Metodo SIMPEST+

Audio Cables Tests Made Easy

A signal integrity assessment method for audio cables based on the SIMPEST+ tool

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Introduction

The cables used in audio reproduction systems, whether for power or signal, have always been a source of controversy, literally dividing enthusiasts, technicians, and industry professionals into two camps. A veritable schism exists between those who argue that cables impact the listening experience and those who staunchly maintain that, provided they are of adequate gauge, they have no influence on the electrical signal passing through them and thus on the final music playback.

A dispute that has lasted for decades and involved tens, if not hundreds of thousands of people worldwide cannot be baseless. Therefore, it would be foolish to think that the truth lies solely on one side or simply in the middle. It is far more logical to presume that there are very specific reasons underlying all this, which is why in the past many technicians and/or enthusiasts with electrical and electronic expertise have endeavored to prove one thesis or the other.

Hence, a multitude of measurements have been taken: resistivity, impedance, parasitic capacitance, frequency response, impulse response, immunity to induced noise, and so on.

All studies conducted to date have ultimately reinforced the idea that a well-designed, well-made, and properly sized cable for its specific application cannot alter the musical signal to the point of influencing the listening experience.

The theories, and even more so the thousands of tests performed on cables, have led a large part of the scientific community, and obviously also a large number of enthusiasts, to assert that cables for audio applications have no substantial influence on the listening experience, even on very high-level or so-called High-End audio systems.

The direct consequence of this assumption has been to relegate those who continue to maintain that audible differences exist to a particular category of people affected by a form of self-suggestion, accused of suffering from a preconditioning that alters their listening experience and has nothing to do with any actual difference in audio reproduction between using one specific cable and another.

To further reinforce this point against the latter group, blind and double-blind listening tests have been conducted, attempting by all means to demonstrate and ultimately confirm that different cables make no difference to the listening experience.

But is it truly the case that this large group of people capable of hearing/perceiving differences between various cables is indeed self-suggested and preconditioned to the point of having, so to speak, genuine auditory misperceptions?

Personally, as a great music enthusiast and scholar of electronics and acoustic physics, I have often found myself addressing this topic, having personally experienced—albeit slight—audible differences when using different cables. My curiosity has frequently reached a level that led me to build remote-controlled switches allowing for instantaneous cable swapping during listening sessions, precisely to disprove or confirm the differences I "thought I heard." The results of these switches have often been surprising.

To my great astonishment, I observed that the audible differences were not constant and became more evident with different music tracks and, most importantly, at different volume levels.

The certain fact is that I, too, had detected audible differences. Consequently, as a technician, I realized there must necessarily be something beyond what has been instrumentally measured so far, beyond current theories and the state of the art.

This has driven me to resume research and evaluate the possibility of using alternative methods of analyzing the phenomenon, different from those adopted until now.

Theoretical framework

The analysis of an electrical cable's behavior when transmitting an audio signal cannot be separated from the analysis of the signal itself.

Starting from the fundamentals of its composition, we can affirm that it is a composite signal where —at any given instant—a mixture of signals with different intensities and frequencies is present.

Every instrument in the musical program contributes to the mix with its own fundamental frequency and its respective harmonics; the same occurs for human voices and singing.

This set of electrical signals, once mixed, thus gives rise—as mentioned before—to a composite signal whose currents are, at certain instants, of opposite sign, i.e., in phase opposition.

But before proceeding with this analysis, and to better explain what I have observed, let us proceed with an example: let us momentarily disregard the complex harmonic content of musical signals and focus our attention on primary signals devoid of harmonic content (signals with multiple frequencies and intensities progressively decreasing relative to the main frequency).

Let us therefore imagine mixing two signals of equal frequency and equal voltage amplitude but in phase opposition: the resulting signal will be zero because, obviously, the two signals, being in phase opposition, will cancel each other out.

For a better understanding by non-specialists, allow me a further example using batteries.
If we connect four 1.5-volt batteries in series, respecting the polarity—that is, connecting the positive terminal of the first to the negative terminal of the next, and so on to the last battery—at the ends of the series we will have 1.5V x 4 = a total voltage of 6 volts.

Now, if we take one battery from the series of four and reverse its polarity, it will cancel out one of the other three batteries. Thus, at the two ends of the series, we will have a voltage of (3x1.5V) 4.5V – 1.5V = 3V. Indeed, the voltage of the battery with reversed polarity will subtract from the total voltage of the series.

It obviously follows that if we reverse the polarity of two batteries instead of one, the voltage at the ends of the series will be completely canceled, i.e., 3V – 3V = 0 Volts.

This example clarifies that voltages, and therefore signals in phase opposition, subtract from each other until they are completely canceled when their amplitude is equal. Thus, the principle is identical for alternating current signals with variable frequency, like musical signals, as it is for direct current voltage from batteries.

Let us now return to our two audio signals of equal frequency but in phase opposition; if their intensity were equal, as we have seen, the resulting mixed signal would be zero. But what happens if the second signal (which we remember is in phase opposition) has an amplitude of only 10% of the first?

In this case, the mix would result in a 10% attenuation, and the output value would have an amplitude equal to 90% of the larger input signal to the mixer.

Having made this observation, let us now set the amplitude of the second signal equal to the first, but shift its frequency higher by a factor of 3; let us set signal A, for example, at a frequency of 1000 Hz and signal B at a frequency of 3000 Hz.

If we now observe the two signals on an oscilloscope, visually superimposed, we can see how cyclically the two signals intersect in phase opposition: the rising edge of A crosses the falling edge of B, giving rise—at the points of these intersections—to effectively opposing currents, i.e., in phase opposition with each other, which produce (continuous) micro (nano) attenuations/cancellations.

This, then, is the new point of observation on which I have focused and which I intended to bring to light in this work: to define and ultimately measure the losses due to opposing currents in musical signals which, in my humble opinion, go beyond the simplistic definition of signal intermodulation distortion and which could be the basis of the slight differences that many detect when listening to music through the use of different cables.

My question is: are there, therefore, losses in cables related to the "opposing currents" intrinsic to musical signals that can vary with the physical characteristics of the latter? And if these exist, can they be measured?

To answer these questions, it is essential to radically change the approach to the problem, the method of measuring and evaluating the physical and electrical parameters of cables—and, paradoxically, it will be necessary to set aside the canonical Ohm's Law universally used for their sizing, as it relates to the transport of electrical energy—and instead examine what truly happens inside the cable while it is subjected to electric fields that cyclically and continuously give rise to instants with currents in phase opposition.

How does the electron flow behave? What is the involved electron mass? Which external factors influence its behavior?

The research work is far from complete, and for now, in an attempt to lay the groundwork for answering these questions, we will proceed to create a tool that allows us to credibly compare what "enters" with what "exits" a cable involved in the transmission of a complex musical signal.

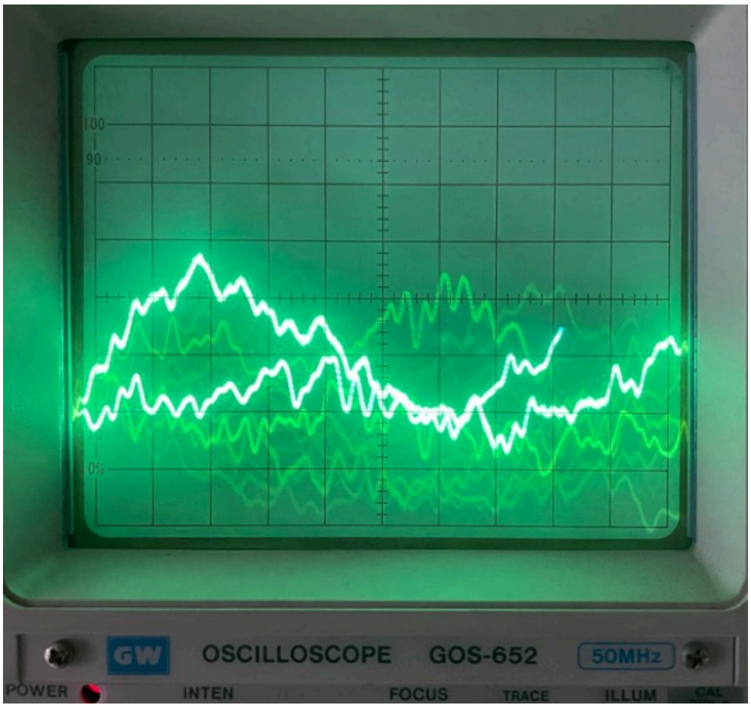


Figure: An instantaneous snapshot of a musical passage transmitted through the cable. A multitude of concurrent signals, both in-phase and in phase opposition, as previously discussed, can be observed.

Measurement method

In this analysis, we will primarily examine the behavior of power cables, i.e., the cables that typically connect amplifiers to loudspeakers.

Setting aside the issues related to current carrying capacity and potential voltage drops in the cable, since that type of investigation has not led to adequate answers in the past and has instead supported conclusions antithetical to our premise, we will focus on analyzing the differences (if they truly exist) between what exits the amplifier and what actually arrives at the loudspeaker.

To do this, we will need a differential measurement instrument capable of detecting very small signals and comparing them, displaying the result on a readout that can show both positive and negative quantities.

The need to also detect negative quantities—i.e., cases where the complex signal A at the cable input could, under certain circumstances, prove to be "less" than the complex signal B detected at the cable output—stems from the fact that, as we will see later (and the phenomenon is far from remote), under certain conditions, phase rotations and phase leads, as well as the instantaneous attenuations mentioned before, can cause the signal at the cable output to be greater in absolute value than the input signal.

But let's see how the measurements are taken. Both the signal at the cable input (amplifier output) and the signal at the cable output (i.e., at the loudspeaker input) are sampled via two probes and fed to the measurement instrument.

Each signal is converted to a unidirectional (DC) form via a precision full-wave rectifier. This is implemented with dedicated operational amplifiers, which ensure that the processed signal suffers no appreciable losses for the purposes of comparison and measurement.

The two signals, A and B, now perfectly rectified, remain alternating in nature but unidirectional in flow. Before reaching the differential amplifier stage—also built using precision operational amplifiers—they are passed through a buffer stage. This buffer stabilizes their behavior and makes them immune to external noise or losses due to the "load" of the subsequent stage.

Downstream of the two buffers, I included the option to insert filter capacitors, which allow the signal to be stabilized and smoothed (no longer pulsating).

The insertion of these capacitors during measurement introduces a sort of "SLOW" function regarding signal variability. This allows for the visualization of differences based on average values from each channel. Their exclusion, conversely, allows for a dynamic, instantaneous reading of the signal.

The two signals, with or without filter capacitors, are then compared via a differential amplifier. The output voltage signal V of this amplifier—further amplified—currently drives an analog measurement instrument with a central zero point.

The instrument's inputs feature a very high impedance, certainly high enough to not affect the amplifier's load or the cable itself in any way. Furthermore, measurements can easily be performed on the real signal, i.e., music under actual operating conditions, at the desired listening volumes.

The instrument thus allows for the analysis of the cable's behavior under real-world usage conditions, not just with standard test signals on a laboratory bench.

Before defining and presenting the two measurement methods I will show later, it is necessary to state that several hundred measurements were performed under the most varied conditions (combinations of sources – amplifiers – loudspeakers, frequencies – power levels) on cables of different types, lengths, and installation conditions.

The instruments and devices used for these measures are:

- App Signal GEN iOS digital signal generator
- App Multi Task Frequency Generator - Android
- Fluke 177 digital multimeter
- Digital multimeter HT 25N
- Oscilloscope GW GOS-652
- Resistive load 8 Ohm

- Piooner CD Player PD S605
- Sony CD player CDP AX50ES
- Harman Kardon PM 645 amplifier
- AERON 4P II Amplifier
- Tower TEN DM22 Amplifier
- Key Silence SE6550D Amplifier

- Wharfedale Diamond 9.1 diffusers
- JBL L100 Classic speakers
- Speakers Key Silence All Round Symphony 82
- Resistive LOAD 8 Ohm

- SIMPEST+ differential analysis tool at the base of the method

Among the cables used for testing, below those of which I will report in summary the data collected:

1. Silver copper twisted cable 2 x 1 mmq
2. 25 mmq copper single-fire pair
3. Multipolar torque twist 2 x 6 x 0.35 mmq (equivalent section 2 x 2.1 mmq)
4. 4-pole 2.5mmq cable used in pairs
5. SIGNAL PATH - OVERTURE 2 x 4 x 2.5 mmq radial structured multi-pole cable
6. Pair 2 poles 2 x 2 x 1 mmq
7. 2.5 mmq copper single-fire pair
8. Manually twisted 2.5 mmq single-wire copper pair

The methods for performing measurements on the behavior of power cables are two-fold:

The first method involves a comparison between two cables by connecting cable A to the right channel and cable B to the left channel, and powering the amplifier with the exact same audio signal, perfectly balanced between the two channels.

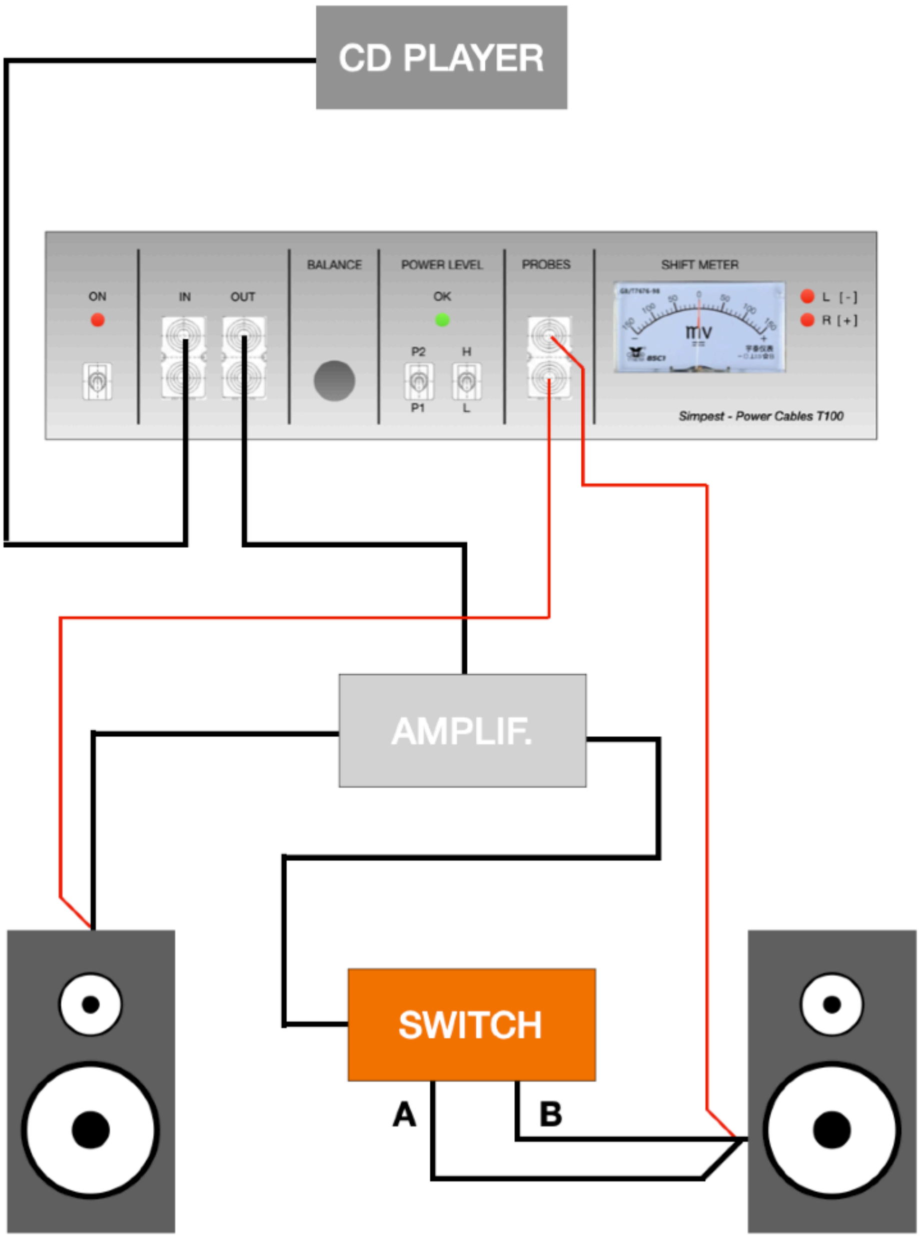
The second method, on which we will focus because it is, in my opinion, more direct, immediate, and less prone to error, involves measuring the signal at the beginning and the end of the cable under test.

The following figures show the connection diagrams for the first and the second method, and a variant of the latter. Naturally, the loudspeaker symbol is generic and can also represent a resistive dummy load in place of a real loudspeaker system.

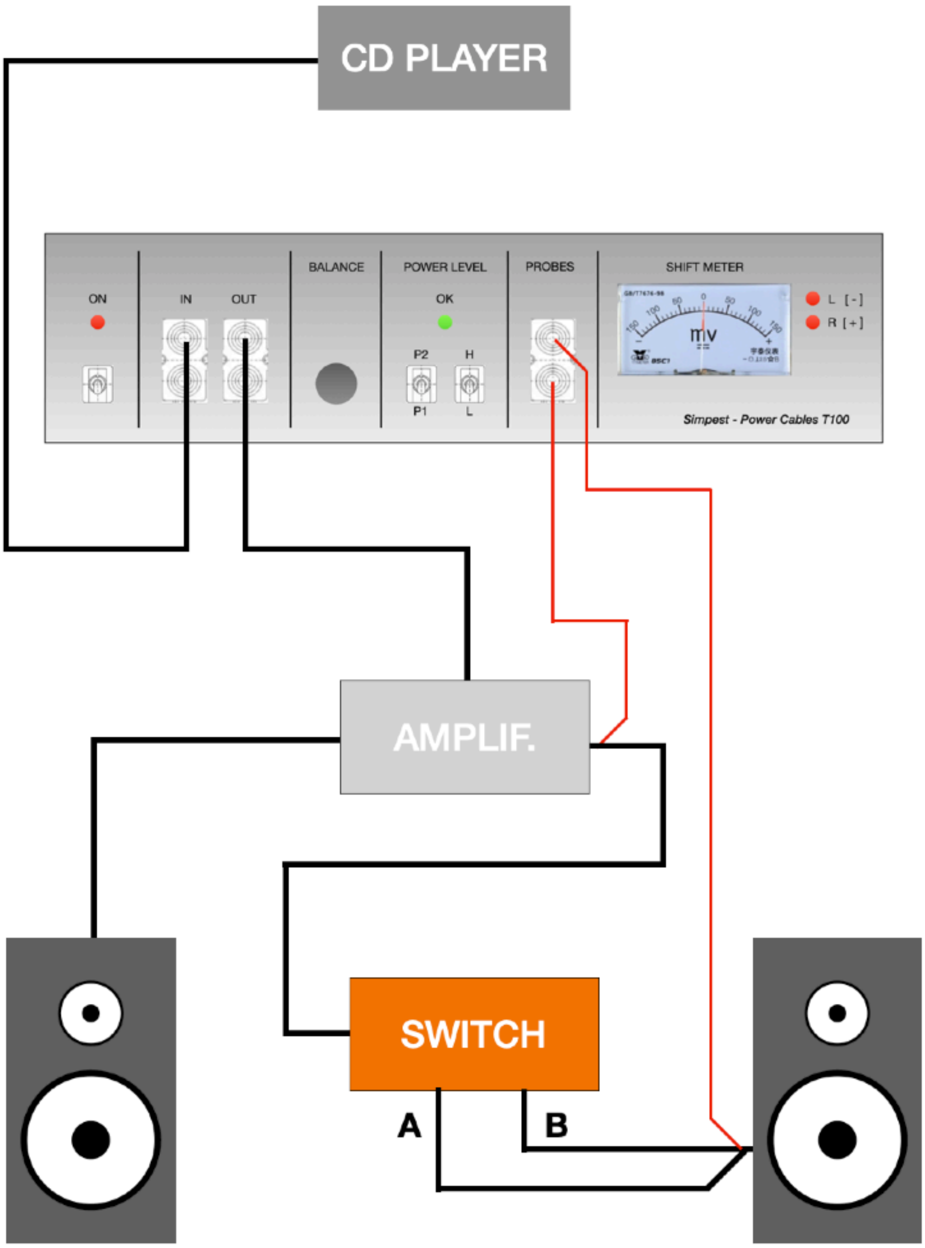
The CD Player acting as the source can obviously be replaced by a signal generator.

In the case of measurement methods 2A and 2B, since the measurement is performed on a single cable, the source can also be connected directly to the amplifier, i.e., without passing through the instrument that allows for balancing between the two channels.

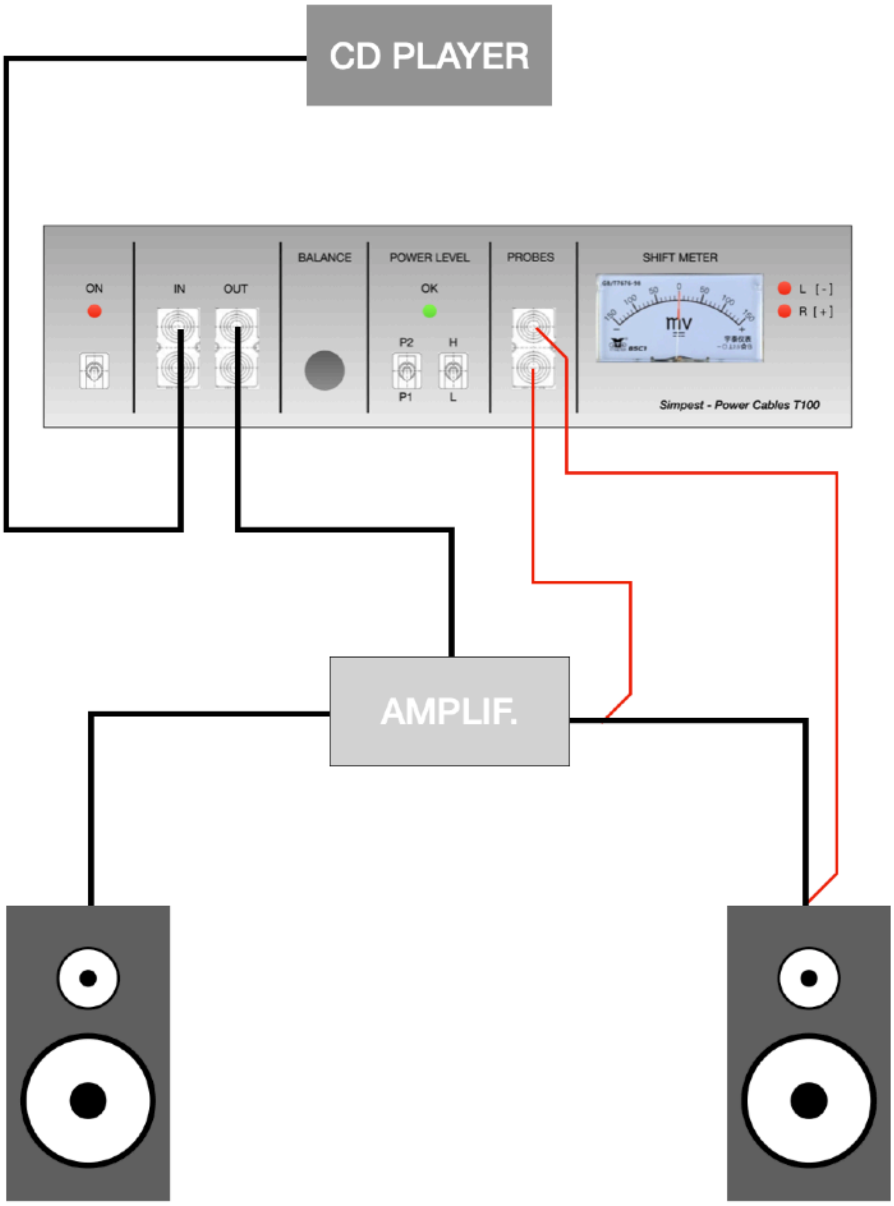
Method 1


CD PLAYER
ON
IN
OUT
BALANCE
POWER LEVEL
OK
P2
H
P1
L
PROBES
SHIFT METER
mV
L [-]
R [+]
Simpest - Power Cables T100
AMPLIF.
SWITCH
A
B

Method 2 A


CD PLAYER
ON
IN
OUT
BALANCE
POWER LEVEL
OK
P2
H
P1
L
PROBES
SHIFT METER
L [-]
R [+]
Simpest - Power Cables T100
AMPLIF.
SWITCH
A
B

Method 2 B



CD PLAYER
ON
IN
OUT
BALANCE
POWER LEVEL
OK
P2
H
P1
L
PROBES
SHIFT METER
mV
L [-]
R [+]
Simpest - Power Cables T100
AMPLIF.

Method 2 B

The set of measurements reported below were performed on a **RESISTIVE DUMMY LOAD** under the following power conditions:

- **Vpp = 30 V**
- **Vrms = 10.64 V**
- **RL = 8.25 Ω**
- **RMS Power = 13.66 W**

Source: Multi-Task Frequency Generator App – Android
Amplifier: Key Silence Model Tower TEN DM22
Test Environment: Ceramic tile flooring on a reinforced concrete slab with hollow brick infill.

All tested cables had a length of 4 meters +/- 20%.

Data Reading Notes

- ✳ **Input Signal:** The signal injected into the amplifier, with a specified amplitude of 30V peak-to-peak.
- ✳ **Variation (ΔV):** The variation read on the measurement instrument, expressed in Volts. Please refer to the attached table for the correspondence between the value indicated by the instrument and the actual measured voltage value in milliVolts.
- ✳ **Noise:** The value of spurious signals measured on the positive conductor of the cable when traversed by the composite signal indicated in the table.
- ✳ **Phase Shift:** Indicates whether, during the application of the variable signal, the Transfer Losses (TL) change sign or not. *(For signal values below 18 Vpp, all cables exhibit phase inversions in the losses at different frequency levels).*
- ✳ **TL (Transfer Losses):** The voltage drop measured across the line (at the amplifier output and at the loudspeaker/dummy load input) and compared differentially; it represents the overall voltage drop during the transmission of both single and composite signals.

$$TL = \sqrt{Sm} * Sc$$

Where Sm is the average of the variations with a single signal and Sc is the variation with a combined signal.

Example of the first cable in the table:

$$TL = \sqrt{(2 + 4{,}6 + 8)/3} * 4{,}8 = 10{,}58$$

- **IQI Integrated Quality Index:** An index of integrated quality that accounts for both Transfer Losses (TL) and the level of Composite Noise (CN) generated during the passage of the combined signal (Sc). In the relationship defining the IQI, these two parameters carry equal weight and are placed in the denominator such that the index increases as their values decrease. Lower values of TL and CN result in a larger IQI, identifying a cable with superior performance.

$$IQI = 100 * 1 / \sqrt{TL * CN}$$

Example of the first cable in the table:

$$IQI = 100 * 1 / \sqrt{10{,}58 * 2{,}5} = 19{,}44 \;\; => \;\; 19{,}5$$

Experimental results

Silver-plated copper twisted cable (2 x 1 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**2**	**-**	**-**
5 KHz	**4,6**	**-**	**-**
15 KHz	**8**	**-**	**-**
50 Hz + 5 KHz + 15 KHz	**4,8**	**(CN 2,5) ~ 250 mV**	**-**
50 Hz ÷ 18 KHz	**-**	**-**	**No**

TL=10,58 (TL Transfer Losses) - **IQI=19,5** (IQI Integrated Quality Index)

Single Core Cable N07VK 2 x (25 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**2,2**	-	-
5 KHz	**2,5**	-	-
15 KHz	**8**	-	-
50 Hz + 5 KHz + 15 KHz	**4**	**(CN 1,5) ~ 150 mV**	-
50 Hz ÷ 18 KHz	-	-	**No**

TL=8,22 (TL Transfer Losses) - **IQI=28,5** (IQI Integrated Quality Index)

*****

Multipole braided cable 2 x (6 x 0,35 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**1,6**	-	-
5 KHz	**4,6**	-	-
15 KHz	**8**	-	-
50 Hz + 5 KHz + 15 KHz	**4**	**(CN 2,4) ~ 240 mV**	-
50 Hz ÷ 18 KHz	-	-	**No**

TL=8,67 (TL Transfer Losses) - **IQI=21,5** (IQI Integrated Quality Index)

*****

4-pole FROR cable 2 x (2 x 2,5 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**1,5**	-	-
5 KHz	**5,2**	-	-
15 KHz	**8**	-	-

Input Signal	Variation	Noise	Phase Shift
50 Hz + 5 KHz + 15 KHz	**3,6**	**(CN 0,8) ~ 80 mV**	**-**
50 Hz ÷ 18 KHz	**-**	**-**	**No**

TL=7,96 (TL Transfer Losses) - **IQI=39** (IQI Integrated Quality Index)

*****

SIGNAL PATH OVERTURE cable 2 x (4 x 2,5 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**1,6**	**-**	**-**
5 KHz	**4,6**	**-**	**-**
15 KHz	**8**	**-**	**-**
50 Hz + 5 KHz + 15 KHz	**4,4**	**(CN 0,4) ~ 40 mV**	**-**
50 Hz ÷ 18 KHz	**-**	**-**	**No**

TL=9,57 (TL Transfer Losses) - **IQI=51** (IQI Integrated Quality Index)

*****

Cable 2 poles FROR 2 (2 x 1 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**1,9**	**-**	**-**
5 KHz	**4,5**	**-**	**-**
15 KHz	**8**	**-**	**-**
50 Hz + 5 KHz + 15 KHz	**3,8**	**(CN 2,7) ~ 270 mV**	**-**
50 Hz ÷ 18 KHz	**-**	**-**	**No**

TL=8,32 (TL Transfer Losses) - **IQI=21** (IQI Integrated Quality Index)

*****

Single Core Cable N07VK 2 x (2,5 mmq)

Input Signal	Variation	Noise	Phase Shift
50 Hz	**1,8**	-	-
5 KHz	**4,6**	-	-
15 KHz	**8**	-	-
50 Hz + 5 KHz + 15 KHz	**2,1**	**(CN 3,7) ~ 370 mV**	-
50 Hz ÷ 18 KHz	-	-	**No**

TL=4,60 (TL Transfer Losses) - **IQI=24** (IQI Integrated Quality Index)

*****

Single core cable N07VK 2 x (2.5 mmq), Hand-twisted

Input Signal	Variation	Noise	Phase Shift
50 Hz	**2**	-	-
5 KHz	**5**	-	-
15 KHz	**8**	-	-
50 Hz + 5 KHz + 15 KHz	**3**	**(CN 1,9) ~ 190 mV**	-
50 Hz ÷ 18 KHz	-	-	**No**

TL=6,70 (TL Transfer Losses) - **IQI=28** (IQI Integrated Quality Index)

From the measurements and their comparison, we can highlight that the Transfer Losses (TL) of the musical signal are influenced not only by the copper cross-sectional area of the conductor but also by the cable's construction morphology and installation conditions.

Indeed, specific repeated measurements were taken with the 25 mm^2 N07VK single-core cable using two different installation methods, in addition to the one reported in the table above, where the two parallel cables were laid on the floor in an arch shape: from the amplifier, they reach the slightly forward-positioned loudspeaker, forming a slight arch.

In the first variant, the cables were lifted off the ground using CD cases placed at intervals of approximately 35 cm. Under these conditions, the following was observed:

Transfer losses at 50 Hz remained substantially unchanged, while transfer losses at 5 kHz and 15 kHz decreased by 60% and 20%, respectively. The noise level decreased by only 10%. Consequently, the overall performance of the cable, albeit slightly, improved. It would be interesting to verify these variations with the cable installed on a completely wooden floor structure and on one made entirely of reinforced concrete or steel.

We would probably see significantly different variations depending on the type of environment.

Note: *If this holds true, an operating audio power cable, when resting on a floor structure containing abundant ferromagnetic material, appears to behave like the primary winding of a transformer under "no-load" conditions—i.e., without a load on the secondary winding—exhibiting its own internal power consumption.*

Another important aspect we can observe is that transfer losses (TL) can be higher even on cables with a larger cross-section and can also decrease for conductors of the same cross-section depending on whether they are twisted or not.

Twisted multi-strand conductors tend to perform better in terms of general noise, even at higher power levels; this could be one of the reasons why bi-wiring is highly appreciated in the fine-tuning of audio systems.

Interpretation of Results

Observing the equivalence table, which allows us to interpret the numbers detected by the instrument, we discover that transfer losses, for a given amplitude of the applied signal, vary not only as a function of frequency (in the case of single signals) but, most importantly, with the multiple combinations of composite signals.

Now, considering that a musical program is naturally far more complex than the composite signal we used for testing purposes, the transfer losses, albeit limited in magnitude, can certainly impact the listening experience.

Within these transfer losses (TL), the primary signals affected are the weakest ones, i.e., the progressively higher harmonics of the musical program.

The loss of harmonics and the micro-attenuations that invariably occur (already above 3-4 Watts RMS) naturally affect the final result of the reproduction.

It might seem unnecessary to say, but let's remember that we are talking about differences that can be detected through careful and trained listening on adequately high-level systems.

INSTRUMENT VALUES - VALORI SULLO STRUMENTO

	50 Hz			1 KHz			5 KHz			15 KHz		
Real Vpp Signal	In A	In B	0	In A	In B	0	In A	In B	0	In A	In B	0
0,2	2	2	0	2	2	0	2,2	2,4	-0,2	2,2	2,6	-0,4
0,5	5	5	0	4	4	0	5,2	3,1	2,1	5,4	2	3,4
1	6,5	6	0,5	6	5,5	0,5	7,6	4,6	3	8	5,2	2,8
1,6	7,2	6,6	0,6	7	6,2	0,8	8	7,2	0,8	8	7,4	
2,4	7,5	7	0,5	7,6	6,5	1,1	8	7,4		8	7,4	
4	7,7	7,1		8	7,1		8	7,4		8	7,4	
6	7,8	7,2		8	7,4		8	7,4		8	7,4	

Figure: The equivalence table showing the correlation between the instrument's reading and the actual attenuation value at different frequencies can be observed here.

Returning to the measurements and their significance, differences between the signal at the cable input and the signal at its output were detected, ranging from 200 mVpp up to 2.4 Vpp.

In the set of measurements, the "worst-performing" cable, identified as the twisted 2 x 1 mm^2 with silver-plated copper conductors, recorded variations of up to 1.6 Vpp above 12 kHz, with average values around 0.75 Vpp.

Given that we supplied the cable with signals having an amplitude of 30 Vpp, we calculate an attenuation in DB as follows:

$$20 * \text{Log}\ (\text{Vout/Vin}) = 20 * \text{Log}\ (\ (30-1.6)/30) = 0.48\ \text{DB (Above 12 KHz)}$$

and

$$20 * \text{Log}\ (\text{Vout/Vin}) = 20 * \text{Log}\ (\ (30-0.75)/30) = 0.22\ \text{DB}$$

Besides showing a different response to various frequencies and composite signals, the tested cables exhibited different levels of "Noise": This refers to a signal detected at both ends of the positive conductor while it is transporting the composite signal.

Its magnitude seems unrelated to the variations causing the transfer losses (TL) and also seems independent of the conductor's cross-section: significantly different values were detected, regardless of dimensional data and transfer losses.

The level of "Noise" detected on the conductor appears to be linked to its morphology and seems to decrease with multi-conductor cables.

The detected spurious signal reached, in the worst case, a value of about 270 mV: (Recall that the measurement refers to the cable transmitting concurrent signals of 50Hz, 5KHz, and 15KHz, each with an amplitude of 30 Vpp).

I cannot currently say if and how much this might actually affect the infamous "infra-instrumental silence" and thus the level of detail in musical reproduction.

However, it is likely that such a signal is, in fact, transferred to the loudspeakers and gets mixed with the original musical program.

Above 13 kHz, with transmitted signal intensities greater than 10/12 Vpp, all cables show a sudden increase in losses which, as can be seen in each table, at 15 kHz - 30 Vpp, all reach a variation equal to 8, equivalent to potential differences between input and output greater than 1 / 1.6 Vpp, naturally due to the inductive component of the line.

In the table below, I provide a summary of the tested cables, ranked by performance defined by the transfer losses (TL) and the Integrated Quality Index (IQI), referring to the tests performed with the Resistive Dummy Load of 8.25 Ω.

For reasons of space, I do not include the values measured with the various loudspeakers and/or other amplifiers used in the experiment, nor the results of the "on-the-fly" cable switching on the circuit, which will be the subject of a future study.

The performance of the various cables on real loads can obviously vary considerably; however, they remain proportional to the values detected on the resistive load. Therefore, I consider the latter significant and potentially usable as a standard reference.

Classification of tested cables

Cable Type	Transfer Losses Average Sm	Transfer Losses Combined Sc	Noise CN	Transfer Losses	IQI
OVERTURE cable 2 x 4 x 2.5 mmq	**4,73**	**4,4**	**0,40**	**9,57**	**51,1**
FROR 4 x 2,5mmq	**4,9**	**3,6**	**0,80**	**7,97**	**39,6**
Single-core cable 25 mmq	**4,23**	**4**	**1,50**	**8,23**	**28,5**
Single-core cable 2.5 mmq hand-twist	**5**	**3**	**1,90**	**6,71**	**28,0**
Single-core cable 2.5 mmq	**4,8**	**2,1**	**3,70**	**4,60**	**24,2**

Cable Type	Transfer Losses Average Sm	Transfer Losses Combined Sc	Noise CN	Transfer Losses	IQI
Multipolar 6x0.35 mmq	**4,73**	**4**	**2,40**	**8,70**	**21,9**
FROR cable 2 x 2 x 1 mmq	**4,8**	**3,8**	**2,70**	**8,33**	**21,1**
Twist bipolar cable 1 mmq	**4,86**	**4,8**	**2,50**	**10,58**	**19,4**

From the table above, we can see a ranking of cables where the top-performing specimen, despite not having the absolute lowest Transfer Losses (TL), boasts a very low level of Noise (CN) compared to the others.

The IQI (Integrated Quality Index) here represents the cable's overall score, based precisely on the global transfer losses (TL) and the Composite Noise (CN) generated during the passage of the test composite signals. A higher IQI score indicates a cable that will consistently deliver superior performance across the most varied Amplifier | Loudspeaker combinations.

Whether in certain circumstances one might prefer a cable with a lower CN noise level or a cable with lower absolute TL transfer losses is a matter we will explore in future studies.

Further data can be collected and published by those who wish—even independently—to continue the study and experimentation based on the SIMPEST+ method announced and made available in this Paper.

Comparison with existing measuring instruments and methods

Among the primary methods for analyzing audio cables and their behavior during the transmission of electrical signals, we find the canonical systems for measuring electrical parameters such as resistance, capacitive reactance, and inductive reactance. This includes the measurement and graphical representation of their frequency response and the measurement of the so-called Voltage Drop (CdT in Italian)—essentially, the losses linked to the resistive component of the line, treating the signals of a musical program as if they were comparable to a "simple" or single-frequency electrical signal.

One of the most extensive works regarding tested combinations of Amplifiers - Cables - Loudspeakers is the study conducted by Dr. Renato Giussani and Enzo Messina in their work titled "Mito e realtà dei cavi di collegamento nei sistemi hi-fi" ("Myth and Reality of Connection Cables in Hi-Fi Systems").

Delving into the tests performed, we find the simple—and simplistic—solution of the equation involving the cable parameters mentioned above. The conclusions invariably end up conflicting with the different "listening perceptions" correctly reported by many enthusiasts, which are then dismissively attributed to psychoacoustics, while measuring and displaying a "frequency response" that says nothing about those differences reported by enthusiasts.

Without wishing to discuss the field of psychoacoustics and all matters related to suggestibility here, one thing should be clear: the bench tests performed to measure the frequency response of various cable combinations, which involve injecting a progressively variable frequency signal within the audible range, are irrelevant for verifying the cable's actual ability to support a complex audio signal without introducing significant or at least appreciable losses.

It is like trying to test the real load-bearing capacity of a bridge by having one car cross it at a time. This does not certify that the bridge is actually capable of handling constant, full-load traffic on all lanes simultaneously, nor does it verify that the oscillations are truly within the design-allowed values.

SIMPEST+ does not measure a frequency response but the differences across the line under "full load," i.e., with a real musical signal under actual listening conditions.

Something seemingly more advanced was done in past years on signal cables with an experiment called the NULL TEST, which carries fundamental errors that—also in that case—distort the final result. However, for obvious reasons of space and context, I will discuss this in detail elsewhere.

Applications in audio engineering and Conclusions

From the myriad of measurements taken—despite the limited availability of amplifiers, speaker systems, and cable types—it emerges that certain combinations seem to work better than others, and some cable types tend to perform better depending on the context.

Although lines consisting of multiple parallel conductors appear to have, overall, significantly lower transfer losses and are preferable for listening at moderate volumes, cables with a lower level of "Noise" (CN) seem more suitable for listening at sustained volumes and with the use of "difficult" speakers.

Far from being a definitive verdict, this study demonstrates—for the first time—that the "listening impressions" of many enthusiasts are anything but psychoacoustics; instead, they have defined and measurable parameters.

The SIMPEST+ method is intended to be a starting point for further in-depth study and refinement, aiming to help manufacturers and enthusiasts engage on common, defined ground, laying the foundation for a classification of audio cables based on measurable parameters.

This is done with the awareness that we are operating in the realm of "Fine Tuning" and not radical changes to an audio system's performance: fitting wider wheels on a Fiat Panda will not turn it into a race car, just as replacing a cable in a system that is not already optimized in its components, not correctly positioned in the room, and where the room itself is not sufficiently adequate, will not improve the musical listening experience in any way.

Data Availability

Further details, the schematic for building the tool, the detailed measurement methodology, and cable certification procedures are available in their respective repositories. Any unpublished material or additional information is available upon request by writing to **assistenza@keysilence.com** with the subject line **SIMPEST+ Info Request**.

Thanks and Greetings

My thoughts go to my mentors: Luigi and Umberto Nicolao, Paolo Viappiani, Bartolomeo Aloia—men of great talent and generosity, who have always been a source of inspiration and a point of reference;

To my father and his last words before passing:
“Never stop studying…”

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Metodo SIMPEST+ Audio Cables Tests Made Easy

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