 mV, Bit 5 ~ 195 mV and the 6th Bit ~ 234 mV.

By looking at the two previous diagrams we notice the **GROUND** symbols are

connected to almost every electronic circuits of the DAC. The generated-power cord-SWR-noise will be impressed upon these many stages of the DAC.

Also, when the signal to noise ratio changes as the input BITS vary from 1 thru 6 to 1 thru 256 Bits as per the input digital signal. This system noise will dominate the weaker/ lower input signal: digital bits.

One of the surprising noticeable audio differences reported by many audiophiles is the change in the depth with and height of the sound stage!

So it is very easy for GROUND noise to highly influence the resultant output signal that is supposed to be an accurate REPRODUCTION of the original Music.

- - -

Like other hot-debates going on, you will now have some experience as to what does and does not make a difference:

- Power-Cords do make an Audible difference! -

Another topic of some concern is solder and soldering.

Solder

Since lead is toxic, the electronic world has moved to using lead-free solders. Exotic solders of unique mixtures are used in trying to replace the lead bearing solders.

Solders of various metal mixtures like: Tin-Silver-Copper, Bismuth, Indium-Silver-Copper, in Europe: 3.4-3.9% Silver, in Japan: solders made of Tin-Zinc-Silver-Copper, are being tested.

The toxic problems of lead-solders may be avoided, but there are some drawbacks. Drawbacks include; higher soldering temperatures are required an increase of 63 *F; solder bridging is increased, tin has a higher propensity to branch-out into solder 'whiskers', Tin-Silver-Copper alloys have poorer wetting properties requiring a stronger flux and metallic migration problems. [Idium Inc.]

Migration is where, like Indium, will travel up a copper lead, causing solder fractures. In order to stop this migration Nickel is plated on the copper traces to act as a barrier or inhibitor.

Our concern in the audio-world is: which solder sounds the best ?

We are unable to show any measurable differences or discuss the audibility of different solders, but we can report that the 'best' connection is not made using solder. One company we worked for only used bare copper wire twisted together and held in place with a wire nut in their 'crossover' circuits !

We used an HP LCR bridge to measure various solders. Our comparison standard was two copper wires [12 Awg] of 1-1/2 in length twisted together. All solders failed to be better than the bare twisted copper wires.

We were also asked to test which contact cleaners helped reduce contact resistance.

None.

[copper oxides or any contaminates have to be mechanically removed]

Any 'contamination', of the bare copper wire's surfaces, was always worse than a clean copper wire. By heating the copper wire to drive off any contaminant also failed to be as good as the twisted copper pair.

- - -

Now to the other end of the audio chain, the Speaker.

CHAPTER 3

Speakers

Speakers have many mechanical problems and electrical limitations of which we will now explore.



After testing a 'broken' speaker one day I went to Richard's office and asked him; "How many frequencies can you hear? "

I would always ask Richard some 'off-the-wall' questions like this, and it was always entertaining and interesting to see his face as he composed his response to my un-ordinary questions.

What ?!; how many frequencies can I hear ?
Uh, all of them I guess [20Hz -20 kHz], was Richard's answer.

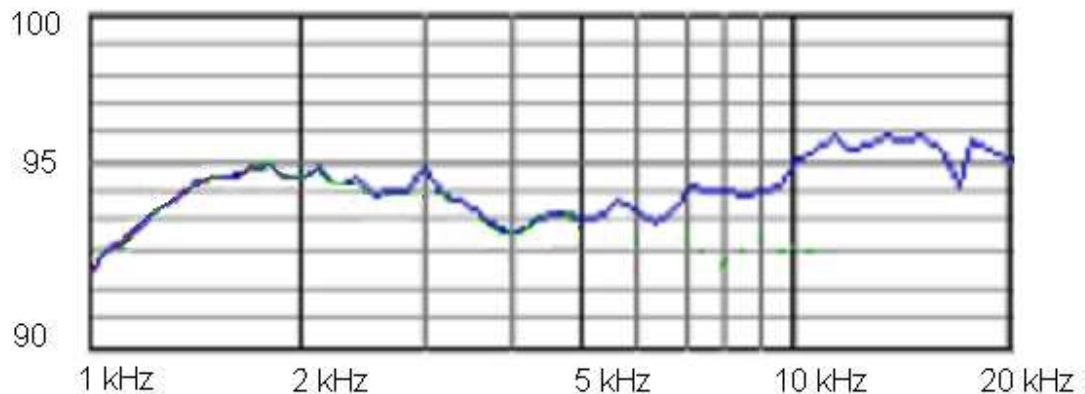
- - -

As for me, about 28 to 15,000 Hz, thanks to a little mortar explosion and the resultant tinnitus.

Speaker's Response

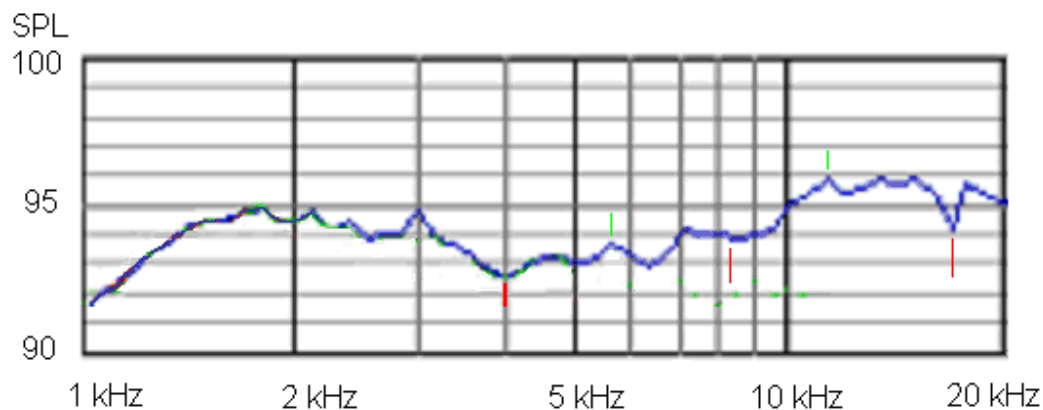
Ever notice the frequency graphs of various speakers; they all seem to have a similar frequency response!

A graph of a well-known Tweeter



The major 'dip' in the upper kHz region has a frequency of 16-18 kHz.

We notice dips at 4 kHz and 8 kHz, which are harmonically related.



Speakers of the same diameter seem to have very similar areas of dips and peaks in their frequency plots.

So, how many frequencies can you hear...?

As for you the audiophile, some of you may hear 'all' of the frequencies from about 20 Hz up to about 20 kHz, maybe ?

If so, why do we put-up with a speaker[s] that cannot reproduce all of the frequencies we can hear ?

Another interesting question is there any frequencies above 20 kHz that we should be hearing; if not heard, felt or sensed by our hearing system ?

An audio test was performed using metal keys of various metals and nails of same weight and length. Several listeners were played back a sound of 'keys' and 'nails' that were band limited to 20 kHz.

With the band limiting on the listeners could not tell if he was listening to keys or nails ! [Audio Engineering: UCLA Berkeley]

For another example of upper sounds, the work of James Boyk on a trumpet clearly reveals that there is sound energy above 20 kHz.

James Boyk

Pianist in Residence, 1974-2004

Lecturer in Music, in the Dept. of Electrical Engineering, 1979-2005

Director of the Music Lab, 1979-2004 California Institute of Technology

<http://www.its.caltech.edu/~boyk/>

We see in the instruments *graph* [refer to the link above] that a trumpet produces 'Audio' or sound-waves far above the 20 kHz 'limit'.

These upper frequencies may not be heard consciously, but the auditory system of the ear uses this 'information' in the processing of sounds related to timbre.

- - -

Now back to the speaker charts.

By recording the frequencies of the dips and peaks in previous graph [above] of the 1 - inch domed tweeter; we can determine what dips and peaks are 'mechanically' related; through harmonic action.

Tweeter Peaks kHz	Ratios	1.80 kHz	3.00 kHz	5.80 kHz	7.10 kHz	11.00 kHz
1.80			0.60	0.31	0.25	0.16
3.00	1.67			0.52	0.42	0.27
5.80	3.22		1.93		0.82	0.53
7.10	3.94		2.37	1.22		0.65
11.00	6.11		3.67	1.90	1.55	

	0.25	0.75	1.5		
Peaks kHz	1.80	3.00	5.80	7.10	11.00
1.80		0.75	0.25	0.25	
3.00	1.5		0.5		0.25
5.80		2.0		0.75	
7.10	4.0				0.75
11.00	6.0		2.0	1.5	

Dips kHz	2 kHz	2.5 kHz	4 kHz	5.2 kHz	6.4 kHz	8.6 kHz	12 kHz	16 kHz
2.00		0.80	0.50	0.39	0.31	0.23	0.17	0.13
2.50	1.25		0.63	0.48	0.39	0.29	0.21	0.15
4.00	2.00	1.60		0.77	0.63	0.47	0.33	0.25
5.20	2.60	2.08	1.30		0.81	0.61	0.43	0.32
6.40	3.20	2.56	1.60	1.23		0.75	0.53	0.40
8.60	4.30	3.44	2.15	1.65	1.34		0.72	0.54
12.00	6.00	4.80	3.00	2.31	1.88	1.40		0.75
16.00	8.00	6.40	4.00	3.10	2.50	1.86	1.33	

The top portion of this chart shows the major mechanical-harmonic relations of the structure of this expensive tweeter and by using this charting process; we can notice the relationships of the frequencies of the 'dips' and 'peaks'.

We used Popsicle sticks to stiffen an 8-inch woofer's cone and by doing so peaks were reduced and dips were augmented. The overall frequency response was improved.

So by 'correcting' the major 'dip' or a major 'peak' several other associated dips and peaks will be 'corrected' also.

The major 'dip' in the upper 15-18 kHz region has a frequency in the range of 16-18 kHz.

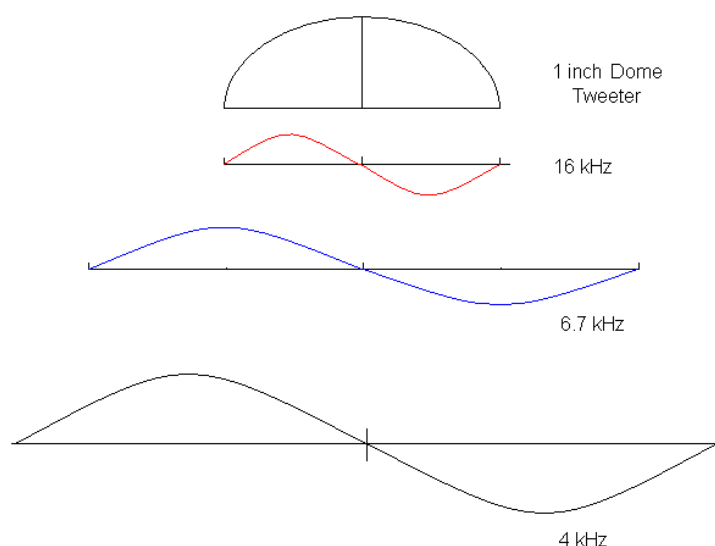
16 kHz = .846 inches, 17 kHz = .796 inches and 18 kHz = .752 inches.

The small red -sine-wave- just below the dome diagram shows how this range of frequencies will lock up the mechanical movement of this tweeter.

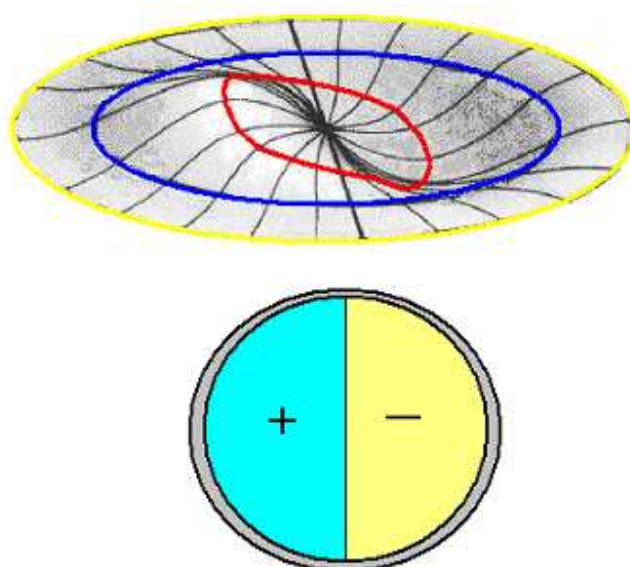
That is, one-half of the tweeter's dome will travel in the opposite direction of the other half, causing a 'twisting-action' - stalling the dome's movement. This loss in movement at 16 kHz relates to about a 6 dB loss in the signal.

The mid-range speaker and woofer also have many related 'dips' and 'peaks' associated with their mechanical structures. These mechanical aberrations cannot be corrected by crossovers or any other added circuitry.

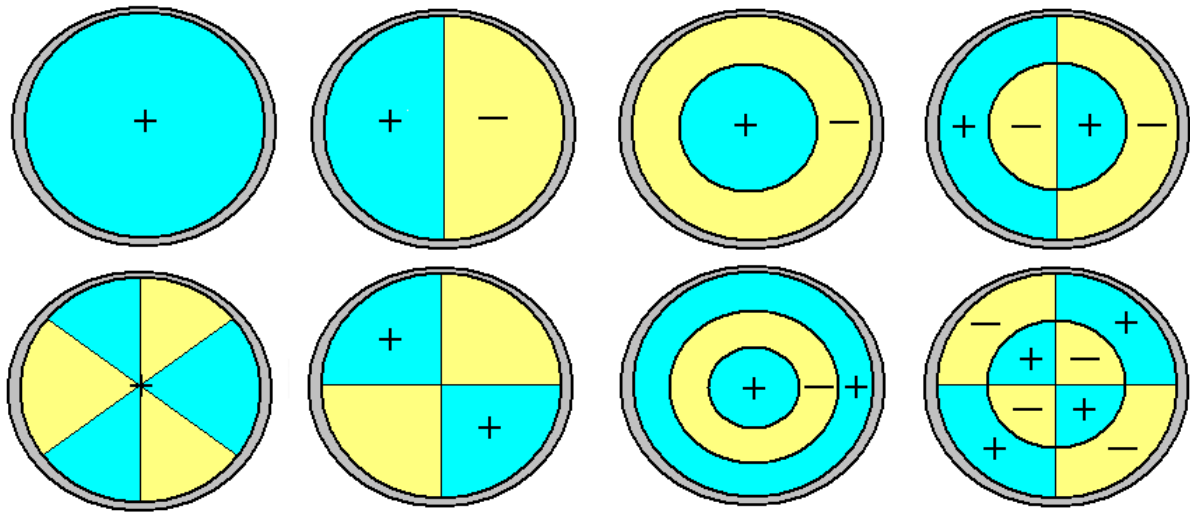
So we must address these mechanical distortions by analyzing what we can change, like shape and voice coil designs.



The following pictures diagram the mechanical warping of the tweeter's dome.



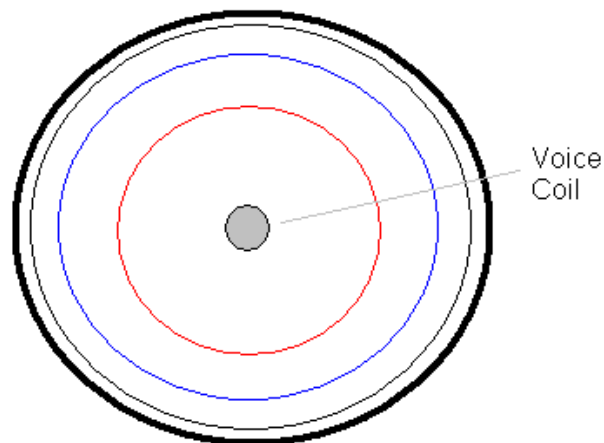
The patterns shown below indicate how speakers can distort.



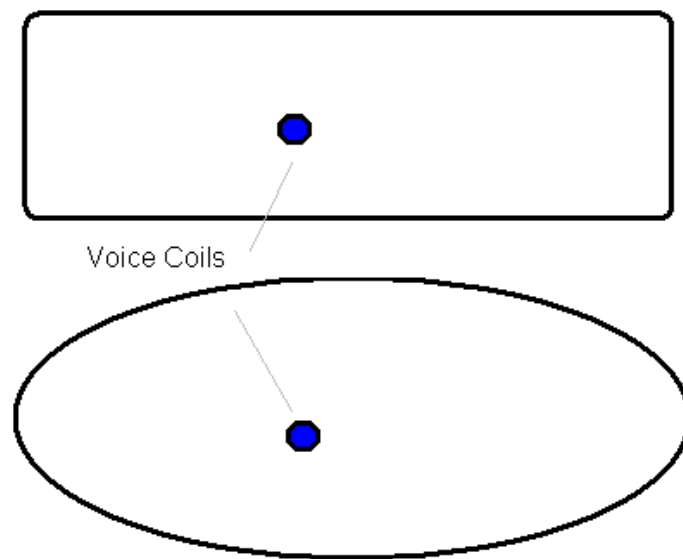
SHAPES

Round speakers as pointed out in the tweeter discussion, have many such modes. Several of these modes are dips and peaks, which varies the amplitudes of the acoustical signal.

Voice coils are in the center of a large circle and the various motions of the speaker are all concentric with the voice coil.



The inner circles denote 'peaks' or 'dips' in the speaker's cone at various frequencies. At these frequencies the speaker produces lower acoustical power.



To avoid concentric movements that develop unwanted modes, speakers that have **off-set** voice coils should be developed. Preliminary tests show this speaker to be amazingly flat in frequency response while also achieving greater audio detail.

Voice -Coils

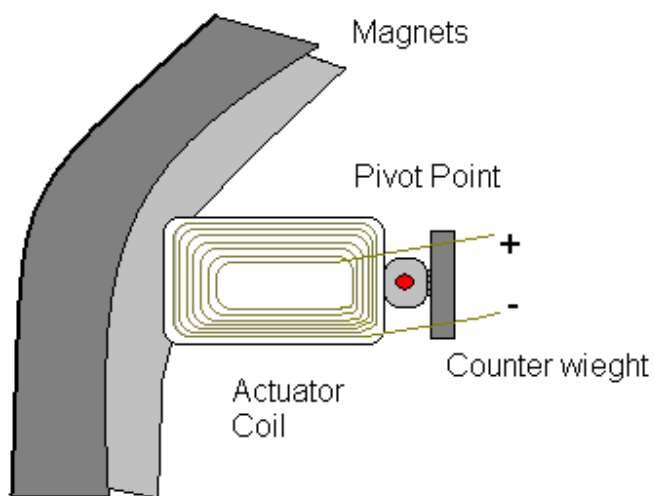
The next major problem with speakers is the traditional voice-coil. The limitations of voice coils are well known and very heavily documented.

Many manufacture have devised several ideas to over come the voice coil's limitations. Some new ideas and changes include; longer magnetic fields of the pole piece, aluminum wire instead of copper, different former styles, etc.

Transient response is a favorite parameter for designers to record in order to measure the response time of a speaker. Some success has been achieved, but still limited by the voice-coil's mechanical configuration.

To increase the response time of a speaker requires the replacement of the voice coil with a new mechanism. The proposed actuator is a common device found

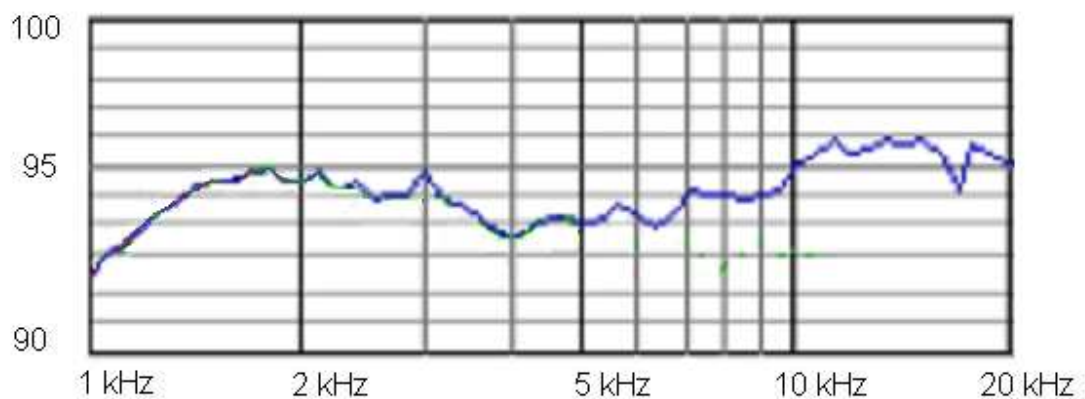
in today's Disk-Drives. Our first proto-type used a small actuator from an old disk-drive. The Device was connected to the out-side edge of the counter weight. It was crude, but had very fast response time, and was driven by our new differential Tri-Amplifier circuit.



Before moving onto box design, a comment on frequency graphs seems appropriate here.

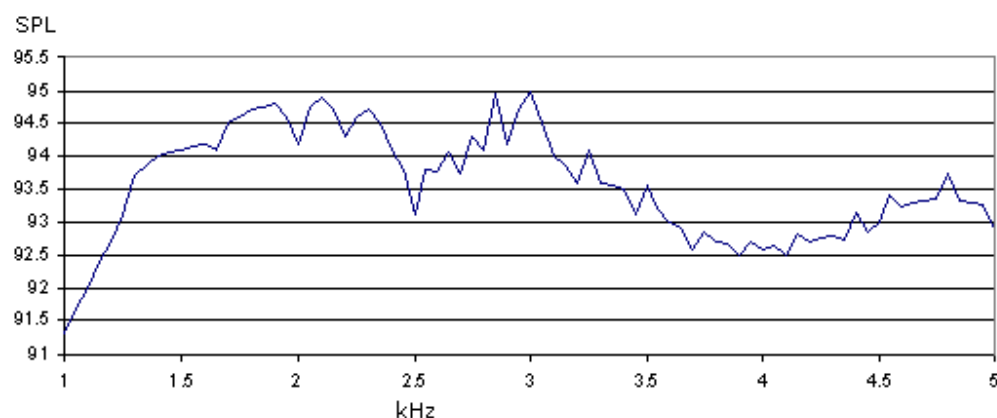
LOG / Linear Graphs

The use of LOG scaled graphing should be replaced with Linear graphs so we can more accurately 'see' the many Dips and Peaks in the speaker's frequency response.



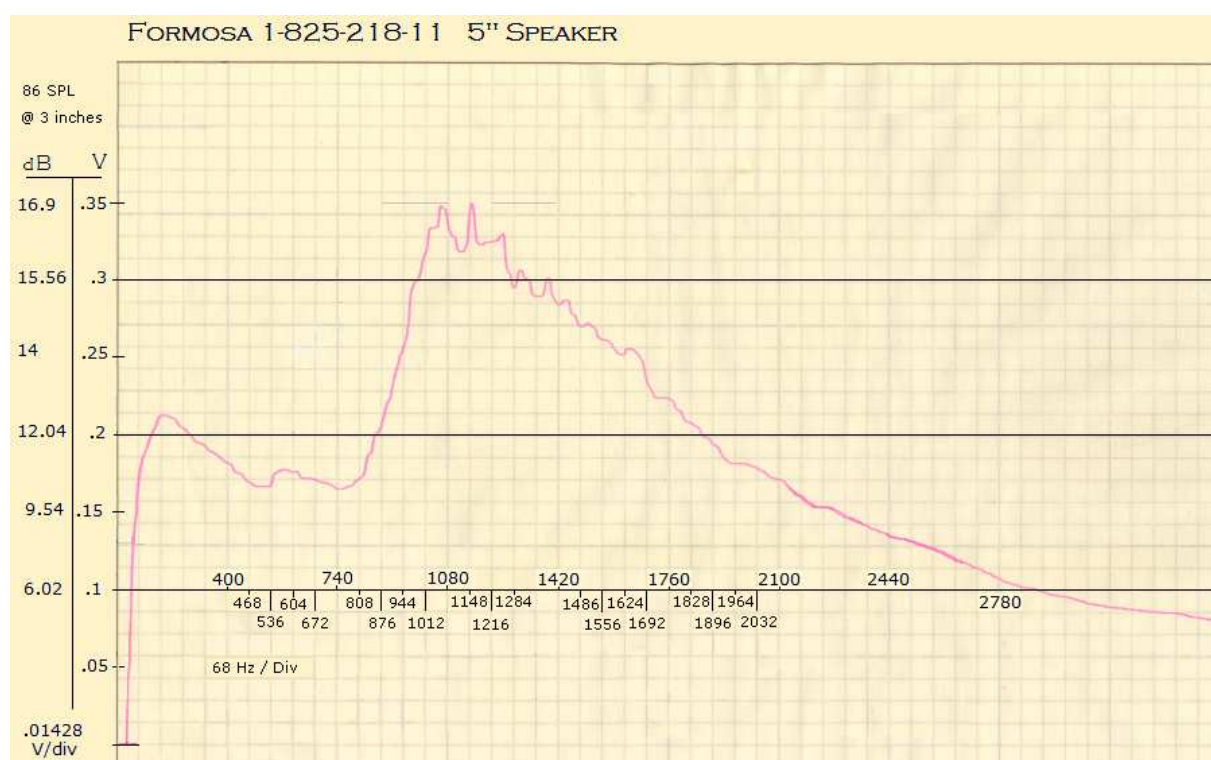
By changing to BRIICE and Linear graphs you will see the real response of speakers, speaker boxes and 'crossover' circuits. This graph is from a MLSSA acoustical measurement system. [Talon Audio]

This data is 'filtered' due to the plotting process and is in a Log-compressed scale, which then is not '**raw**' data, for it is formatted data.

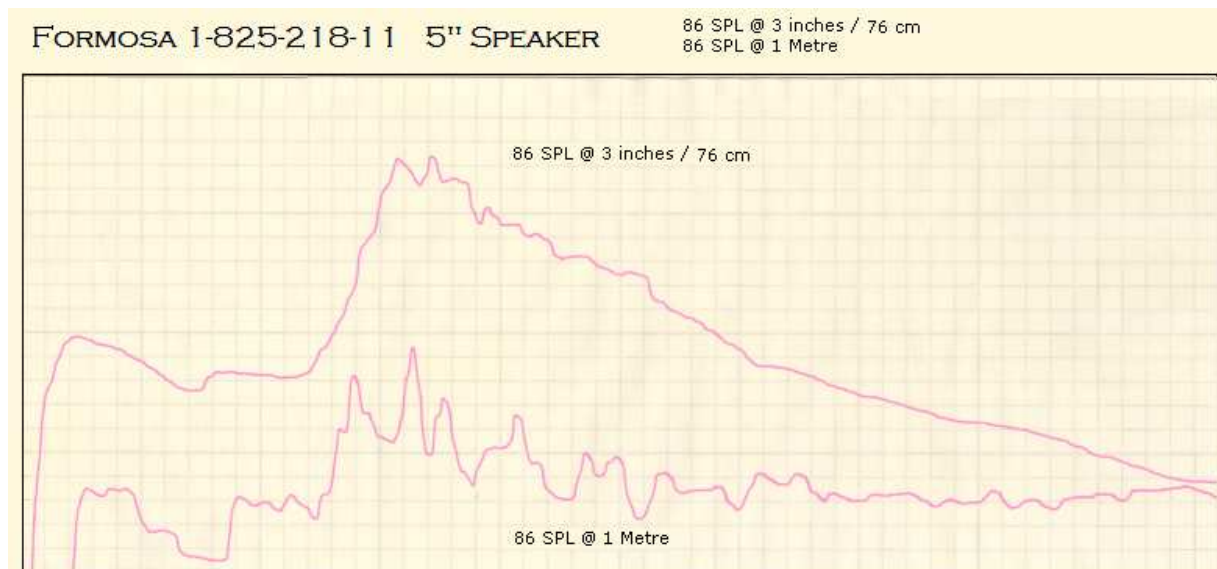


This Graph is of the same Tweeter from the previous page, but displaying only the frequency range of 1 kHz to 5 kHz. **Raw** data shows how a speaker really responds. [Microphone at 1 meter / linear sweep / X-Y plotter]

Or does it ?



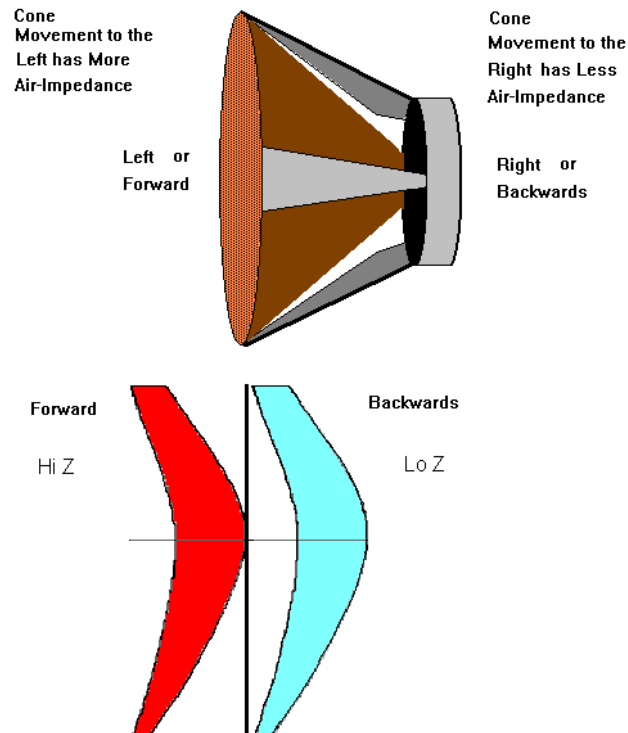
Using the 1 metre distance allows for numerous Standing Waves to be set up. Some of the acoustic waves will have minimum energy at the microphone causing 'dips' in the graph. The following graph shows the response of a 5-inch Speaker.



Placing the microphone at 3 inches, 76 cm – speaker's center, the speaker's actual frequency response is captured. [Top trace]
The lower trace shows the many 'dips' picked up by the microphone at 1 metre.



The tweeter at 3 inches shows a major power level shift a 7 kHz, which would be minimized or 'lost' in a typical speaker graph.



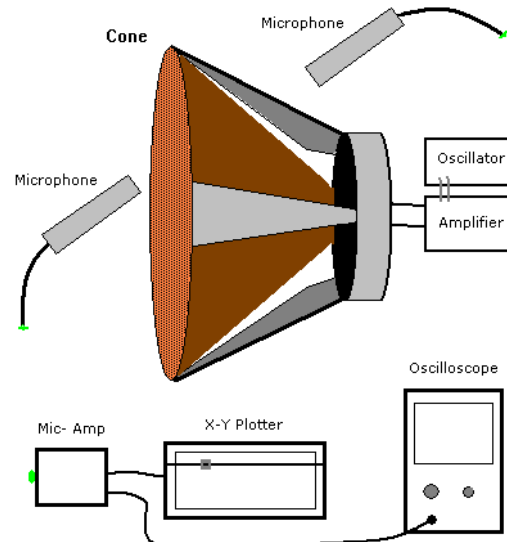
This simple Fall tests demonstrate, blue cone and black cone - inverted -, the difference in air movement.

[See CD or Web-site for folders:
Fall-1 & Fall-2 (frames)]

Fall Test 1 & 2

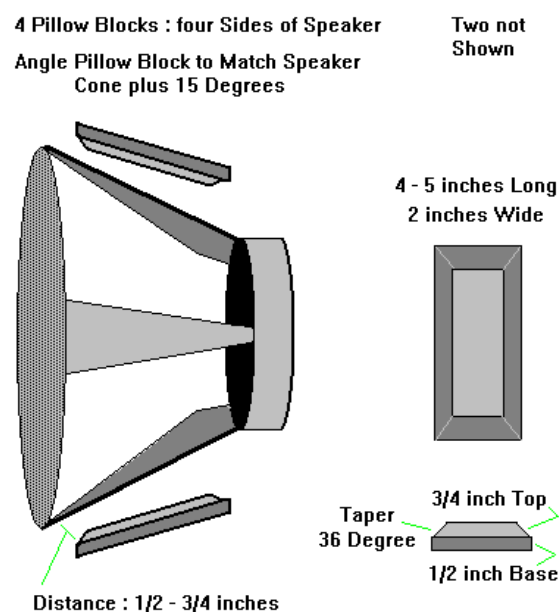
Speaker Box Design

The movement of speakers either compresses the air-mass or rarefies the air-mass. The difference in impedance of the forward movement verses the back-ward movement induces 2nd and 3rd harmonic distortions.



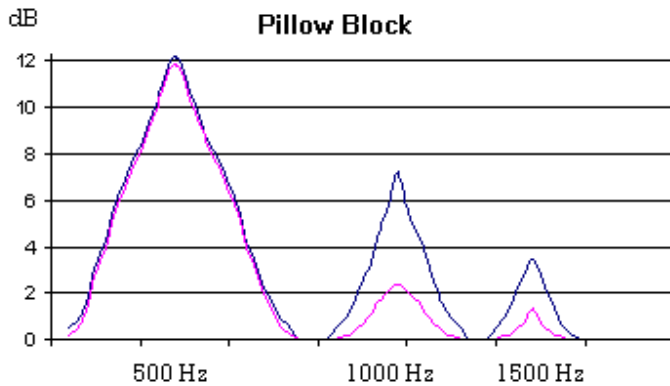
By using a SPL meter with an equivalent DC voltage output-connection, connected to an oscilloscope, you can see the distortion [about 3-7 %] on a 500 Hz sine wave signal.

Place the microphone 3-4 inches away and at a perpendicular position to the moving cone.

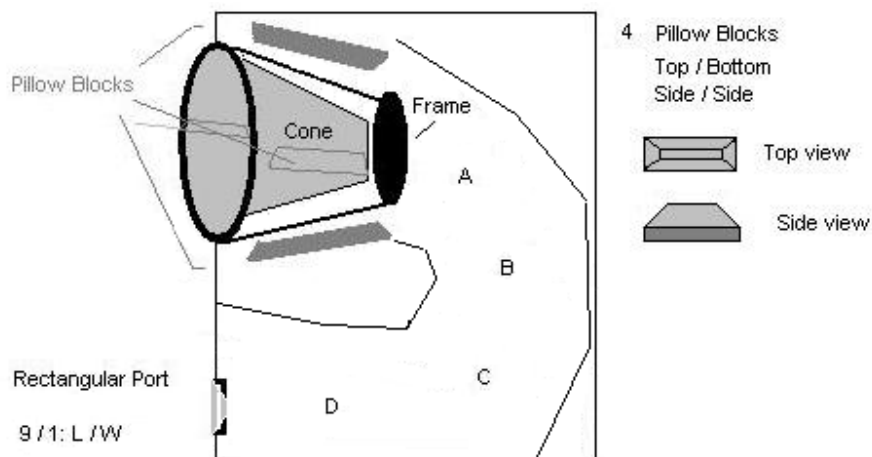
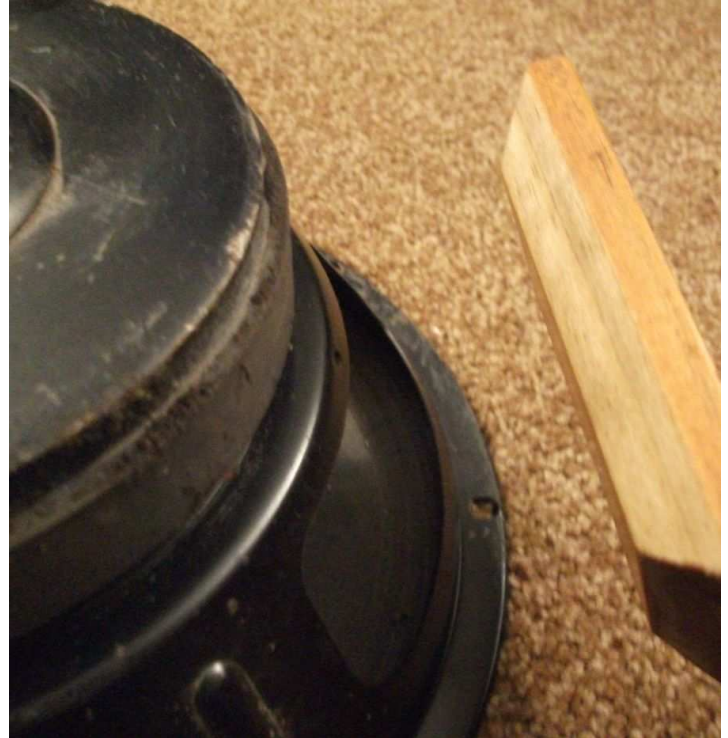


Pillow Blocks

We developed a tuning idea by using the above depicted Pillow-Blocks; by using four blocks of shaped wood you can reduce the 2nd and 3rd Harmonic losses.

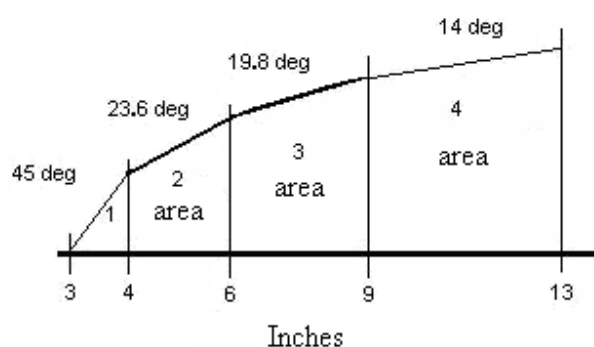


In our Pillow-block testing it was found that the sound-wave should 'see' a lower 'impedance' as the sound wave travels. This is accomplished by designing the Air-channel of the box's internal area to be continuously, gradually increasing; as pictured by A, B, C and D.



By using various angles on a speaker's baffle we incorporated the different angles in our speaker boxes and made a graph of **increasing-areas** that support the expanding sound-wave.

The first stage having an angle of 45 degrees, this wider 'area' eliminates the Bull-Horn effect, by allowing a greater **initial-area** [least initial impedance] for the sound's Wave-front to correctly develop.



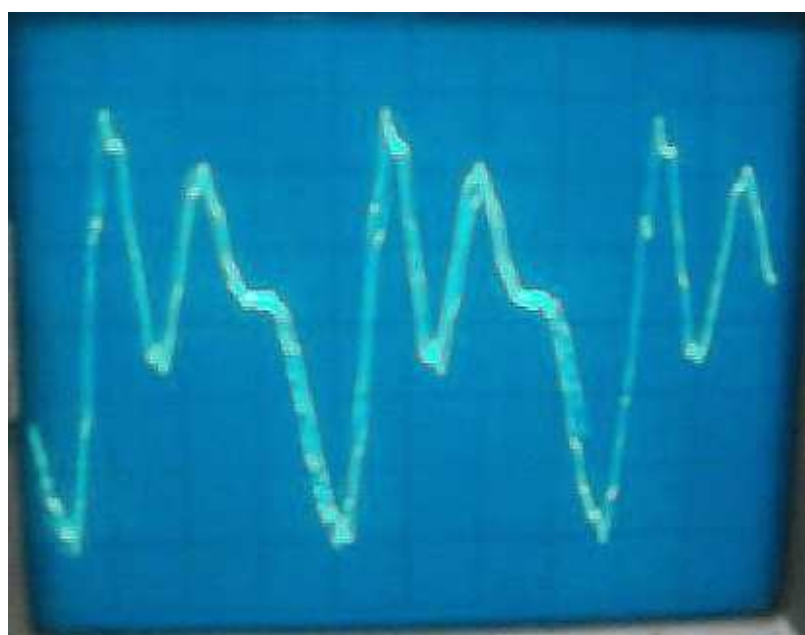
First 3-4 inches of a confined 'area' has surfaces of 45 degrees. Second area has surfaces of minimum of 23 degrees, third 19 degrees and the fourth area 14 degrees [at 13 inches from sound source].

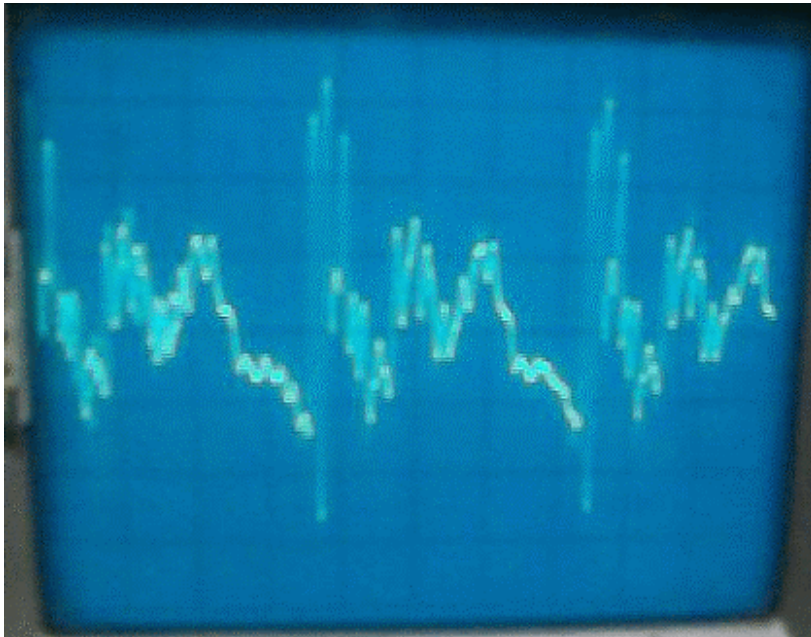
Port Shapes

Round Ports and rectangular ports produce far too many harmonic resonances, so by using larger open areas of the speaker box [see above diagram], harmonic distortions would be highly diminished. We captured some pictures of speech to test for the differences in port shapes by speaking through a round tube and a rectangular tube. The round tube and rectangle pictures were then compared to 'free air' pictures. The round tube was 1-3/4 inches in diameter by 4 inches long and the rectangular box was 1-1/2 inches high, 3 inches wide and 4 inches long. Both the round tube and the rectangular tube were made from white poster-board: 1 layer thick.

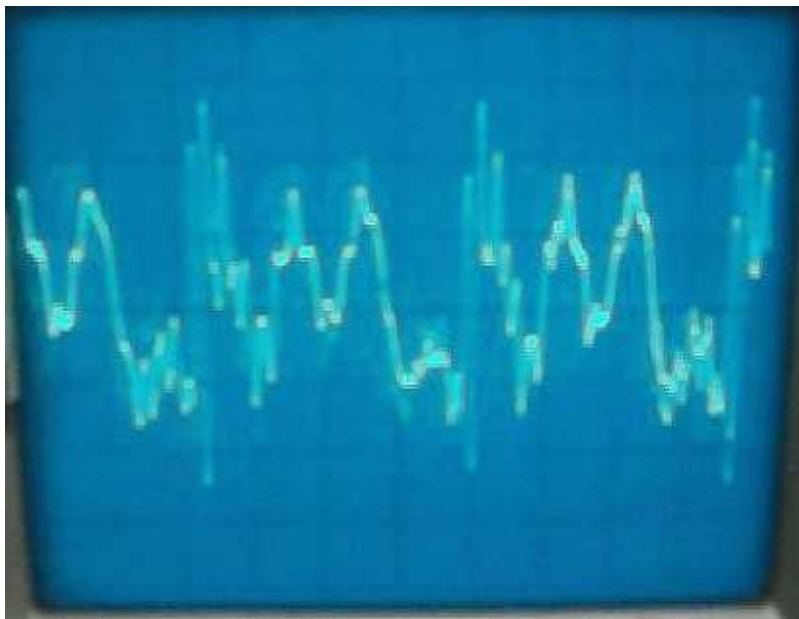
By saying the letters 'A' and 'B' into a amplified microphone which was connected to an oscilloscope, we took a video movie of the waveform. Then the movie was separated into individual frames in order to pick the best of the letter 'A'.

'A'
Into free air

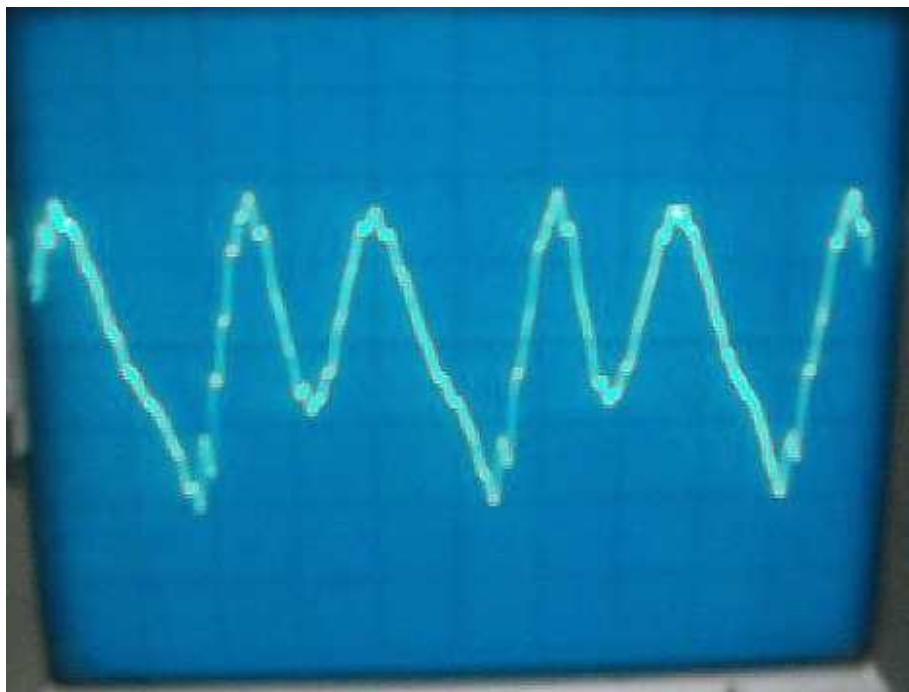




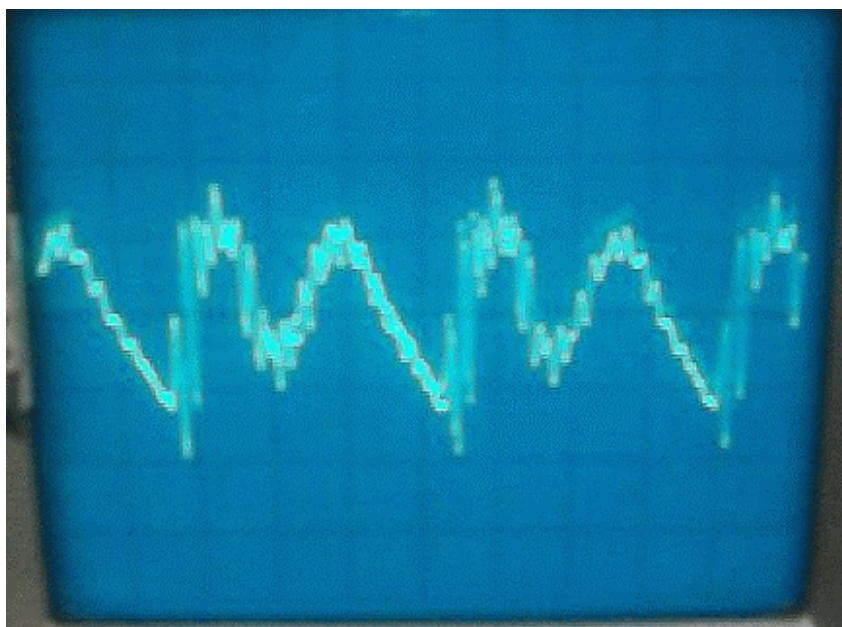
‘A’ into a Tube



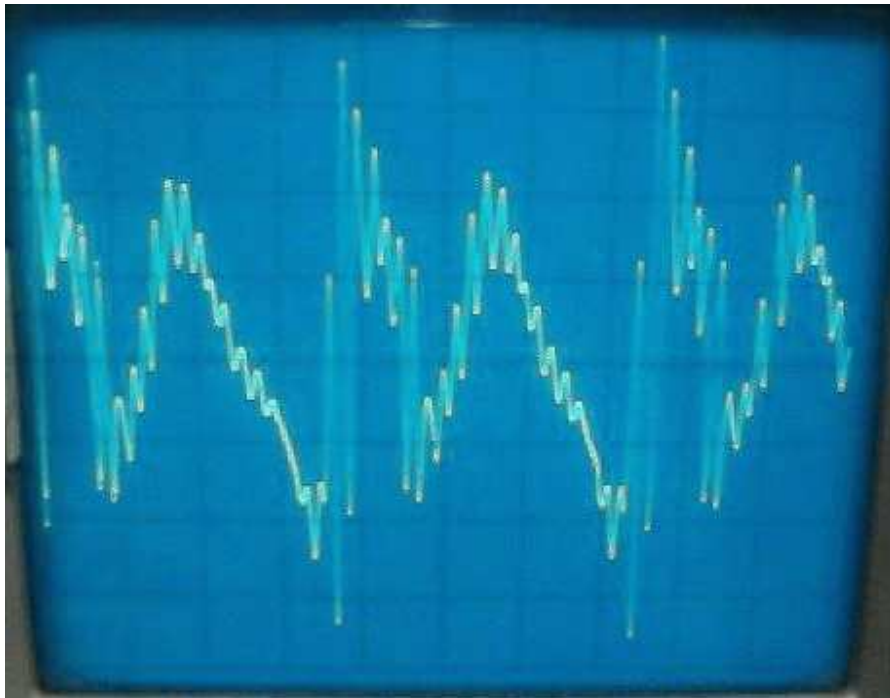
‘A’ into Rectangular Box



‘B’ into free air

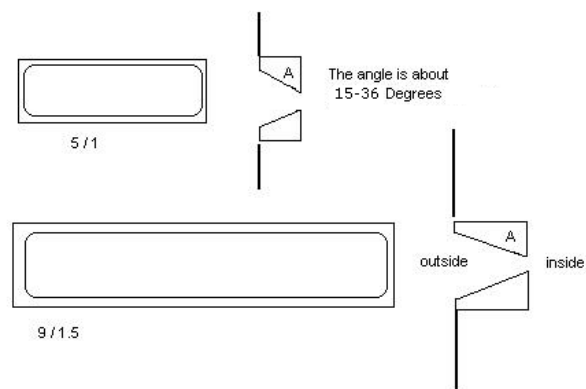


‘B’ into rectangle



‘B’ into a Tube

We tried rectangular ports that were tapered-out-ward on the backside of the speaker as shown below. Seemed to help some.



We then decided to find away to subdue the internal box's resonance as measured with an accelerometer and plotted out on an XY-plotter.

By using several shapes: spheres, triangles, squares, etc., we finally ended up using flat plates. The 6-2-1 system was then developed.

621 Impedance Matching

The internal shape and impedance of a box 'supports' or builds-up some frequencies due to its physical dimensions and at the same time restricts other frequencies.

The use of an impedance matching system like our 6-2-1 plates equalizes the inner impedance of the box.

6 inches square,

2 inches square and a

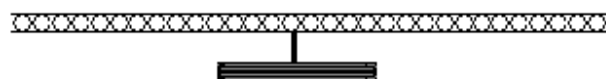
1 inch round dowel, glued to the two plates.

All of the plates are made of American Cardboard, brown cardboard with the round-shaped corrugations. These two parallel plates 'support' a very broad range of acoustical frequencies. [see 621-PDF Rosveta web-site]



Note: the 2x2 plate is positioned downward, while the 6x6 plate centered with the speaker.

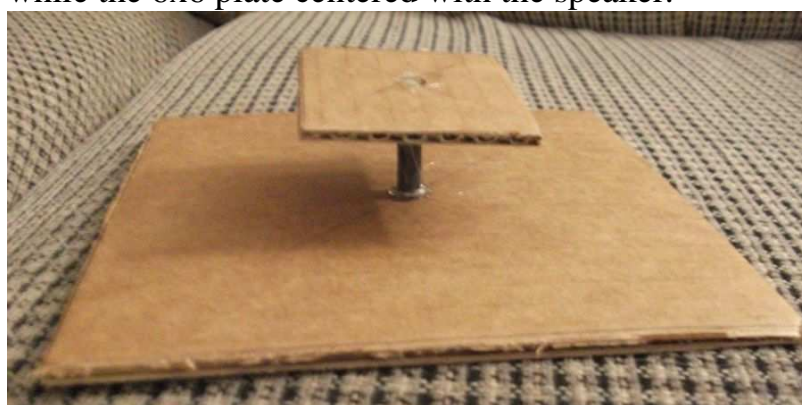
621 Z-match



6x6x1/8" [American Cardboard]

2x2x1/8" Turned 90° to the 6x6 plate

spaced 1"
wood dowel Dia. 1/4" or less

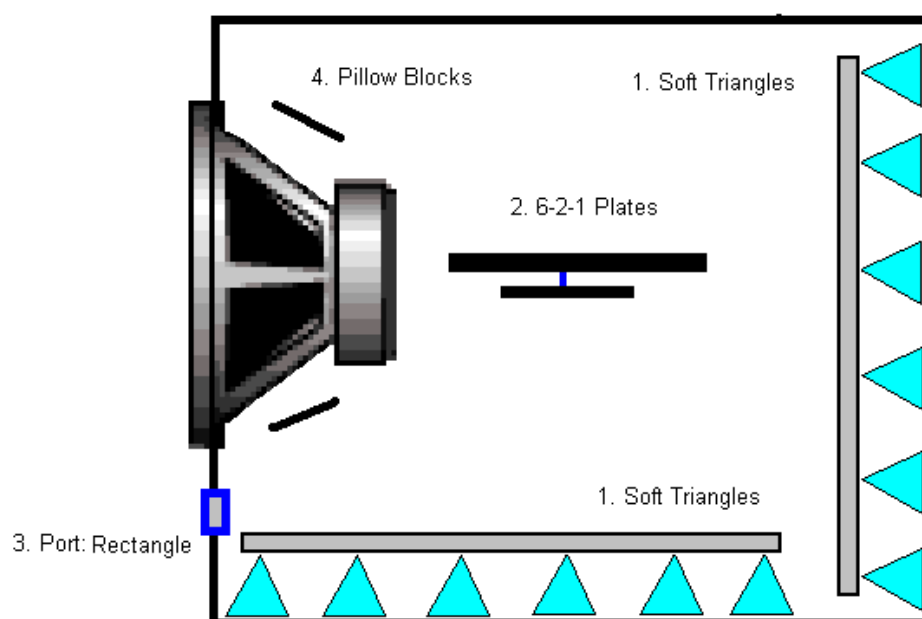


Tests have shown that off-axis amplitudes are greatly enhanced, from the mere 30 to 36 degrees to 80-90 degrees.

Automatic Volume Adjustment System

Typical speaker boxes have a fixed dimensional construction. This may be -ok- for a narrow range of frequencies, but the box needs to be more broad-tuned or flexible. To accommodate increase in amplitudes and longer wavelengths a continuously adjusting internal volume can be implemented.

Automatic Volume Adjustment System



Not all 5 of the inside walls have to be 'moving', just the back and bottom or floor areas, for instance.

The above diagram shows the use of soft Triangular supports. The idea here is to allow an initial quick movement, with a gradual build up of restraint as the volume plates move away from the speaker.

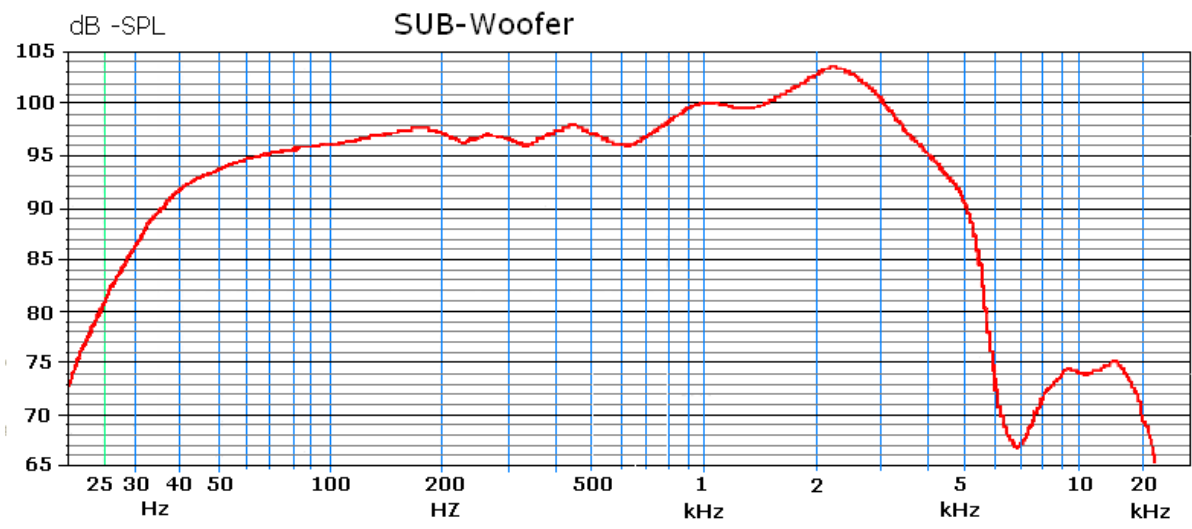
Our test box was 12 " tall, by 9" wide, by 14" deep. A 1/2 inch movement in the 'plates' would increase the inside volume by about 100 cubic inches.

SUB -Woofers

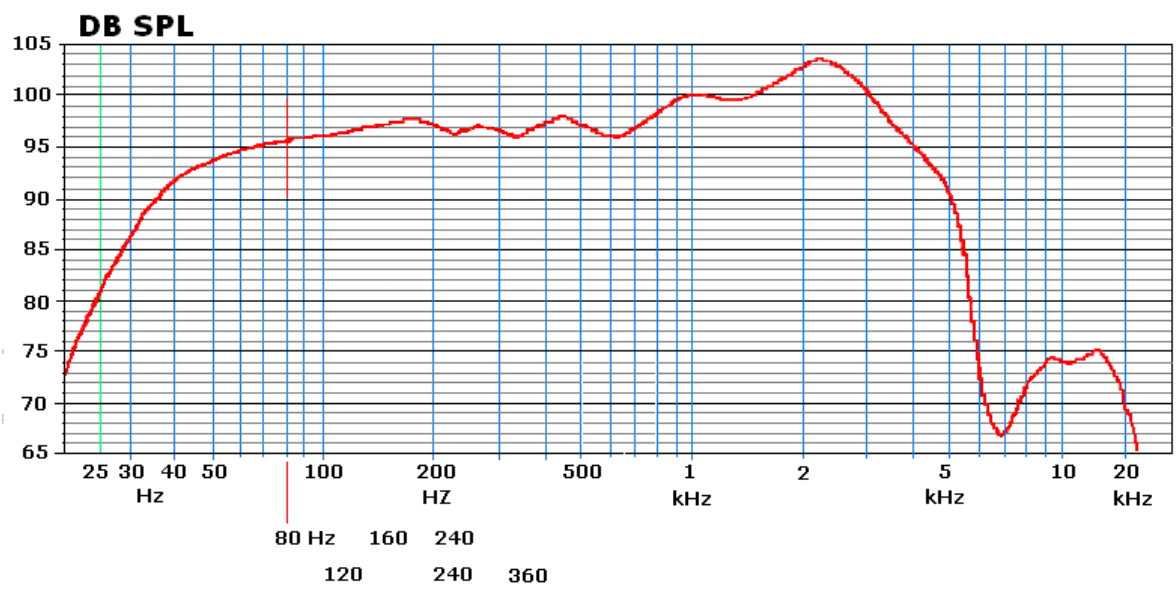
We were asked to help build a home Sub-Woofer unit this last spring [2011]. Never having the time to investigate the sub-woofer add-on, we saw this as an excellent opportunity to learn about very low Audio frequency systems. Using the box layouts and porting ideas previously described, we built a sub-woofer 'box'.

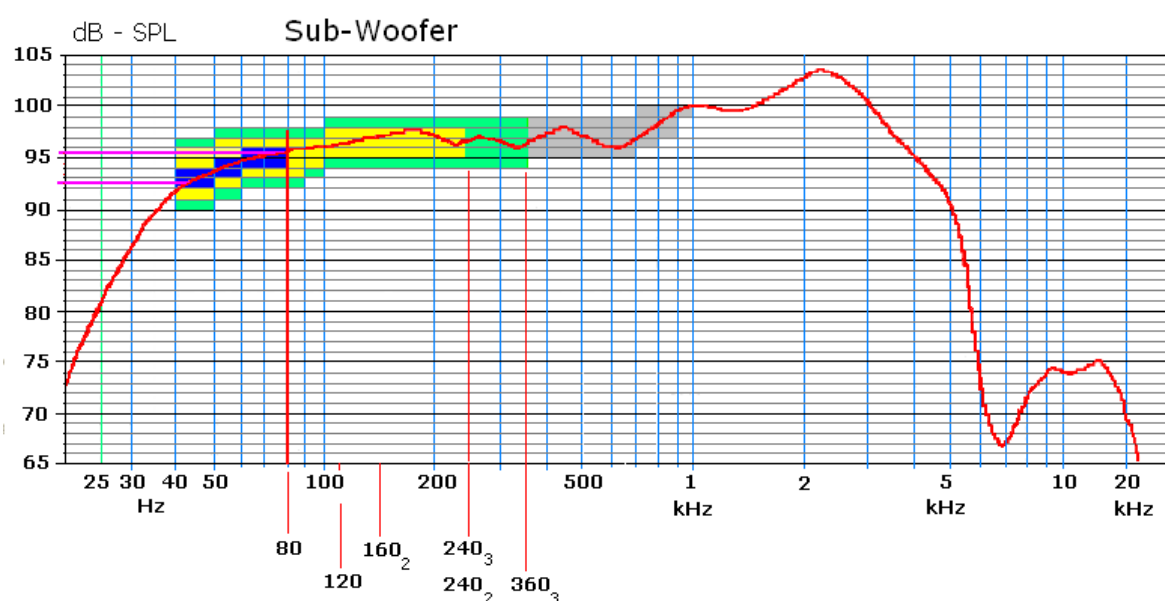
The Sub speaker was a Kappa 12 from Eminence Speaker LLC. The box was made of Birch-wood: 21" Tall, 16" Deep and 20" wide. [~4Cu.Ft.] The speaker was centered on a 21x20 inch surface, no porting and min-waxed finished. The customer bought a Pioneer VSX-819H-K A/V Receiver unit that had a Sub-Woofer output.

Kappa 12 has a good frequency response:



The Roll-off - Cut-Off - was set to 80 Hz. [manufacture setting]





Before we installed the sub-woofer in the home theater, we tested and listened to the subwoofer in our audio system. Nice response and the sub's sound was pleasant, fitting in nicely with our RosVeta's 3-way Speaker system with BRIICe over-lap-circuits.

After installation we listened to some music – Mannheim Steam Roller Christmas selections. The Sub-woofer was weak, producing only a weak thump-thump sound. Pathetic, especially after buying a \$90.00 speaker, a hand made \$300.00 Birch Box and a new Pioneer system !

Two situations limited the great sounds that we heard in our research facility:

1. the output POWER-level from the Pioneer system and
2. frequency band limitation[s] as accepted by the audio industry / users.

Why limit the sub-woofer ?

Let the sub –woofer BREATHE !

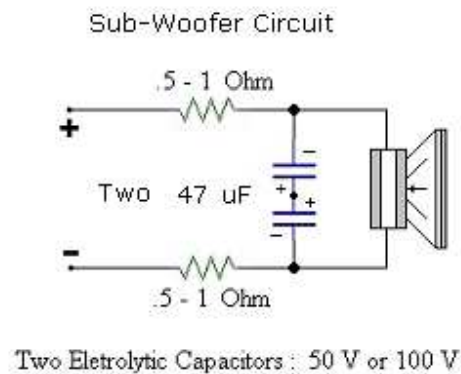
Now we know why the thumpers use a 1,000 watt amplifier !

To correct this institutional mistake, we added a power amplifier to power the sub-woofer and feed it with the center-channel's output, which is a full frequency band output. Much better sound, the Sub-woofer blended in and filled the room, as a good Sub-woofer should.

The chart above shows how the sub-woofer is being severely limited. The dark blue area represents the power and frequency it receives when 'choked' down to an 80 Hz band-limit.

In order to get more audio power and better efficiency at 80 Hz the second and third harmonic need to be allowed to pass onto the sub-woofer. So the actual Band limit will be higher than 240 Hz for a 80 Hz setting. Some manufactures have system limits at 120 Hz, so the actual upper limit should be little higher than 360 Hz for optimum performance. We set our system to roll-off at 1-kHz to allow for voice *blending* with the mid-range speakers.

Also in passing, do NOT place any chokes in series with the sub-woofer, the chokes limit the current feed to the speaker.

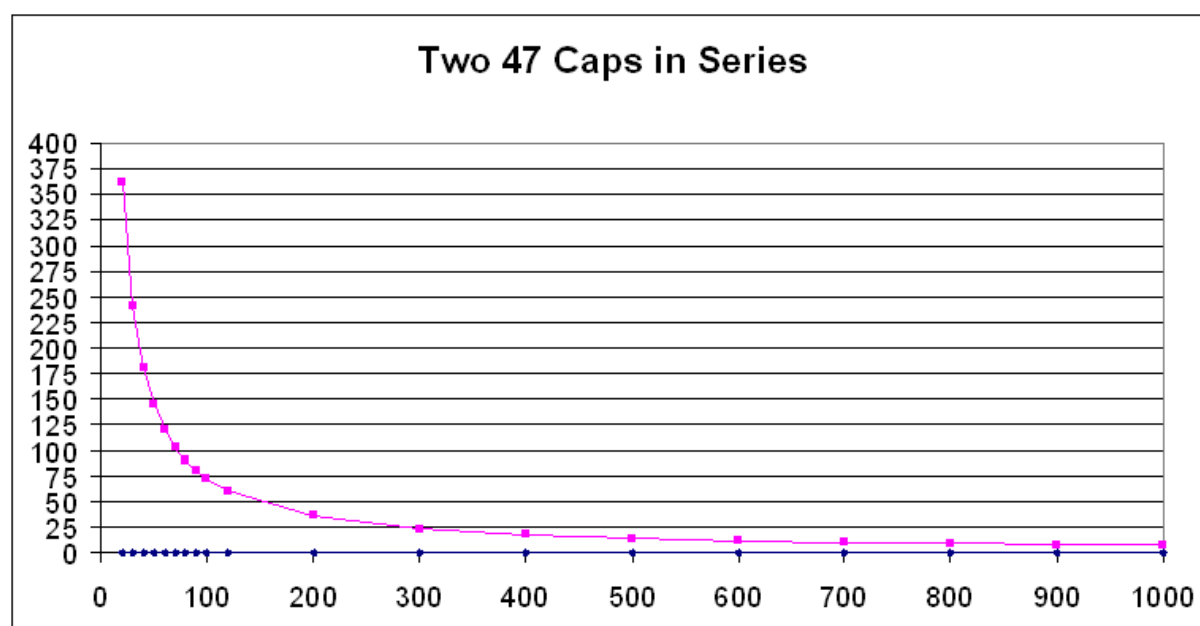


Some Sub-woofer speakers are less than 8 ohms and some older amplifiers cannot handle 4 or 6 ohms, so add a little resistance to achieve about 7-8 ohms. The capacitors are connected as shown with the negative of the capacitors connected to the circuit and the positives connected together. The two capacitors are connected in parallel with the Sub-woofer speaker.

This Chart shows that at 900 Hz the applied frequency is about halved.

[8 ohms Speaker || Xc at 900 Hz]

Frequency Hz	Farad	Reactnce Ohms
20	0.000022	361.72
30	0.000022	241.14
40	0.000022	180.86
50	0.000022	144.69
60	0.000022	120.57
70	0.000022	103.35
80	0.000022	90.43
90	0.000022	80.38
100	0.000022	72.34
120	0.000022	60.29
200	0.000022	36.17
300	0.000022	24.11
400	0.000022	18.09
500	0.000022	14.47
600	0.000022	12.06
700	0.000022	10.33
800	0.000022	9.04
900	0.000022	8.04
1000	0.000022	7.23



We understand a wide-band feed sub-woofer is not traditional, but modern Sub-woofers have much more to offer a system than just...

Thump-thump.

Microphones

Doppler Distortion ?

A dear friend tried for years to ascertain what damage the microphone was imposing on the original audio signal, which it is expected to faithfully capture.

Doppler Distortion - Non-uniform time-delay or Frequency dispersion?

Doppler was for several years blamed for the microphone-effect.

It has taken years to rid the notion of a Doppler shifting effect of the audio wave fronts. Frequency dispersion: frequencies propagating at different speeds, through a microphone ?

The original source of a sound is unfiltered at its origin. But all processes to capture, record and play back the 'original' sound is ultimately 'limiting'.

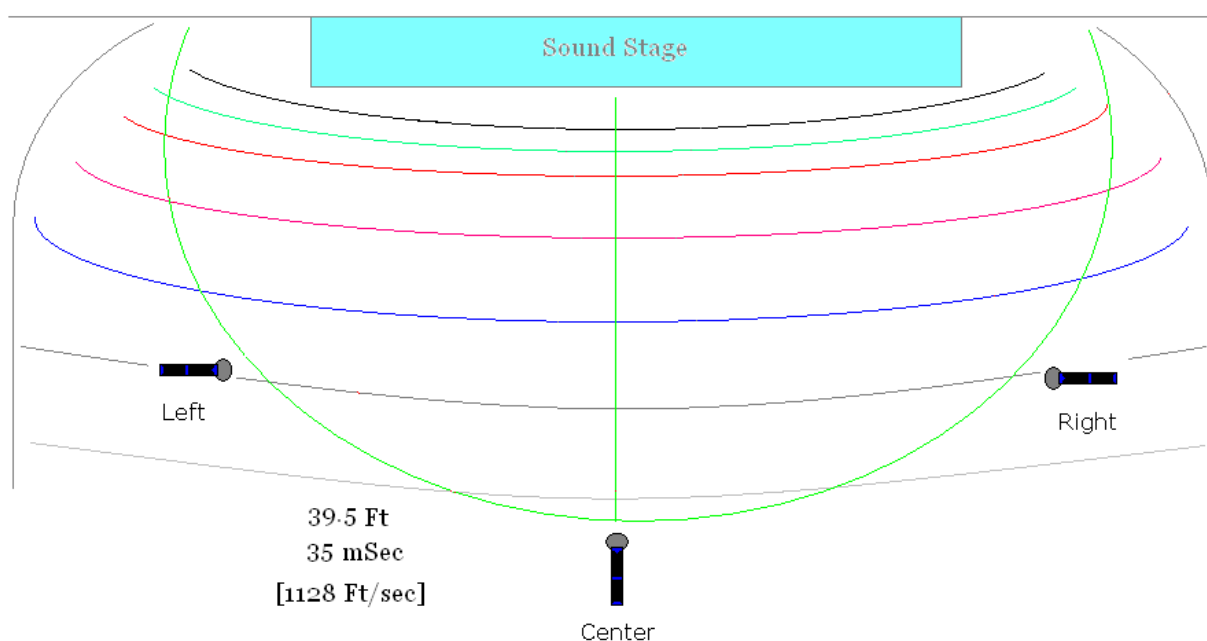
Have you ever wondered about the small input area of a microphone as per the size of a speaker?

Its like a small venturi, the orchestra is forced through the tiny hole of a Microphone, which then is fed down several small wires, amplified, crossed-over-manipulated and then shoved out onto large Audio speakers! :)

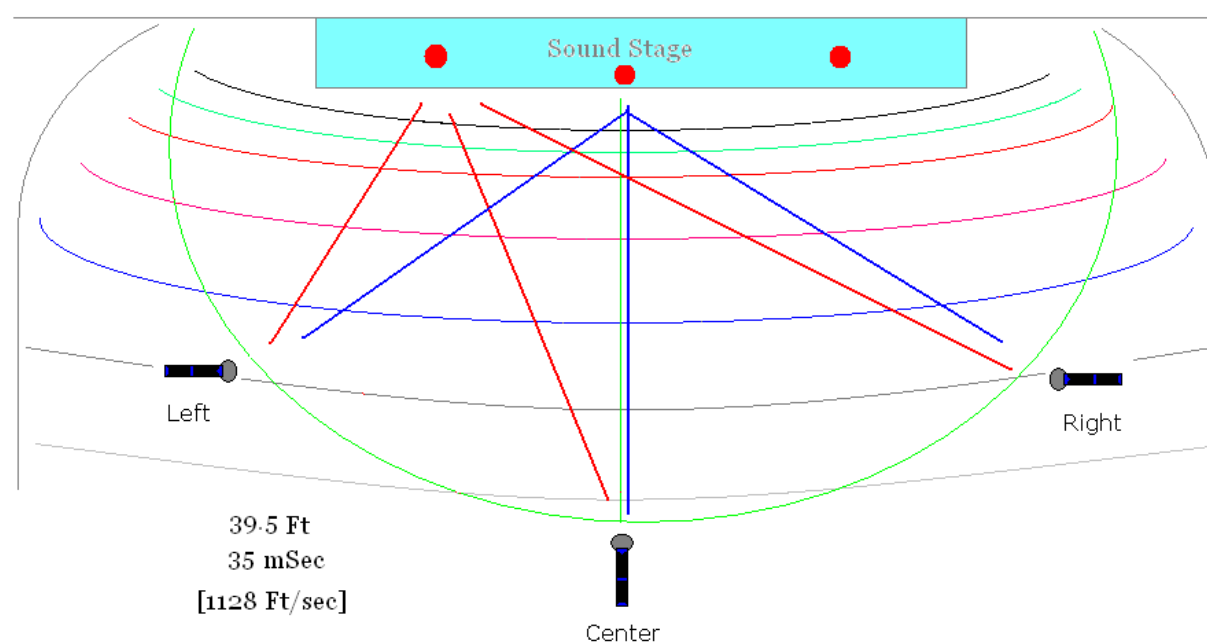
The size and the area of a microphone is limited and is in 'one' place in reference to the source(s) of sound.

Tri-Microphone- L+C+R

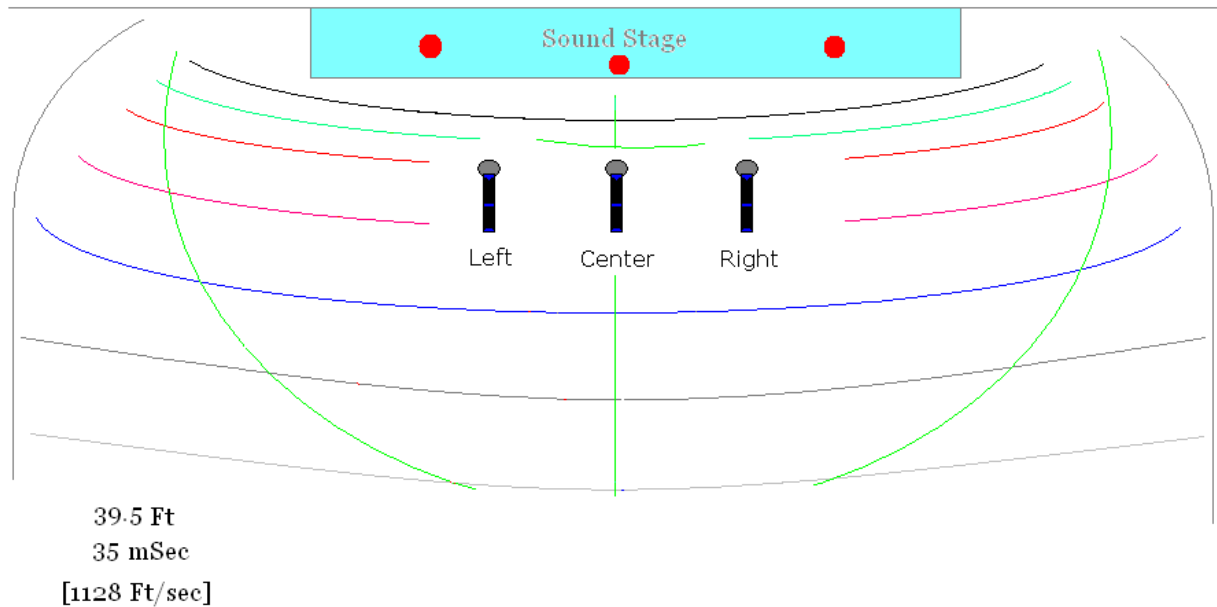
Two microphones can give the left and right of a sound stage, but the middle is lost, supposedly it would be made up in the imaging of the speakers [connected with modern *crossovers*] – hopefully – ?



Having three microphones as shown would capture a larger image for we would sum the three signals into two signals; $L+C$ and $R+C$ or $L+C/2 (+) R+C/2$. This arrangement would open the reproduced sound stage for the center image would be captured and not imagined.



This Set-up would have time-delay or phasing differences from different stage sources of sound.



As was shown on measuring Speaker response at 1 metre or 3 inches, the same situation is in play here. If we record the music from the Sound stage at a far distance we are actually recording a portion of the room's response.

To record the Original Sound Stage we need to be appropriately close to capture the sound of the source. { 35 mSec close, 25- 35 feet }

Would two microphones do the job or would three capture a more uniform, accurate wave-front?

Should the microphones be isolated from each other and how far apart from each other?

- - - more testing yet to do...

MDF - Red Oak

Then finally, what's with the use of MDF for speaker cabinets ?

What would a violin sound like made of various grades of MDF ?

If fine instruments are made of good hard woods that are sanded, varnished and reinforced [braced]; why not a speaker's enclosure ?



Coloration of the sound due to the woods of a speaker is FAR less of a concern than the DAMAGE caused by crossovers !

Let the natural woods be part of the 'sound', the natural woods are far more pleasant than the **dead** MDF boxes !

Epilogue

Striving for a higher level of FIDELITY

By applying what has been shown and cease using the outdated Audio - crossover designs - better advances in fidelity are now possible.

Now that we have displayed and shared what we have discovered, about cables, crossovers, and speakers with explanations on how exotic-esoteric power cords work, this 'information' now passes from the *esoteric* into the *academic*.

Curtis "J" Larson

"The truth is not for all men, but only for those who seek it."

Ayn Rand

"Truth only reveals itself when one gives up all preconceived ideas."

Shoseki



Appendix

PHASE TEST

If phase is not essential for Fidelity we should not hear any differences - ay- ?

By recording my neighbor playing a continuous series of A-notes, on her violin - we produced a known raw 'source' of frequencies from a live instrument.

We then built the following circuits in order to:
separate the highs from the lows, had a circuit to allow us to:
'phase' shift the highs from 0-180 degrees,
remixed the 'phase' shifted highs with the lows and
then amplified the mixer's output.

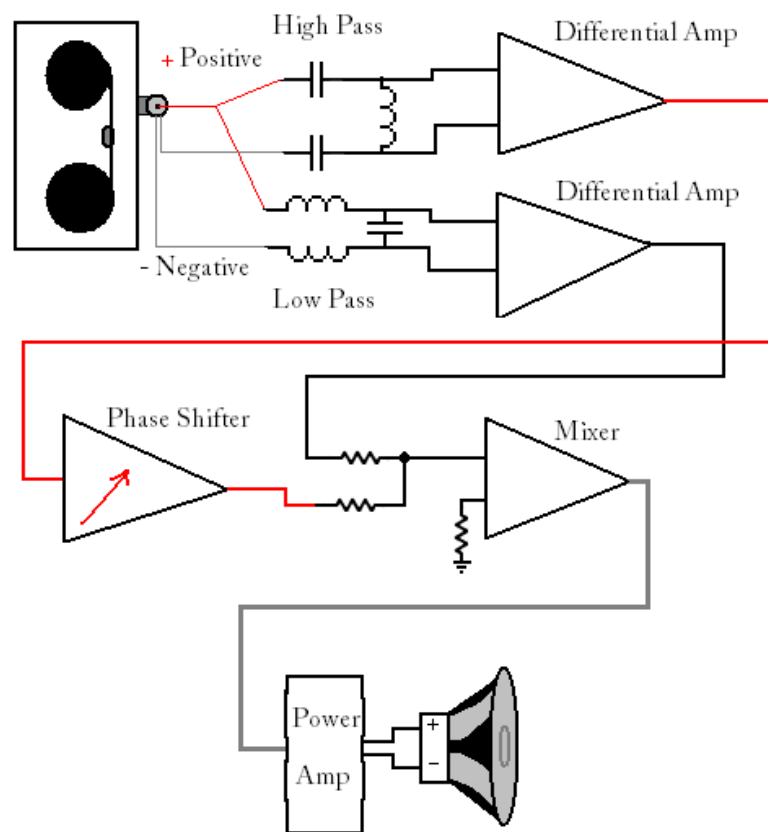
Using a midrange speaker, we had several 'trained' audiophiles listen to the repeating violin-A-notes. We would have the listener hear the A-notes for a moment and then ask them if they heard any change. We did not change the phase at first and so all listeners responded they heard nothing 'different' in the A-notes. Then we would start over, and barely adjust the phase shifter.

We had asked the listener to indicate when they heard any difference. When the listener indicated they heard a difference we would turn back the phase to Zero and resume the testing while waiting again for their signal.

After several hours of testing it was determined that all 'trained' listeners indicated they heard changes with a 6-9 degree phase shift !

We then had many of the assembly line personnel listen and they all heard something when phase shifted 10-13 degrees !

Recorded A-notes



Phase Shift Test - Set Up

SWR - Zo Chart

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Inter-connect Cables IC SWR Zo-Cable

Cardas : Golden Reference	1.07	53.32
GutWire Chime OFC IC	1.16	57.84
Acoustic-Research	1.29	64.68
Kimber - Braid Hero	1.45	72.40
89259 : John Risch - Cable	1.48	36.99
Belden - ZIP Cord IC or SC	1.58	31.55
Coax Mil-Spec RG-58	2.36	117.85
Harmonic : Pro-Silway MKIII+	3.10	154.95

Speaker cables SC SWR Zo-Cable

Kimber-Weave-8-LPC SC	1.28	64.19
River-Cable-Flexygy-6 SC	1.36	68.00
Shunyata Research CS	1.89	94.41
Auto Jumpers SC	2.31	115.47
Nordost: ODIN	2.52	125.98
Spectra-Ribbon-036 SC	3.67	13.63
Stealth-Fine-Ribbon SC	6.70	334.99

- -

Ratio

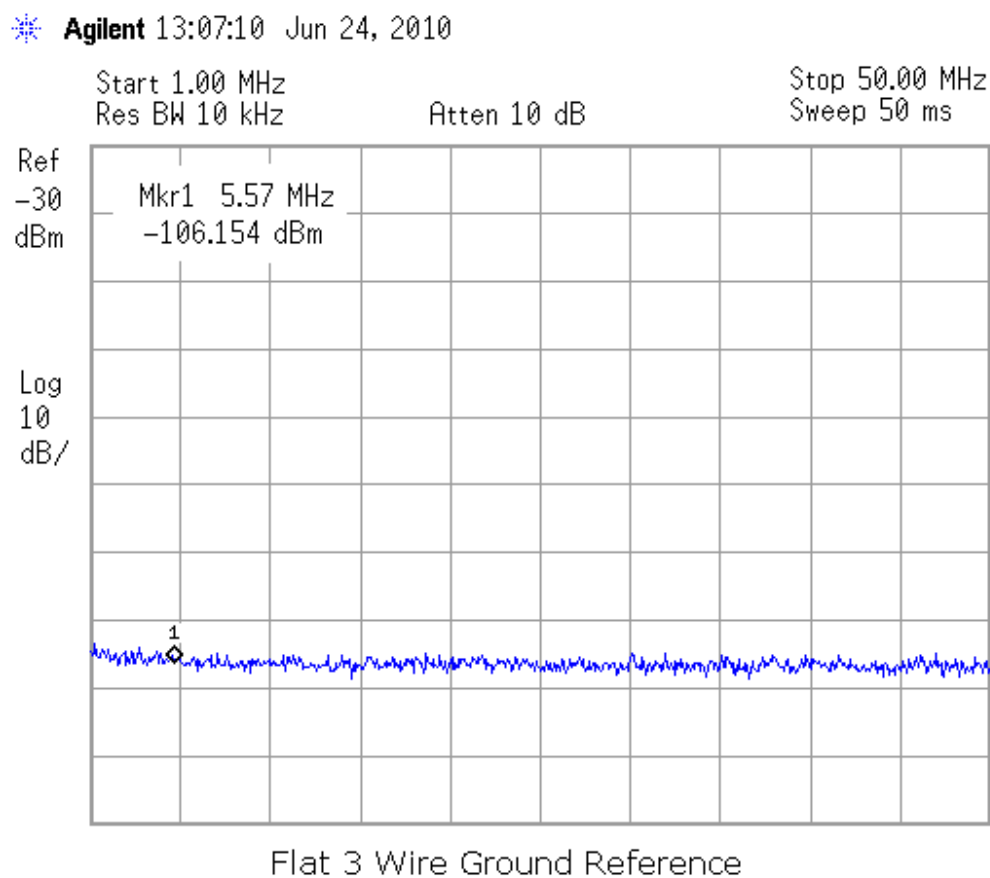
- 1.5 / 4% of Reflected Power
- 2.0 / 11%
- 3.0 / 25%
- 4.0 / 36%
- 5.0 / 44%
- 6.0 / 51%

Zo : Calculated from L-C of the cable / compared to 50 ohms.

Cable Response Tests using: Sine, Triangle and Square wave signals.

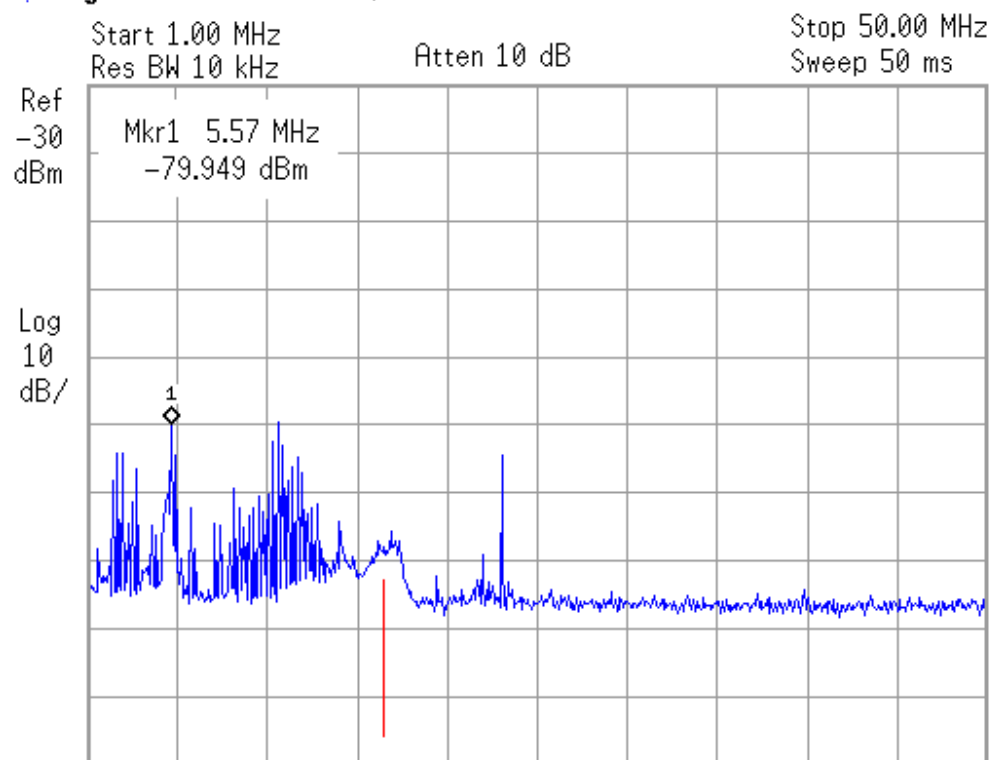
We tested several cables by applying a 1,000 Hz signal into a Spectrum Analyzer. The following graphs are of a 1,000 Hz signal in three different waveforms: Sine-wave, Triangular-wave and a Square-wave. We also tested two lengths of a common '50 Ohm' Coax cable.

These cables were tested from 1 MHz to 50 MHz and 1 MHz to 100 MHz.



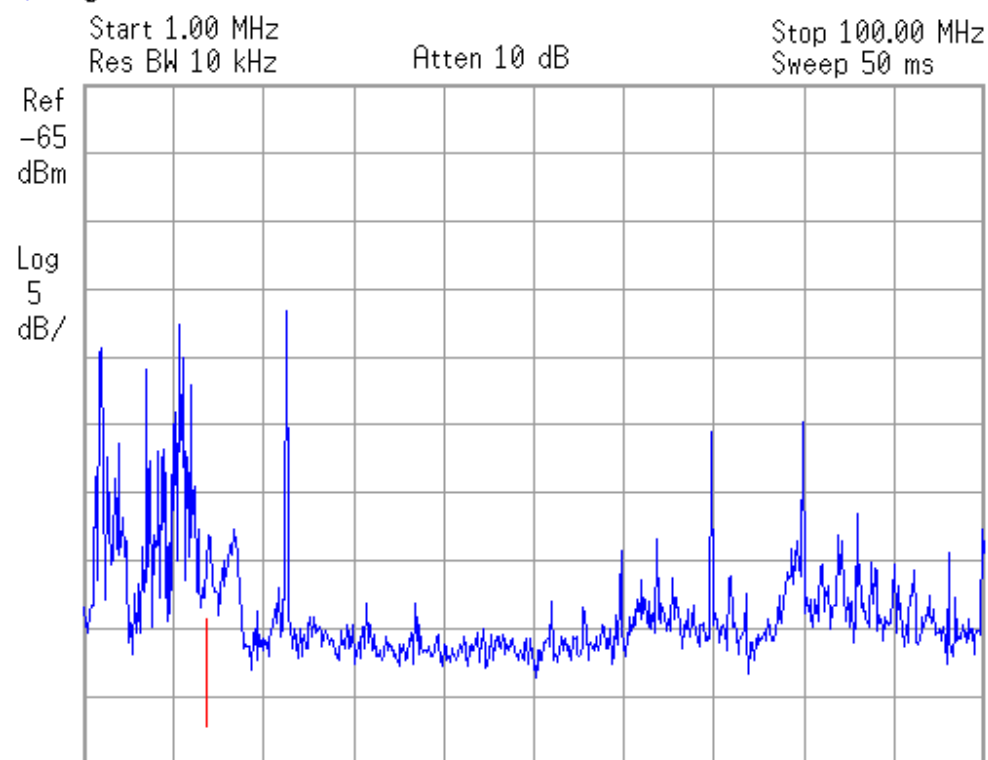
The 3 Flat wire cable was a flat [not round] black power cord.

✱ Agilent 13:07:10 Jun 24, 2010



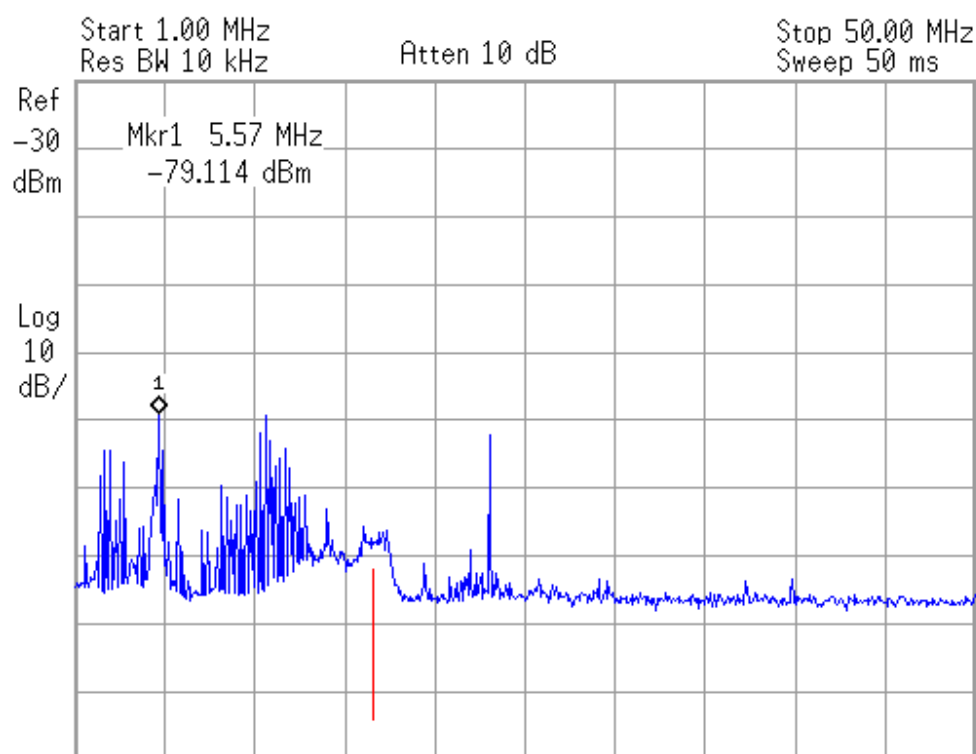
Flat 3 wire Sine Wave

✱ Agilent 13:07:10 Jun 24, 2010



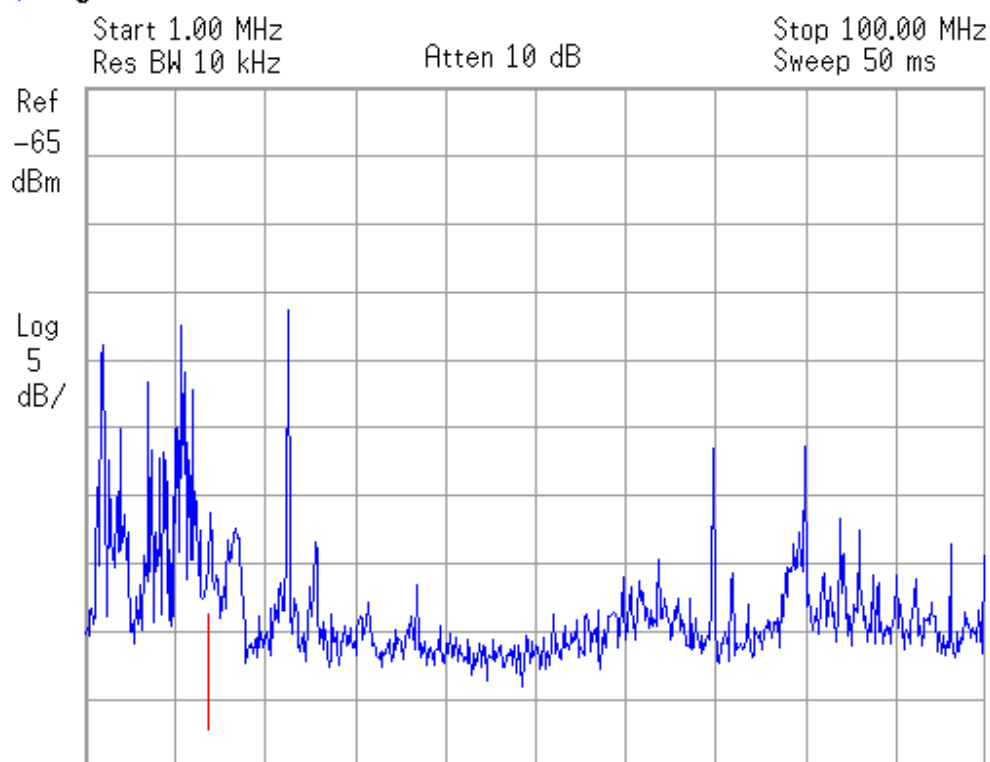
Flat 3 Wire Sine Wave

✱ Agilent 07:05:16 Jun 25, 2010



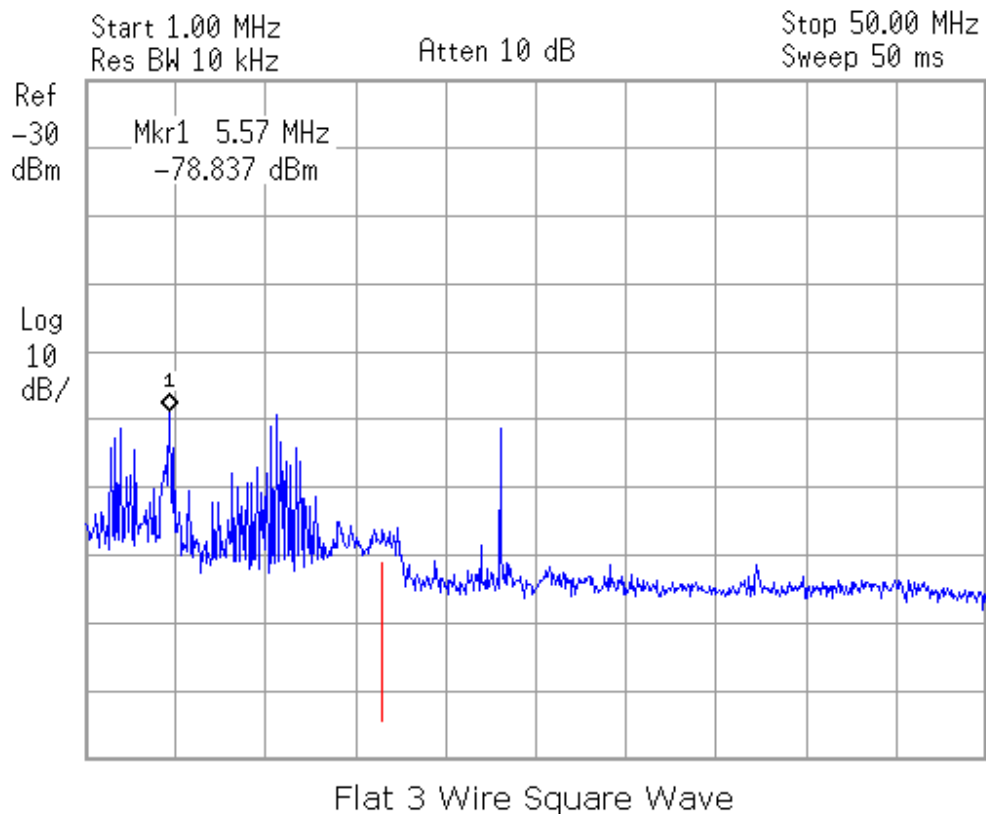
Flat 3 Wire Triangle

✱ Agilent 13:13:10 Jun 24, 2010

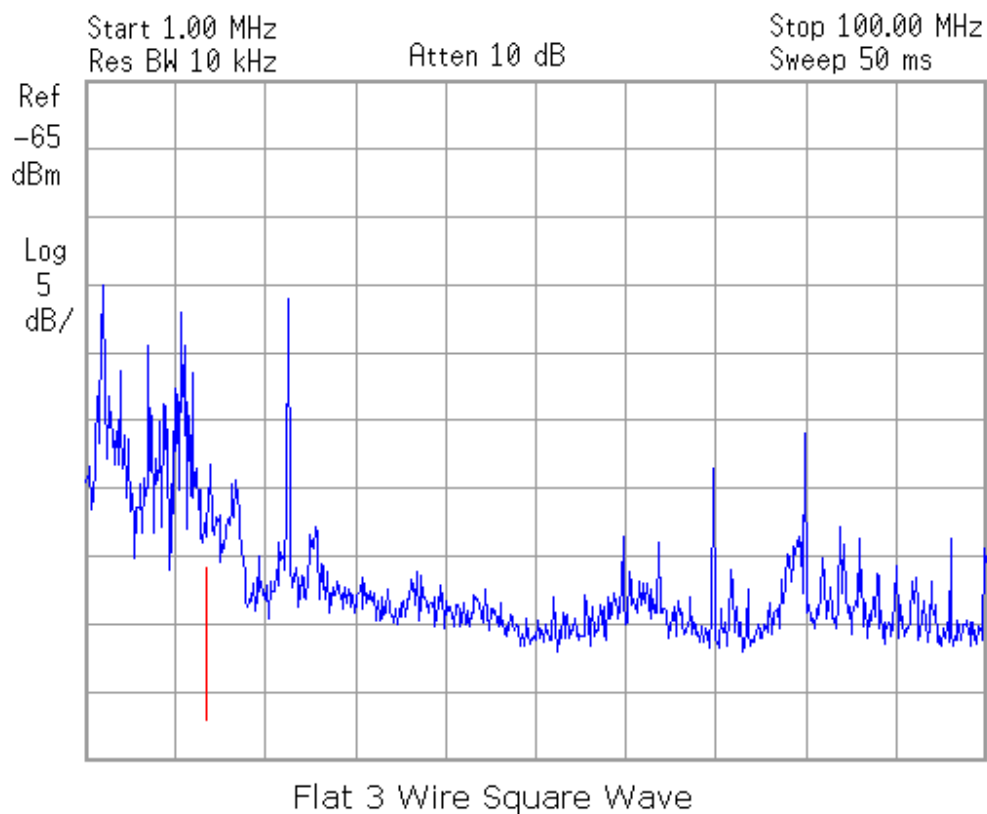


Flat 3 Wire Triangle

✱ Agilent 17:08:16 Jun 25, 2010



✱ Agilent 13:13:10 Jun 24, 2010



✱ Agilent 13:07:10 Jun 24, 2010

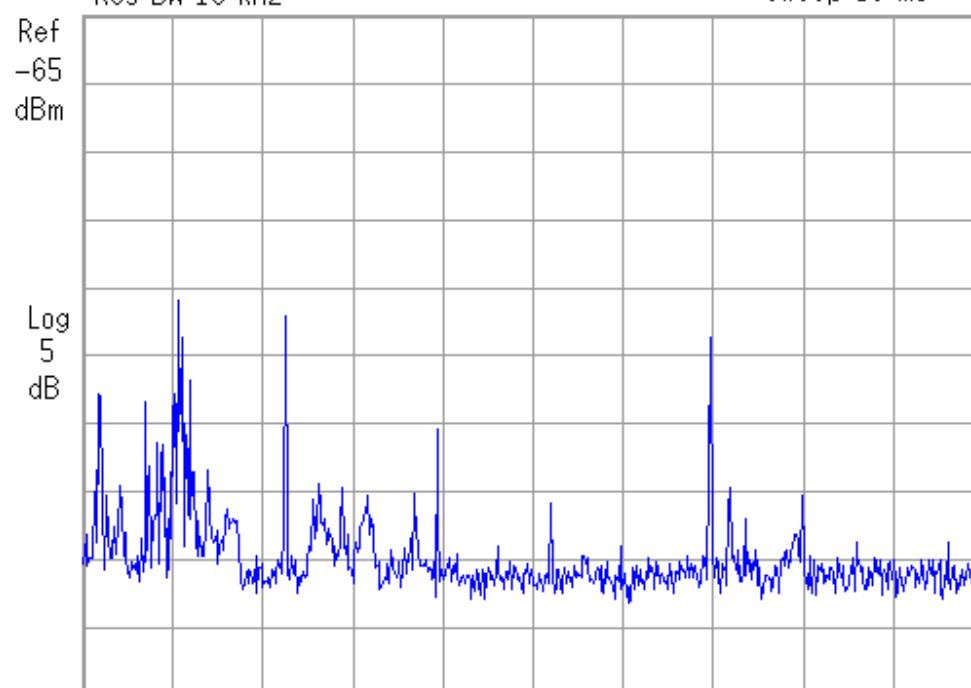
Start 1.00 MHz

Res BW 10 kHz

Atten 10 dB

Stop 100.00 MHz

Sweep 50 ms



Short Twisted Pair Sine

✱ Agilent 13:13:10 Jun 24, 2010

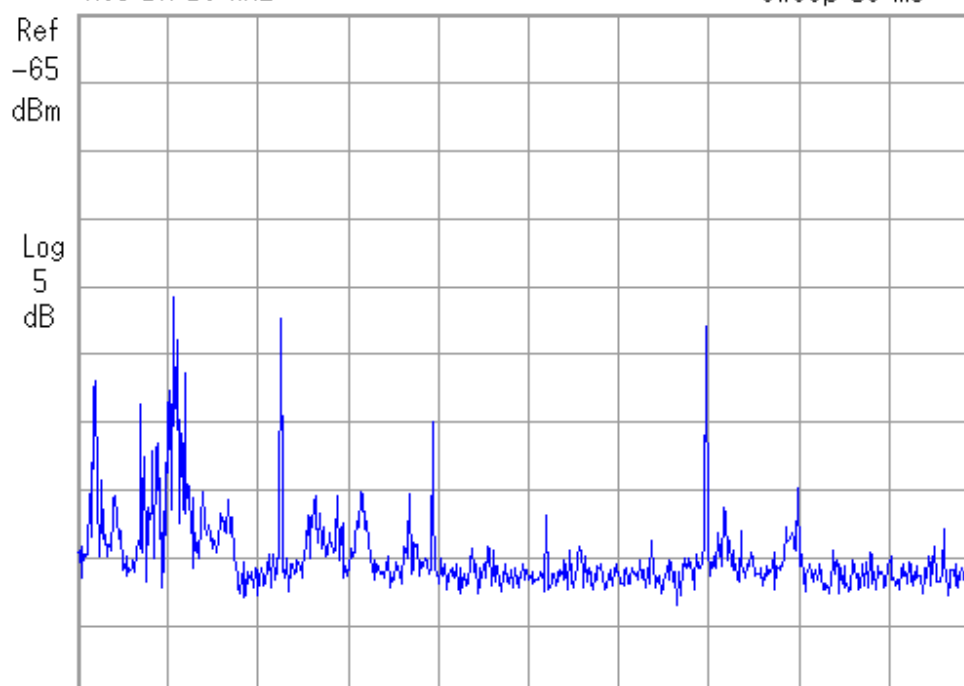
Start 1.00 MHz

Res BW 10 kHz

Atten 10 dB

Stop 100.00 MHz

Sweep 50 ms



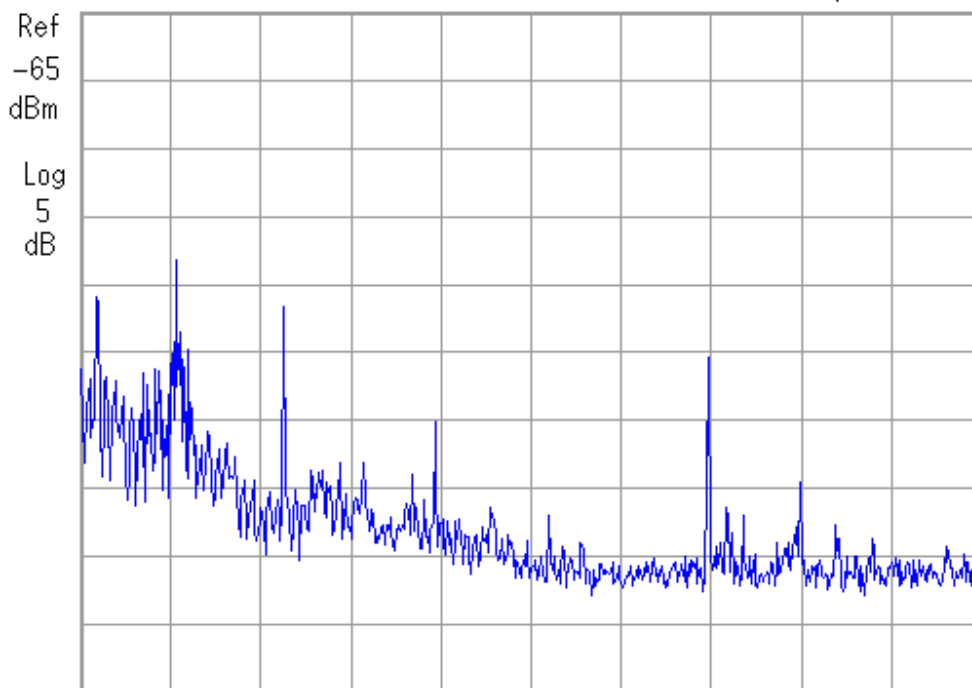
Short Twisted Pair Triangle

✱ Agilent 13:13:10 Jun 24, 2010

Start 1.00 MHz
Res BW 10 kHz

Atten 10 dB

Stop 100.00 MHz
Sweep 50 ms



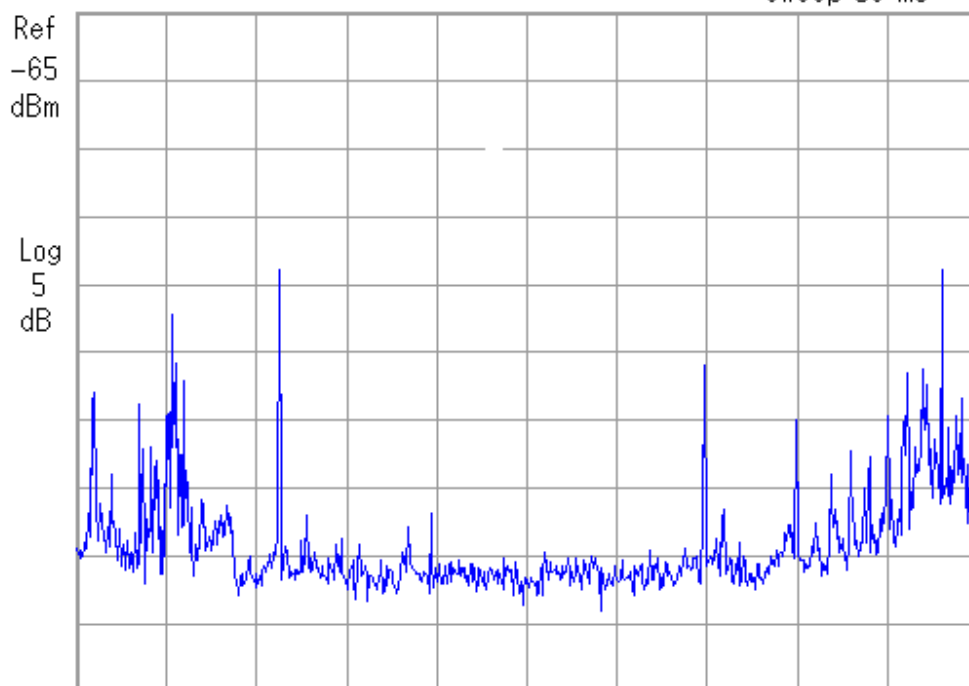
Short Twisted Pair Square

✱ Agilent 17:08:16 Jun 25, 2010

Start 1.00 MHz
Res BW 10 kHz

Atten 10 dB

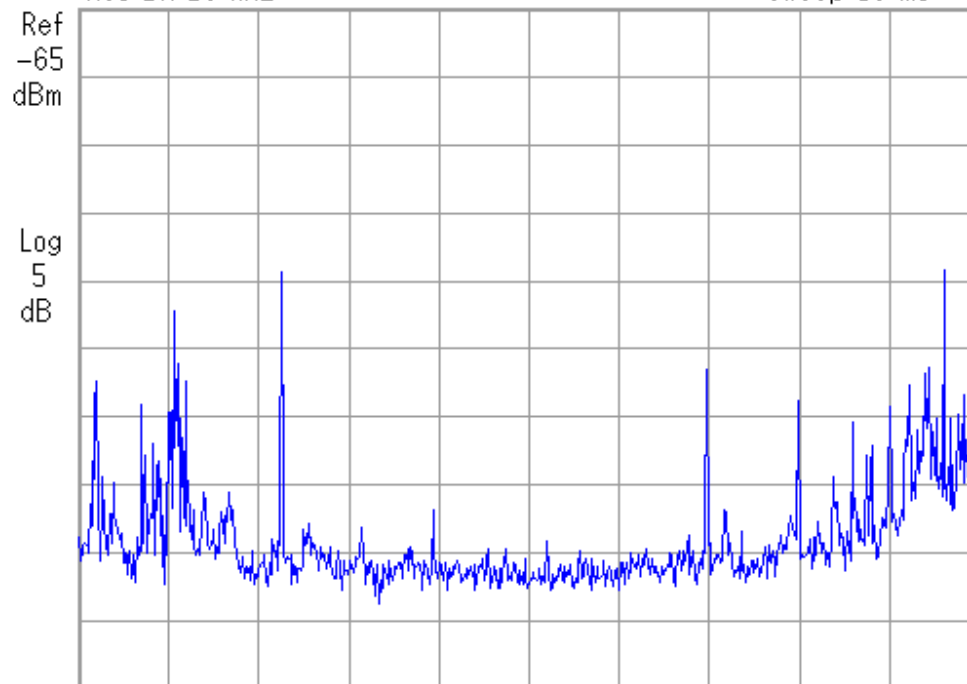
Stop 100.00 MHz
Sweep 50 ms



Twisted Four Strands Sine

* Agilent 17:08:16 Jun 25, 2010

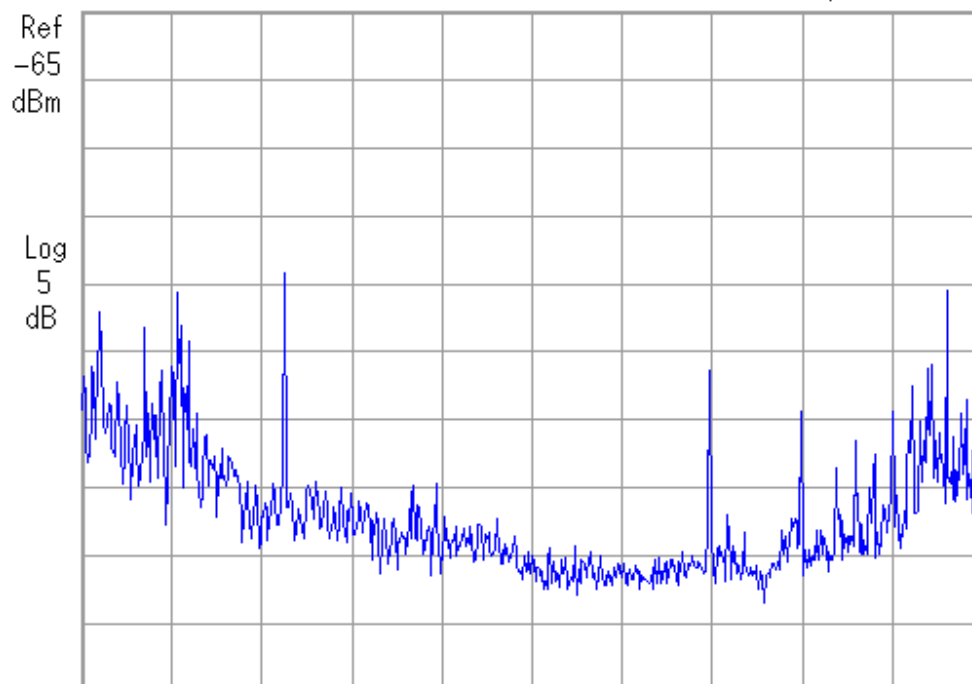
Start 1.00 MHz Stop 100.00 MHz
Res BW 10 kHz Atten 10 dB Sweep 50 ms



Twisted Four Strands Triangle

* Agilent 17:08:16 Jun 25, 2010

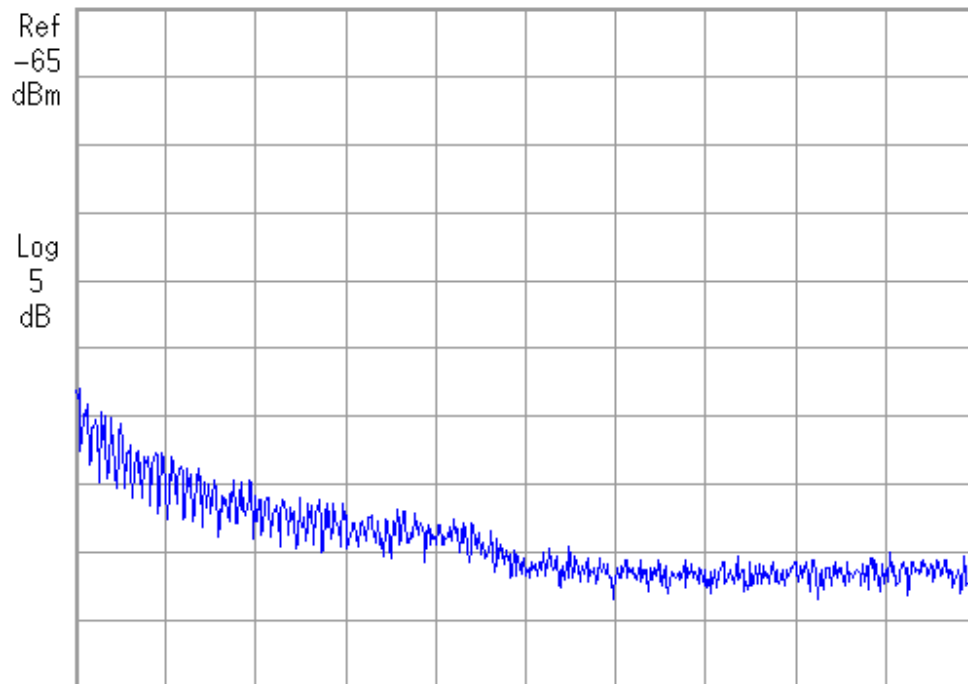
Start 1.00 MHz Stop 100.00 MHz
Res BW 10 kHz Atten 10 dB Sweep 50 ms



Twisted 4 Strands Square

✱ **Agilent** 13:07:10 Jun 24, 2010

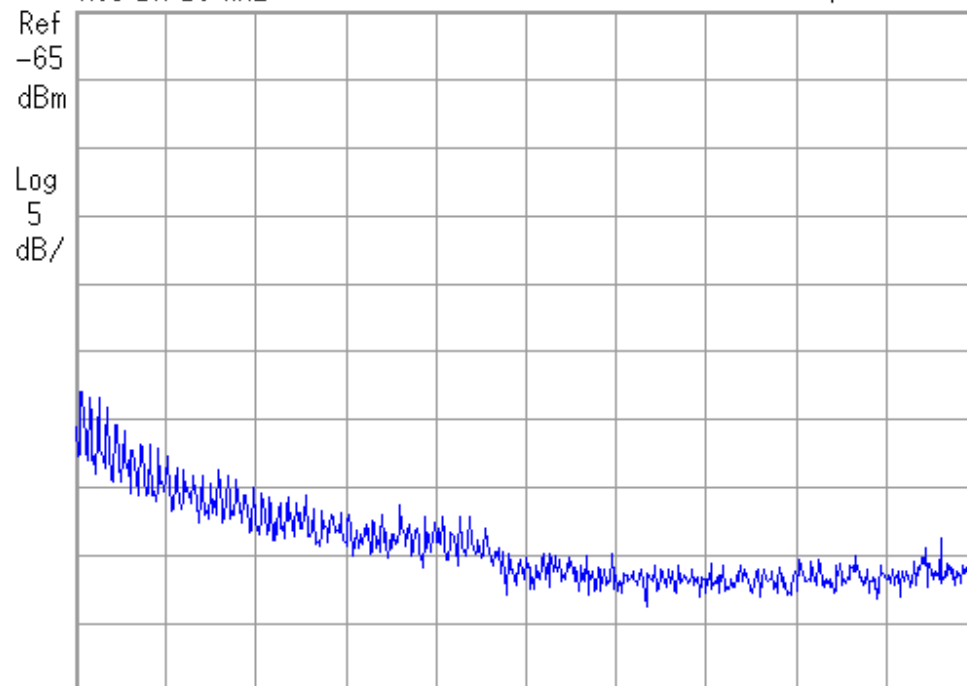
Start 1.00 MHz Stop 100.00 MHz
Res BW 10 kHz Atten 10 dB Sweep 50 ms



Short Coax

✱ **Agilent** 07:05:16 Jun 25, 2010

Start 1.00 MHz Stop 100.00 MHz
Res BW 10 kHz Atten 10 dB Sweep 50 ms



Long Coax

Patent
[Expired: 12 March 2006]
Description / Information

204

RosVeta Audio LLC

12 March 2004

Speaker Interface Circuits for Tweeters, Midrange and Woofer Drivers

I have invented a electrical network that isolates, has a low phase shift characteristic and connects a speaker 20 in a balanced electrical format to an amplifier.

General Concepts: (of basic balanced interface networks): schematics 1 and 2.

Most crossovers in use in the audio industry are single ended. The single-ended arrangement filters only one leg of the transmission line to the speaker. Since the ground side is not 'filtered' the noise in the 'ground' plane is superimposed on the audio signal, which is called common mode 'noise'.

By using a electrically symmetrical interface network the common mode noise is reduced, or to put it another way, the CMRR, common mode rejection ratio, is greatly increased, which produces a large reduction in the low-level-hiss (ground noise) in the speakers.

Also unique is the concept of using resistors, inductors and capacitors in series with each other and simultaneously then placing the speaker in parallel with an inductor or in parallel with a capacitor, resulting in an isolated speaker from ground and in a 'balanced' input configuration.

Using this series configuration an additional benefit is produced. This circuit arrangement has a unique characteristic of having a narrow window of phase shift. The resultant phase angles are from 16-30 degrees over the audio band, which produces a power very high power factors of 86 % to 96 %. Traditional Crossovers have totally uncontrolled phase shifts varying from 70 to 290 degrees with a resultant average power factors of 23 % - 35 %.

These lower power factors are the reason why audio amplifiers of 200 -500 watts are needed to drive speakers.

RESISTORS as shown in schematics 1 and 2

Two different sized resistors are used to for specific functions. The large value resistor(s) 10 are used to help in loading the driver to an amplifier and isolation. Isolation from ground is provided by the large valued resistor 10, or the series inductors 14, or capacitors 16 as demonstrated in the basic circuit schematics: inductor type schematic1 and capacitor type schematic 2.

The extremely smaller valued resistors 12 help in controlling the in-rush noise of a capacitor.

This in-rush current is instantaneous causing a high frequency noise, which induces an unpleasant sharp sound in musical overtones (sibilance-details).

The small valued resistors also change the R-C time constant of the capacitors, useful for timing issues, without hindering the 'bypass' function of the associated capacitors, as shown in schematic 1.

Tweeter Speaker: specific differences: Schematic 3

The Super tweeter 24 and tweeter 22 can not handle too much electrical power.

The input resistors: R1, R2, R3, and R4 perform two functions; one: to help in loading as seen by the power amplifier, and second: to help in isolation from the ground reference to insure a 'balanced' input geometry.

Resistors R5, R6, R7, R8, R9 and R10 help in capacitive and inductive timing control by changing the respective time-constants.

The large valued capacitors C1, C2, C3 and C4 are used to selectively pass a range of desired frequencies.

The small valued capacitors C5 and C6 are used to selectively pass a higher frequency band. The large valued capacitor C7 is selected to pass lower frequencies that are to be 'shunted' away from the tweeter 22.

In the extremely high audio band, 15- 20 kHz, the attendant power drops off very quickly causing loss in the details of many musical instruments.

Inductor L1 in conjunction with capacitors C1 and C2 forms a series resonant circuit, which helps develop more power for the extremely high audio frequencies in the super tweeter 24 as the circuit goes into resonance.

For the tweeter 22 the inductor L2 and Capacitor C7 form a parallel resonant circuit, which establishes a broad band-pass filter from about 2.5 kHz to 7.5 kHz, shunting 9 kHz and above.

Mid-Range and Woofer Speakers: specific differences: Schematic 4

The Mid-Range speaker 26 and woofer 28 can handle moderate to heavy levels of audio power so the input resistors are small in value to none in the case of the woofer.

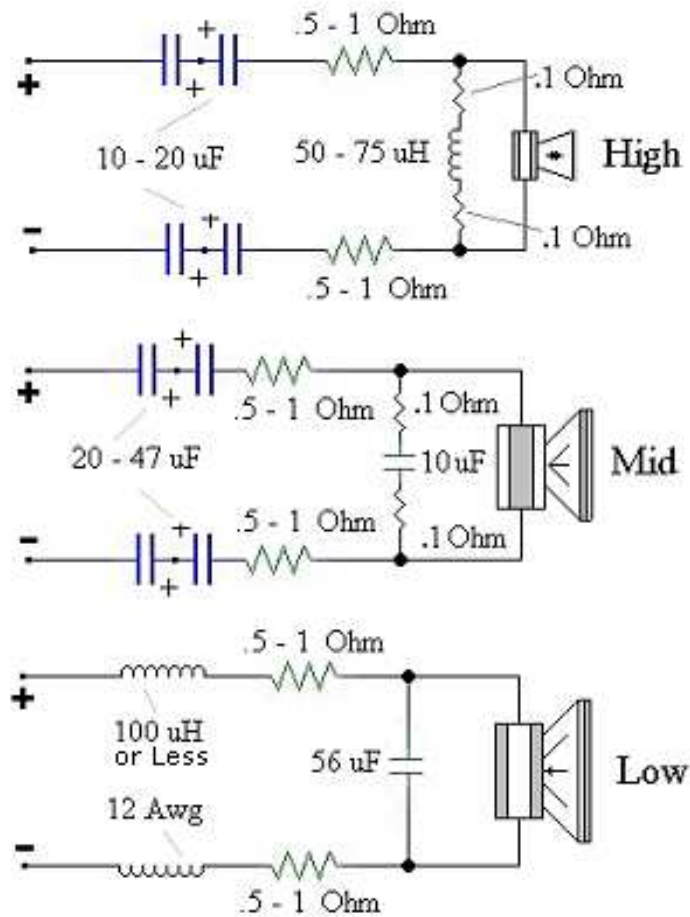
The input resistors: R1 and R2 perform two functions; one: to help in loading as seen by the power amplifier, and second: to help in isolation from the ground reference to insure a 'balanced' input geometry. Resistors R3 and R4 help in capacitive and inductive timing by changing the respective time-constants.

The large valued capacitors C1 and C2 are used to selectively pass a range of desired frequencies.

The small valued capacitors C3 and C4 are used to selectively pass a higher frequency band.

The large valued capacitor C5 and C6 are selected to pass higher frequencies that are to be 'shunted' away from the woofer 28.

Two Electrolytic Capacitors : 50 V or 100 V



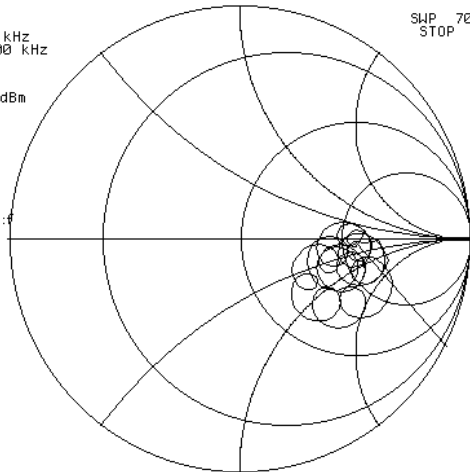
Curtis "J" Larson

Samples of Smith Charts of 4 Cables:

207

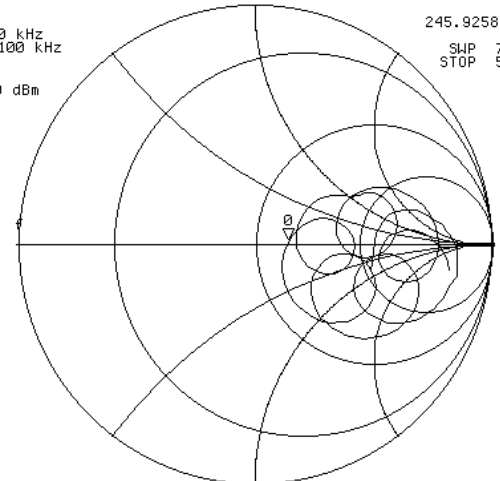
- In shop twisted pair 18 AWG
- RosVeta Frya 2x2 design
- PAE RF Coax
- An older 50 Ohm Coax Cable [Spiral-Wire-Shield]

CH1 A/R FScI 1 U 3 Dec 2009
IF BW 40 kHz
START 100 kHz
POWER 0 dBm
SWP 70 msec
STOP 1 GHz



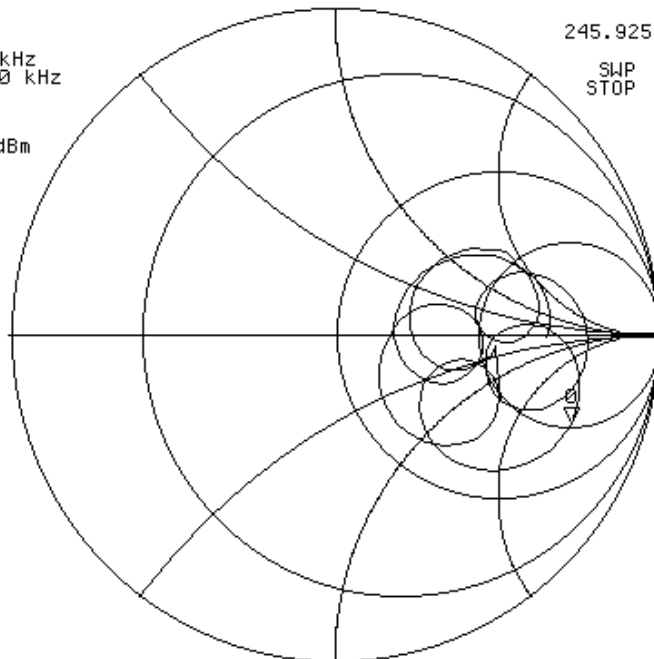
PAE-Coax [1 GHz]

CH1 A/R FScI 1 U 3 Dec 2009 66.414 Ω 2.1102 Ω 1.3657 nH
IF BW 40 kHz
START 100 kHz
POWER 0 dBm
SWP 70 msec
STOP 500 MHz
245.925825 MHz



Twisted Pair 18 AWG

CH1 A/R FScI 1 U 3 Dec 2009 132.36 Ω -178.24 Ω 3.6309 pF
IF BW 40 kHz
START 100 kHz
POWER 0 dBm
SWP 70 msec
STOP 500 MHz
245.925825 MHz

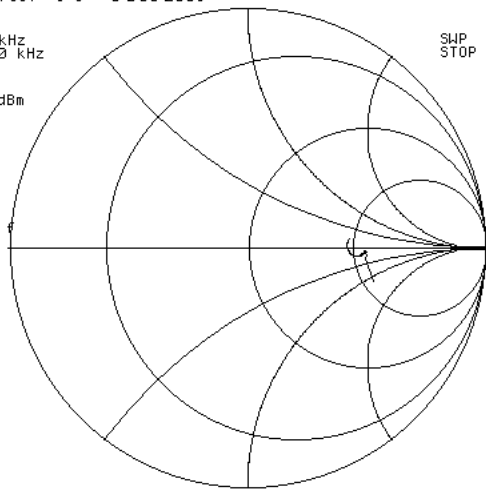


RosVeta Frya 2x2

CH1 A/R FSc1 1 U 3 Dec 2009

IF BW 40 kHz
START 100 kHz

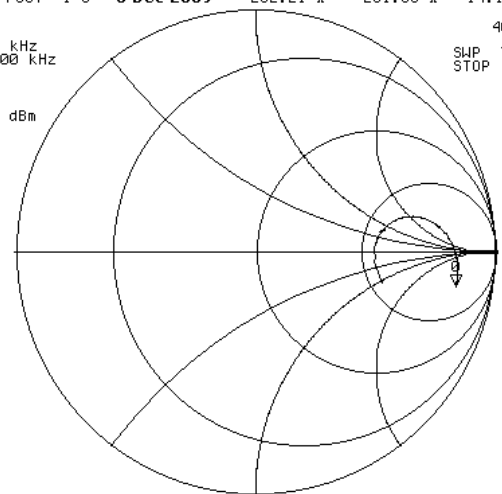
POWER 0 dBm

SWP 70 msec
STOP 40 MHz

PAE-Coax

CH1 A/R FSc1 1 U 3 Dec 2009 292.21 Ω -281.56 Ω 14.132 pFIF BW 40 kHz
START 100 kHz

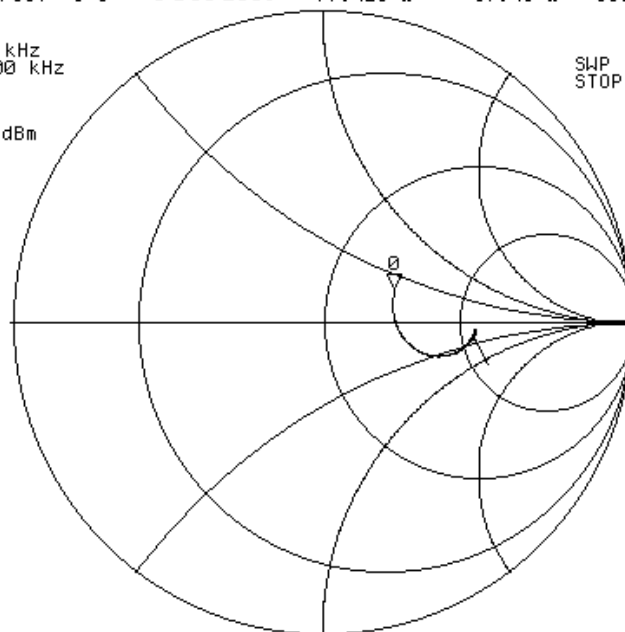
POWER 0 dBm

40 MHz
SWP 70 msec
STOP 40 MHz

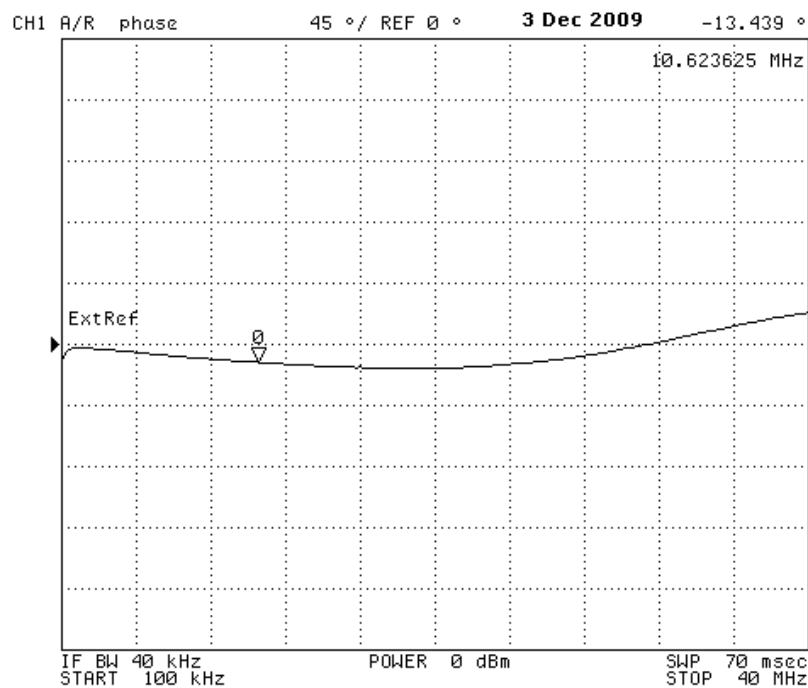
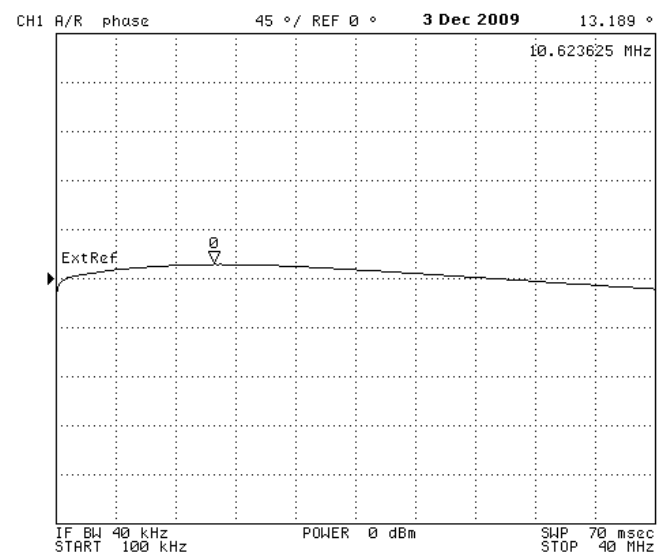
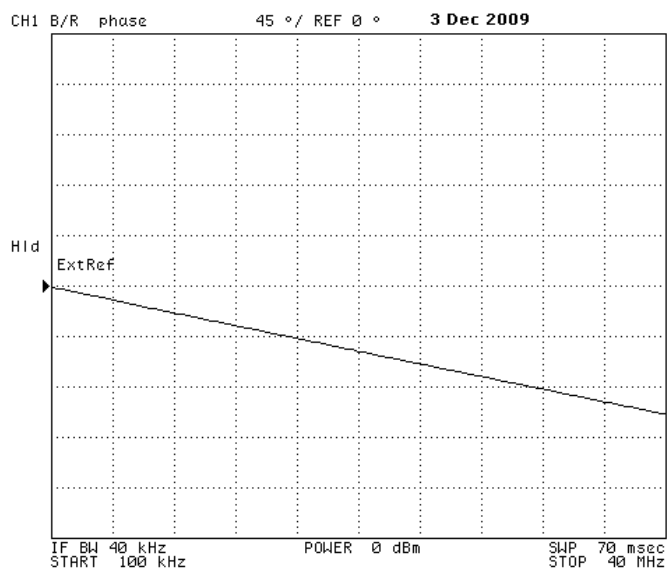
Twisted Pair 18 AWG

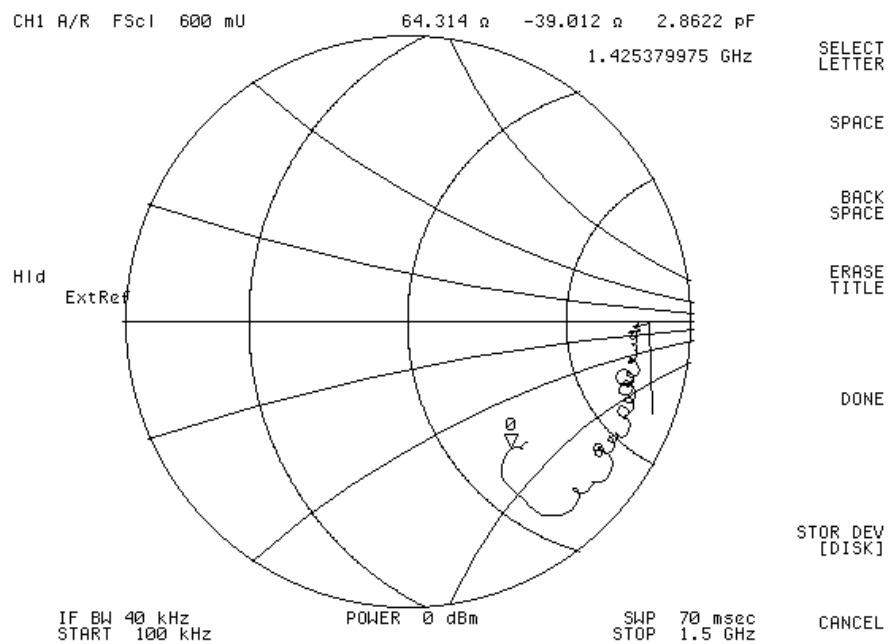
CH1 A/R FSc1 1 U 3 Dec 2009 77.429 Ω 17.41 Ω 69.272 nHIF BW 40 kHz
START 100 kHz

POWER 0 dBm

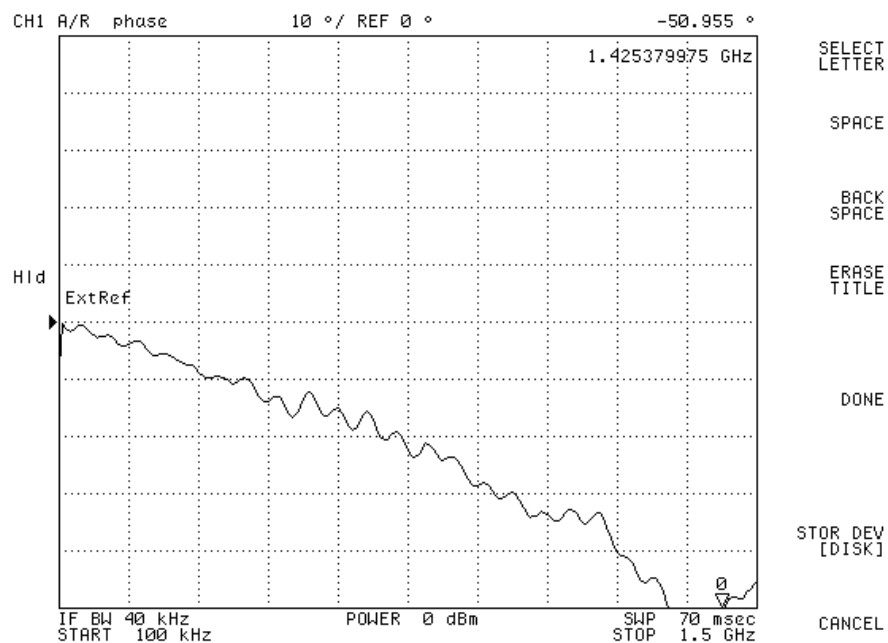
40 MHz
SWP 70 msec
STOP 40 MHz

RosVeta Frya 2x2





An older 50-Ohm Coax Cable [Spiral-Wire-Shield]



Phase of an older 50-Ohm Coax Cable [Spiral-Wire-Shield]

Chicken Test



These chickens represent our 4,000 chickens that took part in a listening test. Over 18 months we varied the type of music that was played into 4 coops. Harsh music like hard-rock was played for about 7 months, then we switched to softer sounding music, long-hair Beethoven-string instrumentals type, played for 11 months with the following results: [1997-1999]

The death rate drooped from 18-34 hens per week to 6-9 per week; egg production rose from 800-960 eggs per day to 1050-1211 per day.

Our Midwest associates with 3,200 hens became worse over time with: the death rate increased from 21-33 to 37-53 hens per week; egg production fell from 680-746 eggs per day to 465-517 per day.

The stable diet of cowboy music played for 10 months, seemed to be disliked by the Midwest hens.

This simple test is what leads us to test our human listeners for 'mental dissonance' or the 'tiring' theory of modern speaker's circuitry and to eventually develop the BRIICe circuits.

We were going to test our BRIICe circuits on the chickens, but our competitors requested we stop producing eggs on our 'welfare farm'. [1999]
[the eggs were used to feed the poor though a local welfare system and the excess eggs were given to other charities.]

Dictionary

Capacitive Reactance: Opposition to an alternating current flow from reactance and associated Dielectric-losses.

Crossover circuits: circuits that are designed to have a point of crossover from a lower frequency ranger to a higher frequency range.

DC [dc] resistance: power loss due to electron heating of a conductor.

Diamagnetic: Slightly repelled by any magnetic field.

Dissipation factor: Energy lost in a capacitor in the form of heat depending on the dielectric material and the frequency.

Dissonance: a set of mingling sounds, or musical intervals that are harmonically unresolved.

E.S.R., Equivalent Series Resistance: Resistance 'value' of a Capacitor that would be equivalent to a wire's resistance.

Frequency Dispersion: Frequencies of a complex signal traveling at different speeds or phase trough a medium or circuit.

Impedance: Opposition to an alternating current flow from reactance and associated resistance. [Some Power loss]

Inductive Reactance: Opposition to an alternating current flow from reactance and associated Ohmic resistance.

Mental Dissonance: We define mental dissonance as:
A tiring Phase-changing process that causes listening fatigue,
a characteristic effect of Crossover circuits.

"The mind being in Conflict with "feelings of experience" clashing with the incoming audio information. "

[This Statement derived from the following listings of information and excerpts]

"An unstable tone combination is a dissonance... its tension demands an onward motion towards a stable chord. Thus dissonant chords are 'active'; traditionally they have been considered harsh and have expressed pain, grief, and conflict."

Music: An Appreciation, 6th Brief Edition, p.41. ISBN 978-0-07-340134-8.
 Roger Kamien (2008), p.41 a b Kamien, Roger (2008).

- - -

There are physical and neurological facts; there is also melodic and harmonic dissonance. Dissonant melodic intervals include the tritone and all augmented and diminished intervals.

Dissonant harmonic intervals include: minor second, major sevenths, augmented fourth and diminished fifth (enharmonically equivalent, tritone)

Sensory dissonance has two perceptual manifestations: beating and roughness are both closely related to a sound signal's **amplitude** fluctuations. Amplitude fluctuations describe of sound signals relative to a reference point are the result of wave interference.

The interference principle states that the combined amplitude of two or more vibrations (waves) at any given time may be larger or smaller than the amplitude of the individual vibrations, depending on their **phase** relationship.

In the case of two or more waves with different frequencies, their periodically changing phase relationship results in periodic alterations between constructive and destructive interference, giving rise to the phenomenon of amplitude fluctuations.

Amplitude fluctuations can be placed in three overlapping perceptual categories related to the rate of fluctuation. Slow amplitude fluctuations (~ 20 per second) are perceived as loudness fluctuations referred to as beating. As the rate of fluctuation is increased, the loudness appears to be constant and the fluctuations are perceived as “fluttering” or roughness.

As the amplitude fluctuation rate is increased further, the roughness reaches a maximum strength and then gradually diminishes until it disappears
 $\sim \Rightarrow 75\text{-}150$ fluctuations per second, depending on the frequency of the interfering tones.

Assuming the ear performs a frequency analysis on incoming signals, as indicated by Ohm's acoustic law (see Helmholtz 1885; Plomp 1964), the above perceptual categories can be related directly to the bandwidth of the hypothetical analysis-filters

(Zwicker et. al. 1957: Zwicker 1961).

For example, in the simplest case of amplitude fluctuations resulting from the addition of two sine signals with frequencies f_1 and f_2 , the fluctuation rate is equal to the frequency difference between the two sine's $|f_1 - f_2|$, and the following statements represent the general consensus:

- 1.) The fluctuation rate is smaller than the filter-bandwidth, then a single tone is perceived either with fluctuating loudness (beating) or with roughness.
- 2.) Fluctuation rate is larger than the filter-bandwidth, then a complex tone is perceived, to which one or more pitches can be assigned but which, in general, exhibits no beating or roughness.

Along with amplitude fluctuation rate, the second most important signal parameter related to the perceptions of beating and roughness is the degree of a signal's **amplitude fluctuation**, that is, the level difference between peaks and valleys in a signal.

(Terhardt 1974: Vassilakis 2001).

When there is no pronounced beating or roughness, the degree, rate, and shape of a complex signal's amplitude fluctuations are variables that continue to be important through their interaction with the signal's spectral components. This interaction is manifested perceptually in terms of pitch or timbre variations, linked to the introduction of combination tones.

(Vassilakis, 2001, '05 and '07)

The beating and roughness sensations associated with certain complex signals are therefore usually understood in terms of sine-component interaction within the same frequency band of the hypothesized auditory filter, called critical band. When the ratios of the frequencies are not simple, the overtone situation appears complex and chaotic in the spectral analysis.

Most listeners perceive the intervals at these points to be "rougher" or more "disharmonious". Dissonance is more generally defined by the amount of beating between partials (called harmonics or overtones when occurring in harmonic timbres).

(Helmholtz, 1877/1954).

Terhardt (1984) calls this "sensory dissonance".

By this definition dissonance is dependent not only on the width of the interval between two notes' fundamental frequencies, but also on the widths of the intervals between the two notes' non-fundamental partials.

Sensory dissonance (i.e. presence of beating and/or roughness in a sound) is associated with the inner ear's inability to fully resolve spectral components with excitation patterns whose critical bands overlap.

If two pure sine waves, without harmonics, are played together, people tend to perceive maximum dissonance when the frequencies are within the critical band for those frequencies, which is as wide as a minor third for low frequencies and as narrow as a minor second for high frequencies (relative to the range of human hearing).

If harmonic tones with larger intervals are played, the perceived dissonance is due, at least in part, to the presence of intervals between the harmonics of the two notes that fall within the critical band.

The Physics and Psychophysics of Music. p-106.
Juan G. Roederer (1995)

"According to psychophysical theory, the roughness of a complex sound (a sound comprising many partials or pure tone components) depends on the distance between the partials measured in critical bandwidths.

Any simultaneous pair of partials of about the same amplitude that is less than a critical bandwidth apart produces roughness associated with the inability of the basilar membrane to separate them **clearly**."

Roughness (psychophysics)

Plomp, R. & Levelt, W.J.M. (1965).

Tonal consonance and critical bandwidth.

Journal of the Acoustical Society of America, Vol. 38, pp. 548–560

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Vassilakis, P.N. and Fitz, K. (2007).
 SRA: A Web-based Research Tool for Spectral and
 Roughness Analysis of Sound Signals.

Zwicker, E. (1961).
 Subdivision of the audible frequency into critical bands.
 Journal of the Acoustical Society of America, 33(2): 248-249

Zwicker, E., Flottorp, G., and Stevens, S. S. (1957)
 Critical band-width in loudness summation.
 Journal of the Acoustical Society of America, 29(5): 548-557

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Paralogism: An argument or conclusion that is fallacious or illogical especially when committed by mistake, but believed to be logical.

Pillow Blocks: Blocks of soft wood shaped to help control the backward movements of a large speaker, in order to reduce second and third harmonic acoustical power.

Q: merit of quality; Relation of Stored power to power dissipated.
Reactance to resistance; Higher the Q, quicker the phase shift.

Reactance: Opposition to a current that causes a phase shift
[ideal] in the Voltage and current, with no Power lost.

Electrical Noise: Fundamentals & Sources

Madhu S. Gupta / IEEE PRESS 1977 [pages-Cited]

W. Schottky [1918] pointed out that thermal 'fluctuations or 'noise' in occurred in passive conductors and is now known as 1/F bulk noise. [p. 9c & p. 168]

J.B. Johnson [p11 & p.168] reported thermal fluctuations in various metals:
Silver, Copper, Aluminum and various electrolytes.

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Audibility and Musical Understanding of Phase Distortion

Andrew Honashon_at_uclink.berkeley.edu

www.ocf.berkeley.edu/~ashon

Music 108Fall 2002; Professor David Wessel

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AURAL PHASE DISTORTION DETECTION

Presented by Daisuke Koya

University of Miami

Master of Science in Music Engineering Technology

Coral Gables, Florida May, 2000

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"On the Audibility of Midrange Phase Distortion in Audio Systems,"

S. P. Lipshitz, M. Pocock, and J. Vanderkooy,
J. Audio Eng. Soc., vol. 30, pp. 580-595 (1982 Sep.)

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The Differential Time-Delay Distortion and Differential Phase-Distortion as Measures of Phase Linearity

W. Marshall Leach, Jr.

Georgia Institute of Technology,

School of Electrical Engineering Atlanta, Georgia

J. Audio Eng. Soc. Vol. 37 No. 9 1989 September

McGraw-Hill

Electrical and Electronic Engineering Series

Electronic and Radio Engineering

Fourth Edition 1955; pages: 256-257

part: 8-2 Distortion in Amplifiers; paragraph. C

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Audio Interconnect Cable Shootout - Part 1 - December, 2000

Milan Cernohorsky - Editor, EUROPE

Cables evaluated by Jiri Michalek, Milan Cernohorsky,

Patrik Blaha, Petr Püschel, and Vladimir Rybar

- - -

Center for Strategic & International Studies

www.csis.ul.ie/ccmcm/cs5611/Riana/PsychoacLect5.ppt

slide 20 of 35; softness of sound .3dB – 1dB

- - -

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Fred E. Davis

J. Audio Eng. Soc., Vol. 39, No. 6, 1991 June

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Electrical and Electronic Engineering SeriesMcGraw-Hill [1955] p23 paragraph 3.Frederick Emmons Terman[Library of Congress Catalog Card Number 55-6174]

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http://www.essex.ac.uk/dces/research/audio_lab/malcolms_publications.htmlJ7 FUZZY DISTORTION IN ANALOG AMPLIFIERS: A LIMIT TO INFORMATION
TRANSMISSION?, M.O.J. Hawksford, JAES, vol.31, no.10, pp.745-754, October 1983[http:// www.essex.ac.uk/dces/research/audio_lab/malcolmspubdocs/
J7%20Fuzzy%20distortion.pdf](http://www.essex.ac.uk/dces/research/audio_lab/malcolmspubdocs/J7%20Fuzzy%20distortion.pdf)

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Liquid Crystal Circuits Continued...

We had our book reviewed by several of our previous associates. Many of the reviewers where desirous for us to elaborate on the design of the LLC circuits. The RosVeta staff and I felt it would help those that are interested in making their own LCC circuits, so we added the following proprietary information as a supplement.

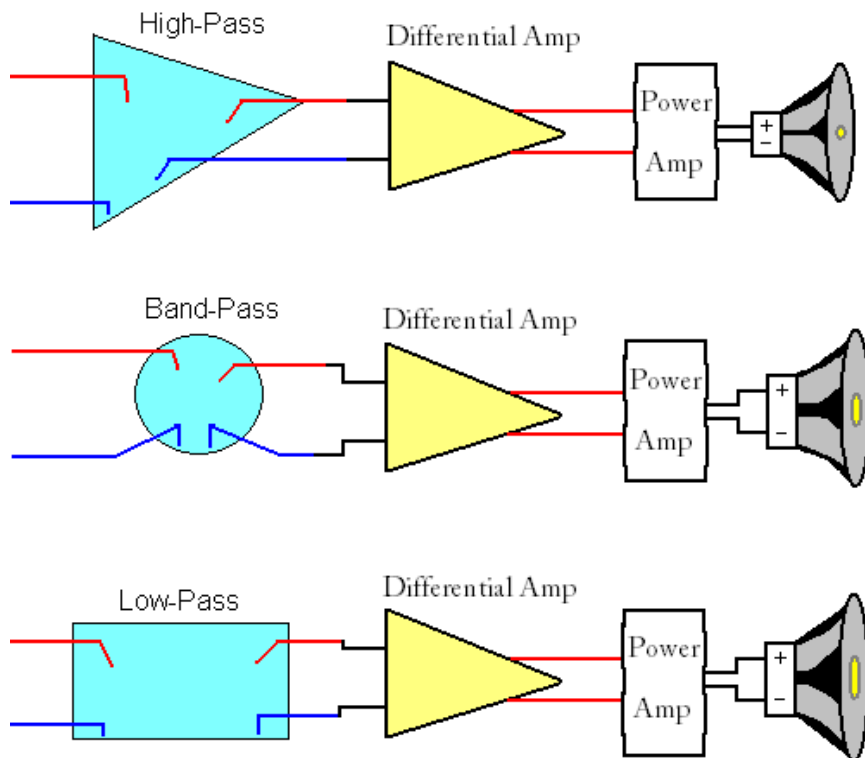
[This avoided the need to re-number the entire book-again!]

It is our earnest desires to have the audio hobbyist eliminate crossovers from their speaker systems. In order to facilitate and encourage this ESOTERIC re-design of speaker systems, we took upon ourselves the project to develop different ways of connecting an power amplifier to a speaker.

REMEBER THESE CIRCUITS ARE USED
IN BETWEEN THE CD PLAYER, PREAMP,
RECORD PLAYER, ETC. AND THE INPUT
A POWER AMPLIFIER. [not to the speakers]

Requiring a differential amplifier per filter; 3 amplifiers for a 3-way speaker.

LCCs



Our first development, as pointed out in our book, was the BRIICe interface circuits. These circuits, as you will recall, were designed to have balanced-reactance and be isolated from ground.

In previous work assignments we had used various materials to make liquid shields. Gassing of the solution was a problem that was finally overcome. The project was finished, but was never brought to market. So from the experience and the information gained from this old project we decided to see if we could make *substitute* inductors and capacitors.

The endeavor was to come up with 'devices' that had far less reactance and could be made to be frequency selective. We felt by using the 'voltage' characteristic of a signal, that is - the associated electro-static fields, we would avoid the signals magnetic - current - characteristics of phase loss.

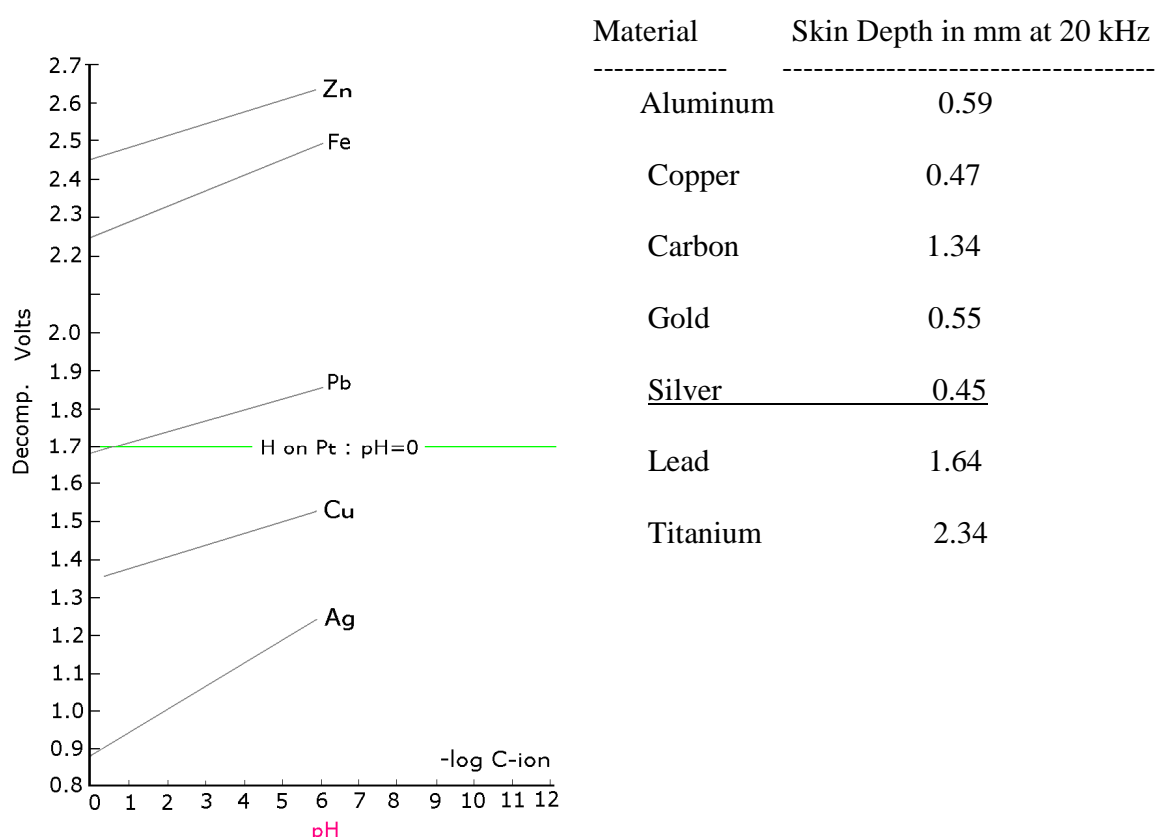
Using a 2 channel oscilloscope and a programmable sweep frequency generator, different types of materials were tested to see how they would respond. Remembering that dc motors and dc generators used carbon brushes that have a unique property of being resistive from side to side, but exhibited low resistance length wise, we decided to test a few types of carbon brushes. We learned that the carbon brush was not frequency dependent.

A pumice rock displayed some interesting static field properties.

The static field's noise was suppressed and any stable frequency change was passed through the pumice crystal. Pumice proved to be too hard to shape and had limited use as an audio frequency 'filter'.

Years before, we had used a **salt**-water-resistor as a RF load [Navy] to terminate our transmitter [2kW] into, so we decided to test various liquid solutions. The various salt solutions were able to be made semi-conductive like solid state materials, as in a transistor.

This solid state doping idea was employed in our testing. By using liquids 'doped' with various **conductive salts** and metals having distinctive 'static-field' properties we came up with new devices with their associated circuits that act like an inductor and a capacitor.



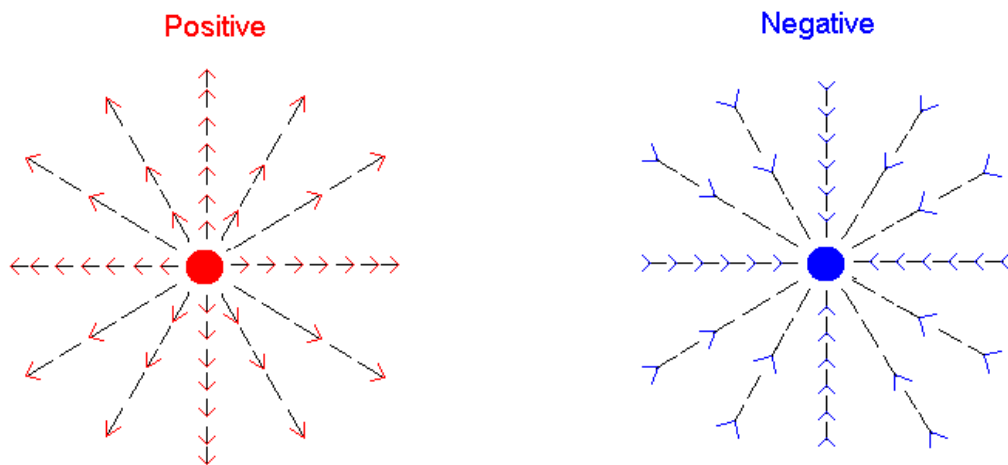
We followed the ideas of the BRIICE circuits that of being balanced and isolated from ground by using differential amplifier circuits in conjunction with the unique Liquid Crystal Circuits.

Using 'salt-water' as an -interconnect- on the 'low-level' side of an audio amplifier avoids most, if not all, of the problems associated with traditional 'crossovers'.

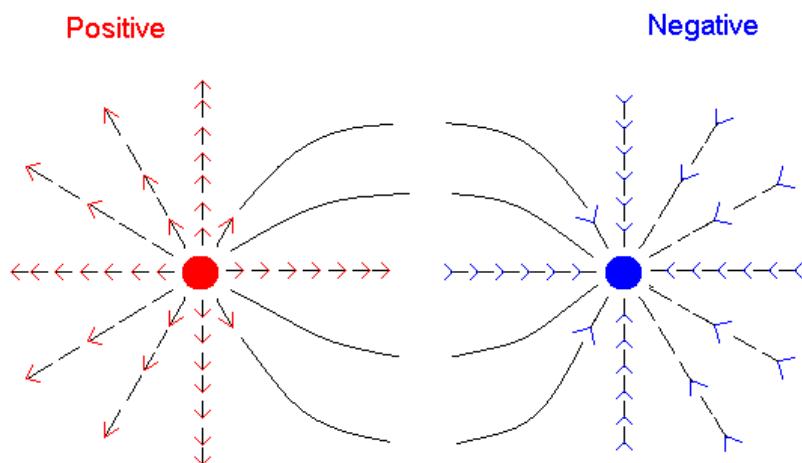
The Liquid Crystal Circuits [LCC's] use four 'poles' placed in a 'salt-water-medium'. We discovered that the shapes of the containers help 'form' the 'space-charge' around the contacts.

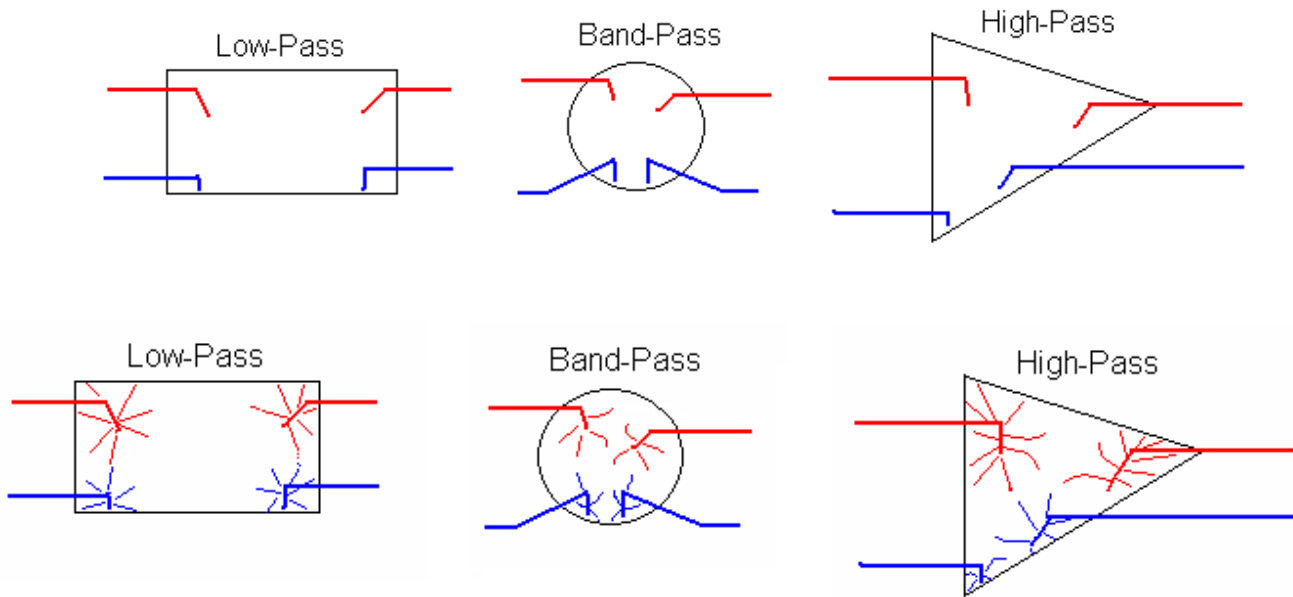
So by locating the four 'poles' in unique physical alignments we found that we could adjust these LCC's to make 'tunable' low-pass, band-pass and high-pass 'filters'.

Static Fields



Static Fields





Since these filters do not have a 'reactance' characteristic these devices have very little phase shift. Compared to traditional reactive elements, the phase shift is 2-10 degrees up into the low 20 Mega Hertz range.

The 'salt-water' solutions are of metallic salts like: Copper-sulfate, Sodium-chloride, Potassium-hydroxide, Sodium-hydroxide, Iron and Copper-chlorides and other soluble metallic salts.

The magnetic fields are not displayed in order to demonstrate the static-fields. The magnetic fields [not shown] are influenced by magnetic materials as required; such as Iron wire, copper discs and various bismuth shapes.

Earlier circuits were sensitive to movement or outside vibrations so we had to stabilize the liquids. These salts solutions are 'stabilized' by using various semi-rigid organic **jells** like Agar-Agar, pectin or gelatin.

The next problem and concern was about the length of time of the eventual decomposition of the jells used.

We contacted several manufactures of Agar-Agar, pectin and gelatin; to ascertain what caused the jells to degrade and liquefy. Bob Ryan one of the manufacture's chemist informed us that bacteria in the products breaks down the jells after 2-3 days. A 50 to 100 bacteria count are allowed per pound in most products.

The bacteria grows rapidly and after several days the jell walls are broken down turning the semi-rigid jell into liquids lumps and finally turns brown consisting of various molds. Fortunately the jell-bacteria are highly susceptible to and controlled by any common copper-salts. After firming up the liquids and eliminating the bacteria concern, we were then able to continue our LCC designing.

The size of the three containers is about 1 to 1.5 inches in diameter or length and width, and the depth of the container is about 1 inch. Copper or other metallic discs are used to 'shape' the frequency response of some of the filter circuits.

The input signal levels should be kept low in amplitude [in order to avoid unwanted chemical reaction] ranging from approximately 25 milli-Volts to 100 milli-Volts.

The Platinum, copper or carbon contacts are used for the input-side of the audio signals and other 'types' of contacts are used as required to 'tune' the frequency response of the LCC filters. Output contacts of brush-carbon, soft iron, copper-tin plated, aluminum and lead.



Sealed LM733C Op-Amp. : Cu-Disc, CuSo₄, Iron & Copper wire

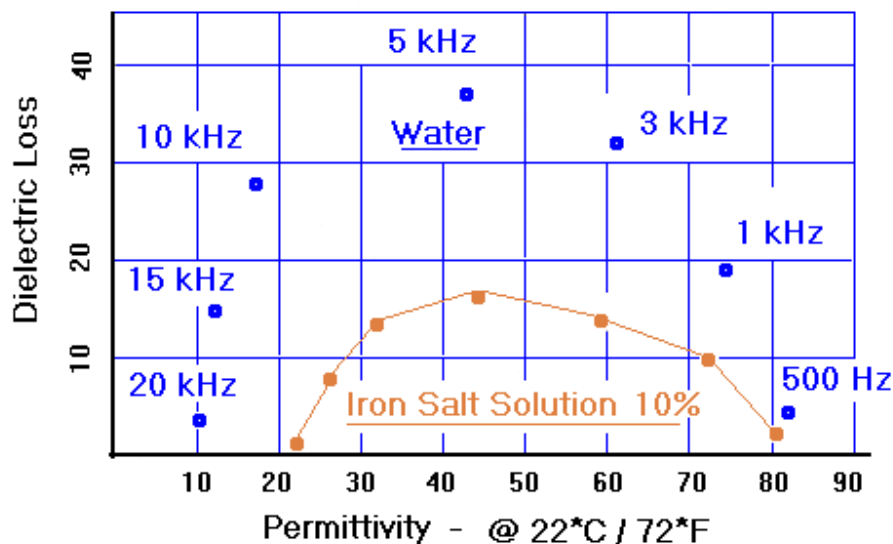
The Phase response, of the LCC circuits, is individually unique. Since Phase changes are dependent upon reactance, and that these LCC filters have no reactance; phase change is very low and stable. Noise is also low since the LCCs are isolated from ground being feed differentially and are connected to a differential amplifier.

Tuning is possible due to differences in the various metal-contact's voltage gradients and what type of 'salt' medium is used.

At this low level of signal the chemical properties of the metals and salt solutions are of great interest.

Aluminum and copper will form various compounds easier than silver. Silver, though, once reacted with chloride is lost to the filtering 'system', since Silver-Chloride is very stable and non-conductive.

So by using various combinations of these materials as mentioned, the tuning of the filters, mildly complex, can be accomplished by any experimenter using simple test equipment.



<u>Substance</u>	<u>Dielectric</u>
Acetic acid	6.2
Acetone	21.5
Alum	4.2
Aluminum hydroxide	2.5
Aluminum sulfate	2.6
Ammonia	15.1
Ammonia solution 25%	31.6
Ammonium chloride	4.3
Caustic potash	3.3
Carbon black	18.8
Charcoal	1.3
Coal dust	2.5
Coal 10-15% moisture	4
Copper Chloride	3.8
Copper Nitrate	3.4
Copper ore	5.6
Corn starch syrup	18.4
Crystalline sugar	2.1
Ethanol	16.2
Ferrite pellets	21
Ferrosilicon	10
Glucose 50% [water]	30
Glue	2
Glycerol water	37
Green vitriol	32.4
Honey	24
Hydrochloric acid	5
Hydrogen peroxide	84
Iodine	11.1

Lime	2	
Linoleic acid	2.7	
Malt	2.7	
Methanol	33	
Molasses	31.3	
Nitric acid	8 - 19	
Potash salt	2	
Potato starch	1.7	
Quartz stone powder 100 mesh	2.7	
Sucrose solution	20	
Sugar	1.8	
Salt water	32	
Rock salt (0-25 mm)	4.3	
Silica sand	2	
Sodium chloride	23	
Sulfur	3.5	
Talcum powder	1.5	
Tartaric acid	35.9	
Titanium Dioxide	78	
Tooth paste	18.3	
Urea	2.9	
Vinegar	24	
Water, Sea	32	
Water Dematerialized	29.3	
Water-in-oil-emulsion	24.2	
Wheat starch	2.5	
Zinc oxide	1.5	
Zinc powder	4.4	