PROJECT REPORT

Title: ICONOCLAST 4X4 XLR and RCA		
Date: 10/19/2018 REV 4	Project Number: PDC2842	Report Number:
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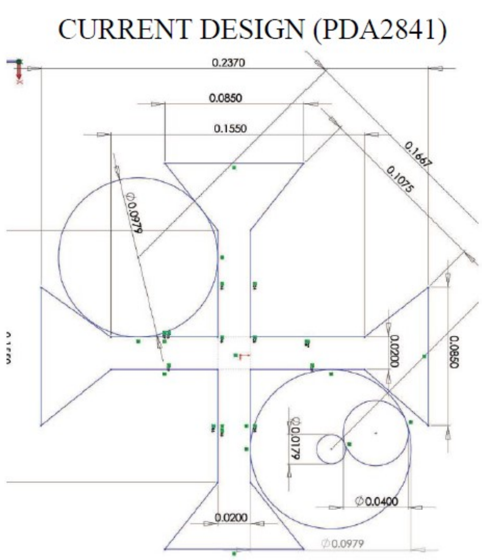
Lab Report Number(s):		

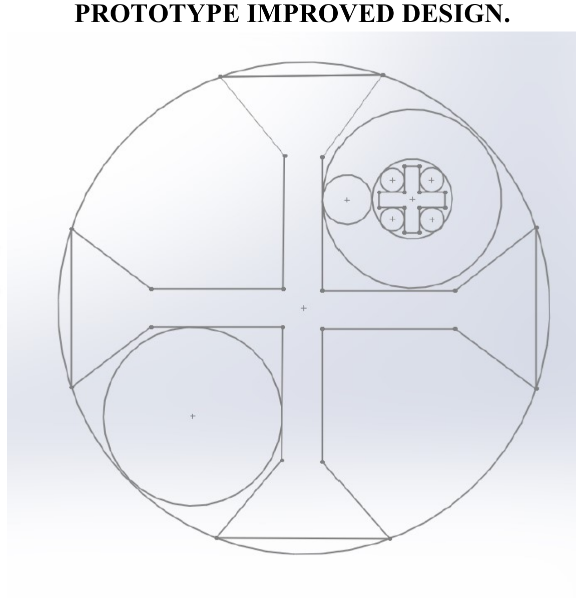
Distribution: Subject File, ICONOCLAST™

BACKGROUND: To possibly improve the performance of the XLR, to maybe achieve even lower L and C, we would need to revise the current design…and it will jump up the electromagnetic complexity. The balanced of L and C would shift some but the coherence will improve substantially.

Changing the "conductor" to a four insulated wire structure will lower INDUCTANCE through signal phase cancellation. The star quad arrangement will retain CMRR for NOISE reduction. Four smaller wires will improve PHASE, and lower wire loop DCR to mitigate ground loops.



PROTOTYPE IMPROVED DESIGN.



Capacitance is the DISTANCE between the plates (wires) and dielectric material(s).
Inductance is two-fold;

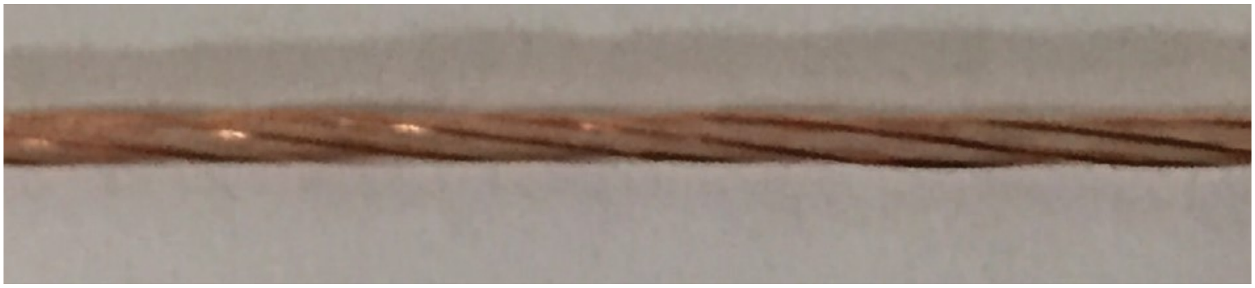
- The electromagnetic field cancellation.
- The loop area between the wires changes inductance.
- For inductance dielectric doesn't really matter, inductance is DISTANCE.

We will have the same nearly loop area in the design (C-C distance is the same) but each conductor in the new design will further remove signal electromagnetic fields based on the cancellation geometry. Inductance should drop compared to the single wire conductor system.

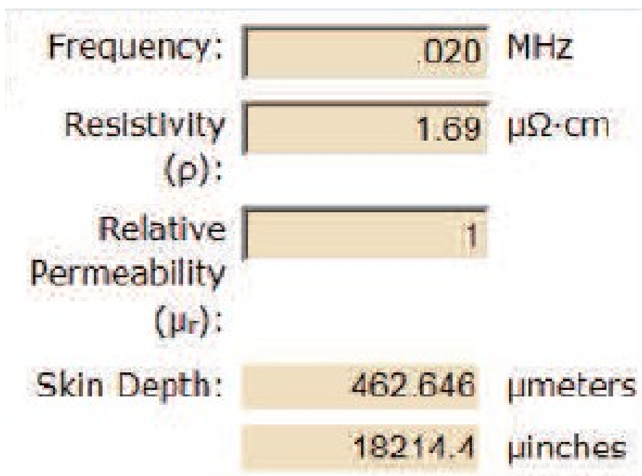
The capacitance requires the same meticulous attention paid to as the group dielectric. Since we are keeping the cable the same size so the capacitance HAS TO go up as we have more wires parallel to a dielectric (the center X-filler, beading and outer tube) , and closer to the dielectrics. The conductor size and dielectric determine the final size. The added wires and X-filler close to the wires are the main contributors to the required capacitance increase. But, lower inductance improves PHASE shift, and your ear is most sensitive to.

The current coherence, the main objective of the design with minimal L and C changes, is based on the skin depth penetration changes going from 1 x 0.018" wire to 4 x 0.010" wire for each conductor.

4 wire "conductor"



Technically, four -wire per conductor will increase capacitance some as we have more wires parallel to a dielectric, but the current coherence improves substantially, time aligning the low to high frequencies.



18214.4 μ inches = 18.2 mils @ one skin depth.

One skin depth is defined as when the surface current is 37% smaller going into the wire. If we had a wire that was 18.2 mils in size, the CENETR of the wire would have only 37% of the current measured on its surface.

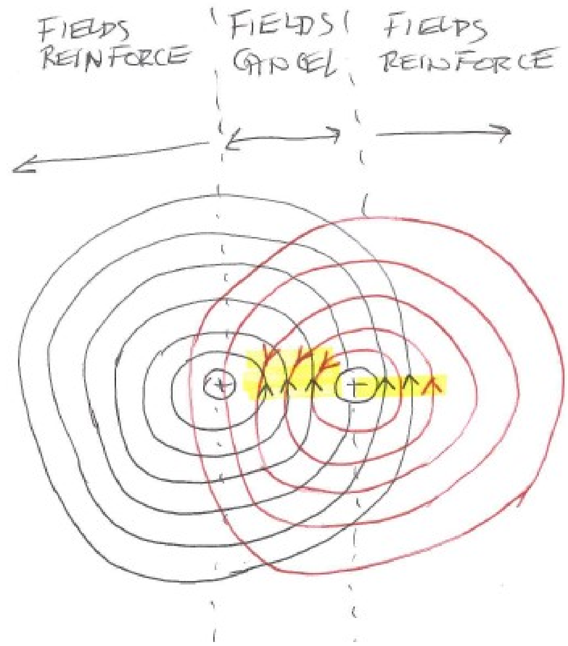
Skin depth equation (below) is a squared equation, so removing wire depth rapidly increases the inner current magnitude. Dropping from 20 mils to 10 mils is a 4X improvement in current coherence.

$$\delta = \sqrt{\frac{\rho}{\pi \times f \times \mu}}$$

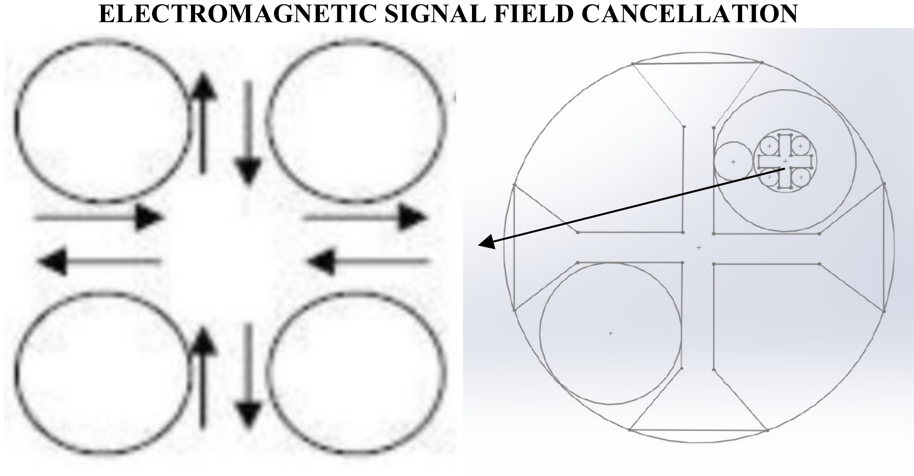
The very good, and easier to make, current design does NOT use electromagnetic signal field reduction technology I developed for the speaker cables in the series 1 signal leads. The current XLR design relies on reduced loop area and uses AIR to reduce the capacitance to a minimum for a given tighter spacing to achieve inductance. The better the dielectric the CLOSER I can physically locate the signal wires for a given capacitance, thus lowering Inductance. The size of the wires determines the current coherence, and with more uniform effect of the dielectric around each wire with respect to frequency. The smaller the wire, the more uniform the velocity of propagation from low to high frequencies.

An XLR cable's external noise utilizes CMRR based on all four noise signals being equal on each wire and which cancels those noise signals in a star quad design through electromagnetic field cancellation. If we look at the four wires, and using the right hand rule (current out of the page). All the external noise currents in the wire go CCW around each wire suspended in space. All the electromagnetic fields cancel adjacent to any wire and across from any other wire. All the fields superimposed onto one another forming a nearly ideal cancellation circuit. Nearly perfect because stray magnetic fields would extends OUTSIDE the four wires and reinforces the field. A first approximation says that this doesn't happen. The stronger fields are closets to the wire and cancel most aggressively. Theoretical outer fields are weak, and don't reinforce nearly as much as the inner fields cancel.

TWO WIRE FIELD CANCELLATION ASSUMING FIELDS EXTEND PAST THE CENTER BOUNDARY. MAGNETIC FIELDS WILL CONCENTRATE BETWEEN THE TWO WIRES, HOWEVER, AND CANCEL



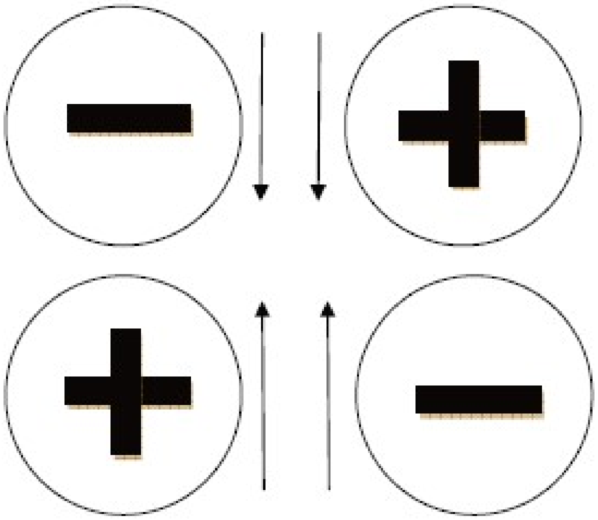
OVERALL 1 X 4 WIRE CONDUCTORS
ELECTROMAGNETIC SIGNAL FIELD CANCELLATION

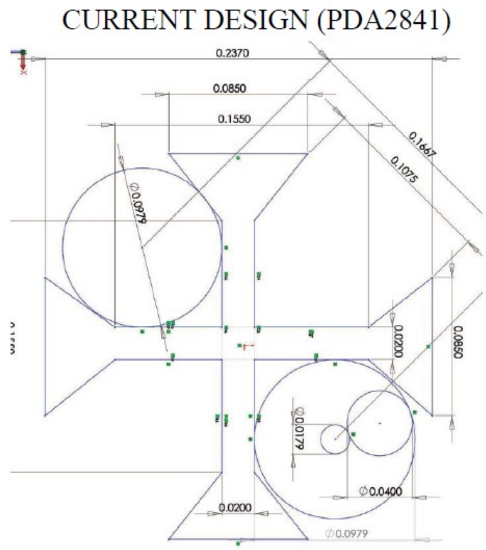


We DO NOT see this nearly "perfect" rejection of signal magnetic fields to reduce the inductance in the signal fields for series 1 RCA or XLR cable. We have a PLUS and MINUS balanced signal current direction whose fields are only partially cancelled. The partial field partial cancellation RAISES the inductance above "zero" theoretically as we have a stronger field, and separated by the distance needed to lower capacitance with any dielectric. The old design has ~36% higher inductance, and thus worse PHASE shift than series II (0.015 uh/foot is reduced to 0.11 uh/foot nominal). Lowering inductance directly lowers phase. See the QED phase analysis measurements on a variety of cable;

QED – The Sound of Science www.qed.co.uk/downloads/qed/soundofscience.pdf

OVERALL 4 x 1 wire XLR CMRR INTERNAL (signal energy)
ELECTROMAGNETIC FIELD CANCELLATION





The two MINUS fields cancel between themselves.
The two PLUS fields cancel between themselves.
But a MINUS to PLUS field REINFORCES the overall magnetic field.

The reinforcement makes the field stronger and the loop area effect worse.

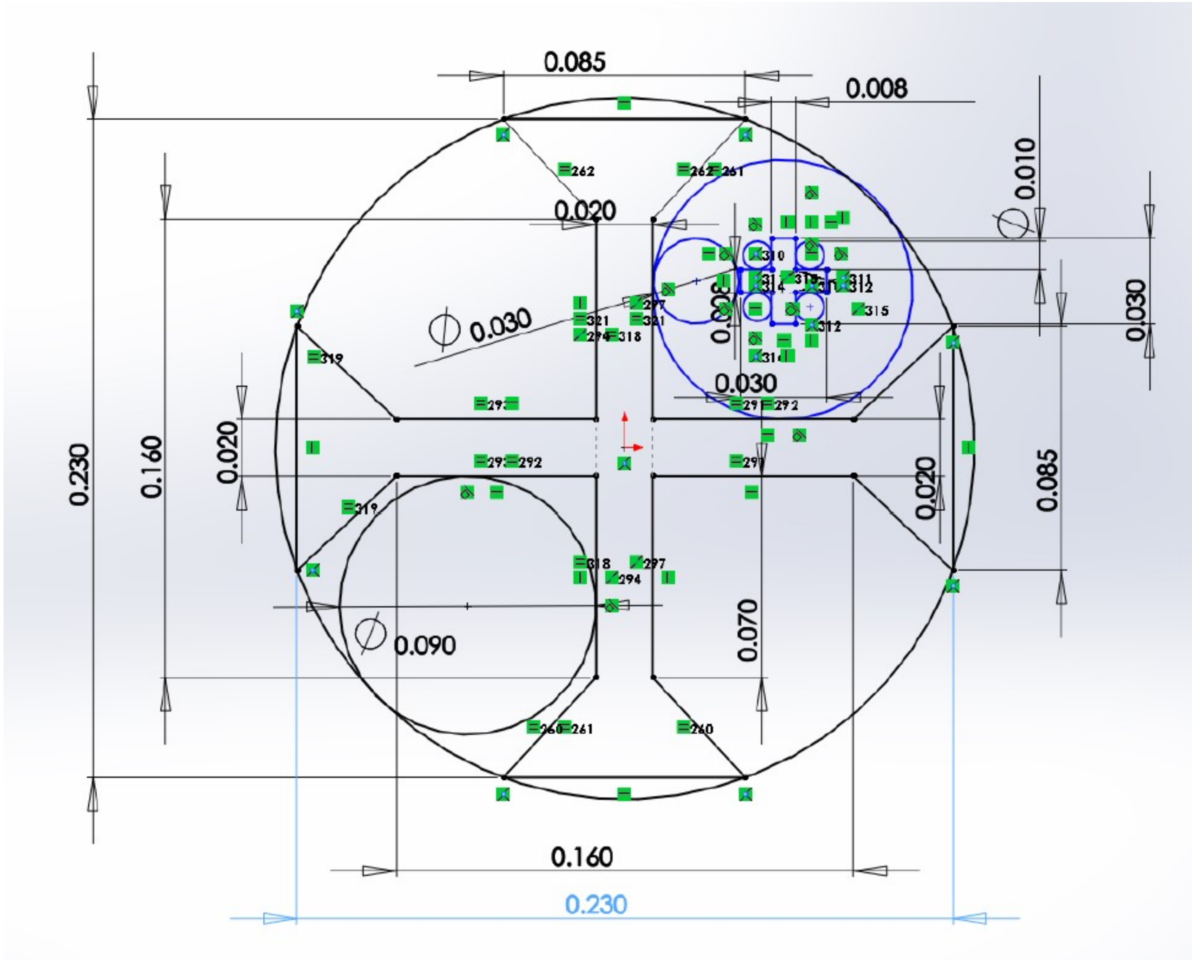
BODY -To make improvements, we need to reduce the signal electromagnetic field to ZERO, in theory, both from an external interference view AND an internal electromagnetic conductor view. To do this, we need to BALANCE the music signal by SPLITTING each of the four SIGNAL wires into FOUR, or sixteen separate wires.

Making this critical change will theoretically remove the signal field currents that interact with the loop, creating inductance. It will also significantly improve the dielectric group and Phase delay by forcing the dielectric to be seen more uniformly across the 20-20KHz frequency range with smaller wires.

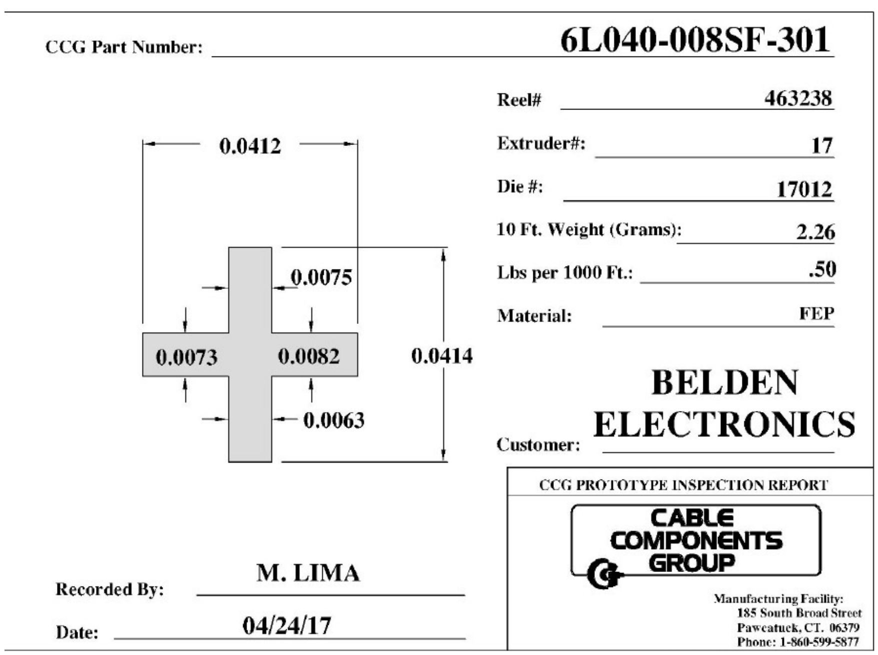
To keep capacitance low for a given loop area, we need to use AIR around the wires, and to make sure any plastics that touch the wire are super low dielectric constant materials (FEP mini X-filler and external FEP bead wire). This is why the wires have to be BARE copper with NO insulation around them. Only the tangential surface of the FEP filler and FEP beading, the rest is air. Capacitance is dielectric AND distance related where Inductance is distance and electromagnetic field strength.

Each of the four wire will be shorted together to make the typical four wires in a star quad. The wires are 10-mil diameter 30 AWG for a total CMA of 4 x 10^2 = 400 CMA. I used 4 x 0.018” in iconoclast for a total 18 x 18 = 324 CMA for each signal wire. 400 CMA is slightly lower DCR than the current design improving attenuation and mitigated ground loop voltages.

The collateral filler is foam FEP to manage capacitance. The power carrying signal braid should also be as far away as possible from the internal signal wire QUAD structure to lower the ground plane inside the cable, lowering capacitance. This means making the outer belting thickness under the braid to the best fit for an XLR connector, but not too big as the reduction in capacitance is a squared law variable, once a threshold is reached, more is not too beneficial.



The X-filler is FEP, as would the 30-mil beading wrapped around the QUAD wire to lower the dielectric nearest the wire where it is most critical. The material issues all control capacitance, not inductance.



CCG Part Number: 6L040-008SF-301

Reel# 463238

Extruder#: 17

Die #: 17012

10 Ft. Weight (Grams): 2.26

Lbs per 1000 Ft.: .50

Material: FEP

Customer: BELDEN ELECTRONICS

CCG PROTOTYPE INSPECTION REPORT

CABLE COMPONENTS GROUP

Manufacturing Facility:
185 South Broad Street
Pawcatuck, CT. 06379
Phone: 1-860-599-5877

Recorded By: M. LIMA

Date: 04/24/17

The overall belt is solid FEP, with a 36 AWG BC braid and a drain wire. A final solid FEP jacket finished the cable.

CORE 0.230”
BELTING 0.030”
BRAID 0.015”
JACKET 0.030”
TOTAL 0.305”

Does it really work on initial Capacitance and Inductance measurements? The final design using the ICONOCLAST™ all FEP design for ultimate performance appraisals measured as follows;

SHIELDED CORE
Lab Rqst - 177575 **Sample ID – 60156Y (PDC2842)**
Requestor – Galen Gareis **Report Generation Date – 22 June 2017**
Capacitance @ 1 kHz per ELP 423, Agilent E4980 Precision LCR Meter, Belden 4TP Cap/Ind Test Fixture
Meas: 18.23 pF/ft
Inductance @ 1 kHz per ELP 424, Agilent E4980 Precision LCR Meter, Belden 4TP Cap/Ind Test Fixture
Meas: 0.10 µH/ft

JACKETED SAMPLE
Lab Rqst - 177587 **Sample ID – PDC2842**
Requestor – Galen Garies **Report Generation Date – 29 June 2017**
Capacitance @ 1 kHz per ELP 423, Agilent E4980 Precision LCR Meter, Belden 4TP Cap/Ind Test Fixture
Cap @ 1 kHz Spec: 10.5 pF/ft max
Meas: 17.48 pF/ft
Inductance @ 1 kHz per ELP 423, Agilent E4980 Precision LCR Meter, Belden 4TP Cap/Ind Test Fixture
Meas: 0.10 µH/ft
Velocity of Propagation (VOP) per ELP 392, HP8751A Network Analyzer, HP VEE Instrument Control Software with Velocity of Propagation program and a GPIB card installed.
Meas: 85.3%

Lab Report: 177587 Description: PDC2842

	Length(ft)	Freq#1 (MHz)	Freq#2 (MHz)	Freq#3 (MHz)	K1	K2	K3	VP1%	VP2%	VP3%	Avg. VP%
1	10.16	103.01	144.88	186.18	5	7	9	85.08	85.48	85.44	85.3

4 x 4 DESIGN
231 pF / 12.67’ = 18.23 pF/foot
1.29 uH / 12.67’ = 0.10 uH/foot

1 x 4 REFERENCE DESIGN
12.5 pF/foot
0.15 uH/foot

To really get better XLR performance, both loop area and the field cancellation technology need to be leveraged, with the latter being most critical. The capacitance is all about materials and DISTANCE between them. Improving inductive field cancellation has the added, and significant, benefit of improving signal coherence through four smaller wires and phase with lower inductance while improving attenuation performance.

A cable with smaller signal wires and better coherence, low inductance (better phase) and slightly higher capacitance will sound better sounding than a cable with larger signal wire and less coherence, higher inductance and lower capacitance…as long as capacitance isn’t too high!

The prototype run does indeed lower inductance with the expected rise in capacitance.

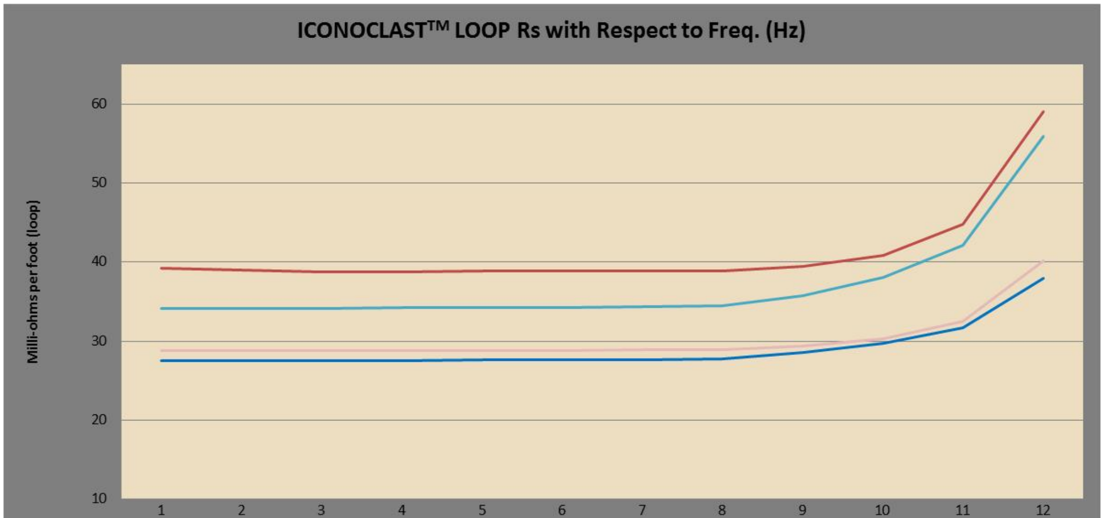
0.15 uH/foot (X) + X = 0.1 uH/foot, X= 33% lower.
Or the current design is 50% higher.

12.5 pF/foot (X) + X = 18.23 pF/foot = 45.8% higher
Or the current design is 31.4% lower.

Since the original design is working from such low L and C numbers, the percentages are not really illustrating the advantages of the improved signal coherence with much smaller wires, and an advantage that should play out in audible performance. The -3dB first order filter frequency is still well above the audio band so first order filter phase distortion is not going to be an issue. What must be the major contributor is coherence with the smaller wires. Rs response, while lower, is hard to quantify.

Rs (swept frequency resistance) Values

The 4x4 XLR lowers swept Rs (proximity effect) values significantly, and flattens the high-end linearity. Can you HEAR that improvement, over the single the wire design? The truth is BOTH are superimposed when the wire is used, and pushing the XLR designs to as near perfection is certainly a better and better design. The lower DCR is evident in the trace compared to the 1x4 25 AWG wire as is the flatter upper frequency measurements.



	1	2	3	4	5	6	7	8	9	10	11	12
FREQ	100	1000	2500	5000	7500	10000	15000	20000	50000	100000	200000	500000
4x1 XLR	34.11	34.14	34.15	34.19	34.21	34.19	34.30	34.46	35.79	38.07	42.13	55.87
4x4 XLR	27.53	27.54	27.54	27.56	27.58	27.61	27.69	27.79	28.54	29.74	31.67	37.99
1x1 RCA	39.198	39.012	38.758	38.744	38.818	38.820	38.885	38.899	39.427	40.894	44.739	59.037
1x4 RCA	28.787	28.787	28.791	28.790	28.801	28.812	28.880	28.907	29.331	30.336	32.542	40.132

The RCA interconnect has also been updated with the new 1x4 (ONE wire made with FOUR conductors) design. The reactive variables will track with frequency like the single wire designs, but map to the altered L and C values.

The following table shows the effects of changing the wire size and number. The 4 x 4 has almost the same CMA as a single 22 AWG, but 1.82 times more total circumference, which shows up only at increased frequencies. The lowest frequencies are essentially DCR.

XLR GEOMETRIC WIRE PROPERTIES

	CMA	Circumference Surface Area
1 x 0.022"	484	0.06908
1 x 0.018"	324	0.05652
4 x 0.010"	400	0.1256

	PER foot Data					
		RCA		1X4 XLR		4x4 XLR
FREQ	RCA	% Change	1x4 XLR	% Change	4x4 XLR	% Change
100	34.90	Reference	33.48	Reference	27.62	Reference
1000	35.03	0.378	33.50	0.041	28.01	1.419
2500	35.06	0.457	33.57	0.252	27.67	0.193
5000	35.29	1.114	33.82	0.996	27.73	0.396
7500	35.69	2.260	34.23	2.217	27.89	0.984
10000	36.22	3.780	34.79	3.901	28.03	1.476
15000	37.69	7.992	36.32	8.478	28.44	2.969
20000	39.65	13.616	38.32	14.460	28.87	4.545
50000	58.01	66.227	55.86	66.823	32.24	16.730
100000	98.00	180.802	92.47	176.160	36.45	31.960
200000	183.33	425.310	171.60	412.499	41.05	48.616
500000	439.93	1160.554	409.80	1123.905	51.58	86.741

The maximum Rs is lower with the 4x4 design. Beta test feedback from customers on the 4x4 has been extremely positive and, consistent with the numbers, shows this revision to be a significant upgrade from the original Iconoclast design for analog applications.

DCR INTERCONNECT LOOP CONSISTENCY

The interconnect cables of a given wire design (single to single and verses quad to quad) have essentially the same loop DCR values.

From the Rs chart above at DC, we see;
4x1 XLR and 1x1 RCA are 34.11 and 39.19 Milli-ohms/foot respectively.
4x4 XLR and 1x4 RCA are 27.53 and 28.79 Milli-ohms/foot respectively.

How was this done? The double braid on the RCA was necessary to mitigate ground loop DCR variation between sources, and the DCR was designed to be near a “free” return path for loop[DCR. The loop resistance ios the braid plus the conductor. But, the braid DCR is so low that the loop DCR is pretty much the RCA center conductor. This is true for eother design.

The XLR DOUBLES the number of conductors in each leg as a star quad. This reduces the DCR to one-half the conductor’s value. Thus the two pairs in parallel are the same DCR as a single conductor.

This was also done on purpose to make sure that the RCA’s loop performance was as good as the XLR, and that the RCA BRAID was essentially a ZERO DCR return path between grounds. If the RCA braid was insufficient DCR, we would see more divergence between the two singel ended and balanced design.

CONCLUSION

The measured XLR electricals are very good, and follow design theory perfectly. ICONOCLAST once again shows that proper engineering fundamentals are paramount to performance. Sound Design Creates Sound Performance!