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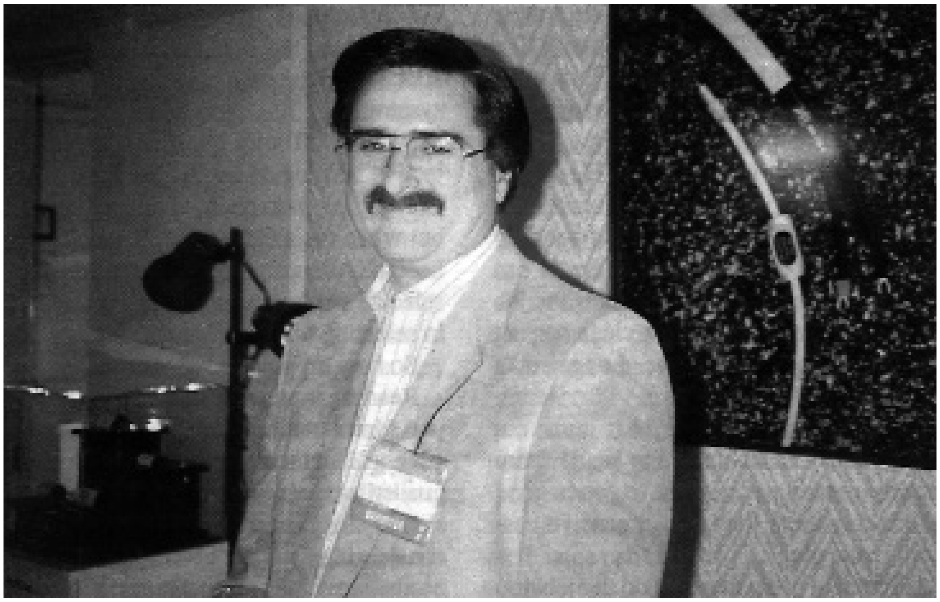

# Bruce Brisson:
## Seeing Cables as Filters

***Bruce Brisson is the founder of MIT, maker of the world's most expensive audio cable. He helped launch the "wire revolution" by arguing that a cable had to do more than just transmit a signal.***

**UHF:** *When did you first become aware that all wires were not alike?*

**Brisson:** It was in the middle to late 70's. I bought a large audio system, paid a lot of money for it, took it home…I turned it on, and my wife said, "Turn it off!" (LAUGH) That led us into biamping, triamping, and trying different cables at each of those amplification stages.

**UHF:** *What were you then doing for a living?*

**Brisson:** I was an automotive engine rebuilder. I've always been interested in high-tech things, so we had a racing engine division.

**UHF:** *It's a big jump from high-performance engines to high-performance audio. Or is it?*

**Brisson:** Well, a lot of the philosophy is the same! Actually, I had worked for *Fairchild Electronics'* integrated microsystem division, and enjoyed it. I was also a ham radio operator, and built my own antennas and linear amplifiers. I had done a lot of work with cables in ham radio, so the jump into audio cables was not just overnight.

**UHF:** *Was there anyone else at the time saying that making a good audio cable was not just a matter of making it big?*

**Brisson:** Yes, Dr. Polk was the first one I heard say that a cable could not simply be built uncompensated. In 1980 or 81, he attached a resistance-capacitance network to the end of a cable, constructing a filter out of it. He considered the cable and the filter to be as one. He was, in other words, running a *terminated* cable. This was the first time, as I recall, that someone viewed a cable as something other than just copper and dielectrics, merely something passive.

**UHF:** *Cables remain controversial even today. But in the beginning, scientists and engineers were saying that it was all a matter of resistivity, and that no other phenomenon was of sufficient magnitude to make an audible difference.*

**Brisson:** That's correct. We still have that camp today, that views the elements as being of first order. They say there are only minute amounts of capacitance and inductance, and these minute elements cannot affect the audio frequency range. Viewing it in that way, they are absolutely correct. But these elements change when we pass current through them — they change with frequency, they have parasitics, they resonate, and that's where the problems start.

**UHF:** *How did you decide to make your own cables?*

**Brisson:** It began with a series of questions and answers. We had questions when we hooked up *Mogami* and *Fulton* Brown speaker cables to my speakers, and realizing that, in a biamped or triamped system, the cables sounded different if we moved them from tweeter operation to woofer operation. About the same time, Peter Moncrieff was beginning to discuss speaker cables at length in *IAR* magazine. We lived about 40 minutes apart, and we would get together and help each other. I began building my own cables in 78 or 79. In fact, a fellow named Len Hutt, of *Audio Horizon* magazine, and I used to talk on the phone almost daily about cables, what he was hearing and I was hearing: what it sounded like if we twisted the wire to the left, or we twisted it to the right. We were bothering the large cable manufacturers and driving them crazy trying to get them to do things for us.

**UHF:** *The mainstream magazines would tell you that you were imagining things.*

**Brisson:** For the most part they could have been right at that time. We didn't have the amplifiers, preamps, turntables, all the electronics that we have today, and the tests are influenced by the architecture of the system. We'd modify a lot of our turntables. We had a *Linn* Sondek, and we made our own platter for it, and dampened the suspension in order to conduct the empirical tests, to be able to define the differences in cables.

**UHF:** *You were involved at one time with* Monster Cable.

**Brisson:** Absolutely. At the June *CES* in 1980 or 81, I was introduced to Noel Lee. He had heard about what I was doing, winding cables different ways, and he wanted to audition the cables. So I got together with Noel and his manager at that time, Andy Choy, and demonstrated a few of the cables. They liked what they heard. We licensed Noel, in June of 82, and he still uses that license today. He calls it the "bandwidth balanced" cable design— he uses three different-sized conductors in the bundle. The patent describes a method of twisting the different cable in different ratios, in a helix, which allows him to control the impedance of the conductor from the inside out, so that the frequencies propagate through the conductor at the same rate of travel.

**UHF:** *When did you begin making your own cable?*

**Brisson:** I think it was 78-79. By 1980 we were twisting up cables on a week-to-week basis. We were hand-making cables and selling them to other audiophiles. That was a lot of fun.

**UHF:** *Sounds rather tedious!*

**Brisson:** We had a two-storey home. If you ordered a 30 foot pair of cables, we extrapolated it out that it had to start out at 80 or 90 feet. My son would be downstairs in the kitchen, and I would be upstairs in a bedroom with a power drill. He'd say, "Okay, go ahead." I'd turn the drill on, and he would slowly walk out of the kitchen and up the stairs, as the cable shrunk up. (LAUGH) I enjoyed it a lot.

**UHF:** *If you got flooded with orders, it must have taken up time around the household.*

**Brisson:** Yeah. It was also a lot of fun putting the twisted-up cables into the heat-shrink tubing. We used a lot of different apparatus to do that. The heat shrink was pretty expensive, so if we tore a hole in it, we'd all be flabbergasted as to how we were going to patch it so the customer wouldn't know. It was a great time period, it really was!

**UHF:** *Let's digress to the name of the company.* MIT *makes people think of the* Massachussetts Institute of Technology. *We presume that's not a random choice.*

**Brisson:** When I left *Monster Cable* in February of 1984, one of my good friends was Rick Fryer of *Spectral.* I talked to Rick to get his ideas and opinions, because he's regarded as a very good marketer. We tossed different names about for an hour or so. I always liked the name "interface," rather than "hookup." And we wanted to get "music" into the name, and one of us — I don't remember who — added "technologies" to it. So it made *MIT.* We didn't feel that would hurt us, and the company always has been — and as long as I'm running it will remain — a research and development company.

**UHF:** *Did you ever get a complaint from the other*MIT?

**Brisson:** No. One of our competitors called up the university's lawyer one day, to tell him about it. But we have the name *MIT* registered in America.

**UHF:** *You began to develop a particular concept — thinking of a cable as a filter.*

**Brisson:** Yes, this goes back to my ham radio experience. In ham radio, you can use an open or shorted piece of cable as a filter. So it was very early on that we used equivalent circuits to approximate a piece of cable: distributed capacitance, distributed resistance. And also parasitics — values don't remain constant. For example, a 1 µF capacitor can be 1 µF at 1 kHz, but it may not be 1 µF at 10 MHz or at 20 Hz. When there is a bad resonance, a 1 microFarad capacitor can be 3 to 5 *milliFarads.* Quite a difference! Early on, we purchased a little LCR bridge made by a company named *Leader.* Today we wouldn't allow it in our lab, but it was all we could afford back then, and we began to measure cables. I did this for Peter Moncrieff at *IAR,* showing him how the inductive values changed at low frequencies. We began to realize that the only valid criterion for a cable is to consider it a low-pass filter. The cable is going to have a certain high-frequency rolloff, whether it's at 100 kHz or 10 MHz. It has a "3 dB down" point, then a transitional point, then a stop-band. The cable *should* extend down in frequency to direct current. That causes most other engineers to raise their eyebrows. What we mean is that the cable should not resonate until DC, and if it doesn't, then it will be a perfect low-pass filter. That's assuming the high-pass cutoff is optimized: not too steep, because the delays go all to hell, and there will be a peak on a square wave or a pulse.

**UHF:** *All right, but power amplifiers usually have a high-frequency rolloff. Indeed better power amps have a deliberately-engineered rolloff, to avoid problems with transient intermodulation. If you have a rolloff in the amplifier, and the rolloff in the cable is at a much higher frequency, what additional difference can it make?*

**Brisson:** Let's take the example of a cable that is at -3 dB at 4 MHz, a good figure for a short interconnect. And let's say the -3 dB point for the amplifier is 1 MHz. If you look beyond the -3dB point of the amplifier, you'll find what we call a pole and a zero. The zero gives zero transmission, and the pole, on the other side of the zero, will give a *maximum* of transmission. It's the inverse in the impedance domain, but we can get into that another time.

That's where our problems are. We have to look for these poles and zeros. We find them

We were making cables and selling them to other audiophiles.

in cables, typically, at very low frequencies and at very high frequencies. Some of the worst cables we've seen, though, begin to have problems as high as 3 to 5 kHz. We see series resonances there, which become unstable, and add overtones to the music.

**UHF:** *Presumably you're not saying that a cable should have as little capacitance as possible, but rather that the capacitance should be optimized in some way. In what way?*

**Brisson:** In viewing a cable as a low-pass filter, the series element has to be inductance. Inductance passes low frequencies and impedes high frequencies. In viewing capacitance, in the first domain, we view it as a shunt component between hot and cold. If we have *enough* capacitance, we can roll off enough of the high frequencies at that port, bypassing the load. In other words, these high frequencies, which cause audible resonances, are removed. They are shunted around the load and go back to ground, not influencing the audio at all. Everything else goes through the series element — the inductor. That's why we wind our cables in a tight helix to *generate* inductance. Other people don't do that, because they feel inductance is bad. It *can* be bad, but by winding up a short piece of cable, I'm not restricting anything in the audio band.

So you can regard a cable as half of a T-element or half of a pi-element. In our CVT cables, we add other elements, making the cable equivalent to a full pi filter. We feel that's the best approach.

**UHF:** *One point you make in* MIT *literature is that high and low frequencies don't travel at the same speed. There are engineers who say that the difference is not significant until you get into extremely high frequencies. They would argue that the two "skin effects," — that high voltages and high frequencies travel along the outside of a conductor — are not significant until you get to extremely high voltages or frequencies.*

**Brisson:** You certainly don't hear nanosecond delays. and I've never claimed to. Some of this has been blown out of proportion by reviewers who meant well, but didn't take the time to understand. We find that if we can optimize the delay through the center of the conductor, and at the skin of the conductor, we generate less noise. The noise that's being generated is typically of a very high frequency. For instance, if we have a nanosecond delay, that transcribes to a gigaHertz frequency. A 20 nanosecond delay means noise at 50 MHz. We find that the noise generated within a conductor is stored within the dielectric insulation of the cable, and it is released at random times.

**UHF:** *Why random?*

**Brisson:** It is *always* released as the signal goes from a negative voltage to a positive voltage. The energy is then combined with the audio signal, and since it is of very high frequency, it stimulates resonant areas at the load end of the cable. If a cable is connecting a CD player to an amplifier, it will stimulate the resonant area at the input of the amplifier. We call it *phase noise.* It is a short term phase or frequency shift. It is always aperiodic — cyclic but aperiodic. It depends on what has happened in the cable in the past, not in the present.

**UHF:** *What's more important in a cable: the way it's made, or the materials it's made from?*

**Brisson:** Well, the *MIT* philosophy says you have to use good quality copper. We use a premium copper, and we see no reason to go beyond that. Our cables are wound tightly, so the wire needs to be capable of a lot of elongation, otherwise it will break. We spec ours at 22% elongation, but this is not the whole story. Minimum resistivity, minimum capacitance, minimum inductance, and high-quality copper and dielectrics is not the way we build cable. We would not use what is known as "electrolytically stressed" copper, which has a lot of contaminants in it.

**UHF:** *Again, some of your critics say that, providing that this doesn't affect the usual electrical measurements, in fact the signal doesn't "know" whether there are contaminants in the copper.*

**Brisson:** I've done some experiments with some pretty ugly-looking copper, that has corrosion and contaminants. We've looked for an area of clean copper so we could make a good solder joint, and given the cable to audiophiles. They say it sounds great, but I'm not saying I would spec a cable to be built that way.

**UHF:** *You don't believe in exotic materials, such as monocrystal silver.*

**Brisson:** I really don't. A. J. van den Hul and I get along very well personally, but his view of designing cables is very different from ours. I don't mean everything he does is good, bad or evil, but A.J. and I take different design criteria.

**UHF:** *Over the years, prices of* MIT *cables have been creeping up to the point where your best cables cost more than some quite good components. Have you ever thought you might be going too far?*

**Brisson:** Yeah, absolutely. I wish I could do what I do with the 750 CVT cable cheaper. We'd certainly do better in the marketing area. Because our company has always been oriented to research and development, we always ask how we can improve the product, and that continues to lead us into new areas that are expensive to get into. Does it cost me that much money to produce a pair of cables? Probably not, but what does cost me is our half million dollar laboratory, and the payments to *Hewlett Packard* and *Tektronix* for instruments. These costs have to be passed on.

**UHF:** *We have a question about your Music Hose speaker cable. It has two wires at one end, and three at the other. What's going on there?*

**Brisson:** That was our second patent. Open-ended cables that are under a certain wavelength are capacitive. Shorted conductors become capacitive over a certain wavelength, or inductive below that wavelength. Electrical audio wavelengths are miles long. We wanted to provide some capacitive tuning. We wanted to drop the impedance, but we knew we had to run series inductance in order to make the cable function as a low-pass filter, which would resonate at a lower frequency than was

I wish I could do what I do with the 750 CVT cable cheaper

common in that era. We had to add capacitance, so we came up with the idea of using open-ended tuning stubs. We found it was also a great way to control overshoot on square waves, and a great way to remove noise from the series elements of the cable.

We were among the first to use shielding on speaker cables. It's not that we're concerned about radio frequency interference, but shields can be used to tune cables, to add or remove peaks.

**UHF:** *We've heard a lot of people ask why the Music Hose is as large as it is.*

**Brisson:** It's not any larger than it really has to be. There are three conductors that carry audio on each side — positive and negative. They're about 11 gauge, and they're twisted together in a light helix. The three are housed together within a low density polyethylene, and then housed in a high temperature PVC. They're then twisted together with rope, to fill in the interstices. We put thermoplastic rubber around that, enough to make it perfectly round — if it isn't round, it bothers my dealers.

That's unlike what we did with MH-750E, where we added extra TPS to make the cable bigger, because it needed an identity.We had to change color and size.

**UHF:** *The CVT version of the Music Hose has just one conductor per side, but the cable is much more expensive. The first people say is that they seem to getting less.*

**Brisson:** It's actually the same amount of wire. We have added a proprietary Teflon double-braided co-ax. We use it to act as a capacitor. It is laid into one of the interstices instead of rope filler. It is left open on one side. A patented network is added to that.

**UHF:** *That's in the little box?*

**Brisson:** Yes. The network works with the distributed Teflon capacitor to remove the noise above 1.2 to 1.8 MHz, depending on the load.

**UHF:** *Does the CVT device do exactly the same thing in the interconnect cable?*

**Brisson:** Yes, except that we don't use a distributed capacitor, we use a straight capacitor. It's a very high quality RC network.

**UHF:** *How much importance do you put on connectors?*

**Brisson:** Well…I place a lot of importance on connectors, but not nearly as much as I do on the cable, and on the joint that holds the two together. The biggest problem we have in audio today is in fluxes and solders. We worked closely with *Multicore* some years ago to try to overcome existing problems, and we came up with "No, it can't be done." If any of us have time in the future — that includes speaker manufacturers, amplifier manufacturers, cable manufacturers — we have to overcome problems of solderability, especially in high-current applications. With anything pulling a lot of current through it, the solder joint isn't going to be worth a damn after about a year. Flux problems get worse in high humidity, like in Florida. You can send something to Florida, and after about a year, the humidity will react with any flux that wasn't burned off. The joint looks as bad as though it were rusted.

So the connector is third. Our CVT connectors start out with a very pure tellurium copper. We have to *make* the connectors, and they're expensive, but we've sold more than I thought we would. They're aimed at a very small market, where people have to have this kind of quality.

The worst solution — and I hope to see it change — is to use balanced lines with XLR connectors using beryllium copper. It degenerates the quality of the sound by as much as 50 to 80%.

**UHF:** *Do you believe in crimping as an alternative to soldering?*

**Brisson:** No. This is going to sound far out, but in video we have an effect we call pigtailing: we flatten the braid and pigtail it. That changes the impedance of the cable. It's the same in audio. The impedance of the cable must be left intact from input to output. Everything must be kept round. Don't crimp it, don't flatten it.

If anybody out there can help me, please write or call!

**UHF:** *But crimping can be done without flattening.*

**Brisson:** If it can be done without flattening, and without ferrous or even tin-plated connections being added, do it. These are areas we're looking at, and I would like to use a method other than soldering. If anybody out there can help me, please write or call. I'll hire you as a consultant! (LAUGH)

**UHF:** *Are all your connectors built in-house?*

**Brisson:** Just the CVT's. The others are the only thing that we import from abroad.

**UHF:** *When we listen to a system using the top* MIT *cable, instead of some other cable, what sonic differences are we actually hearing?*

**Brisson:** Lack of resonances. Resonances create large delay differences, large magnitude variations, and that what we're listening to. To extrapolate, group delay can be figured out by looking at the phase, which is derived from the transfer function. It should be an ever-decreasing negative phase. The slope of the phase line is the group delay. That's all, there's nothing else. It's all a matter of where you'll go to find it. You can do a frequency response test, which is half the transfer function, and never see any of this.

**UHF:** *What's next?*

**Brisson:** We were just awarded four patents this year, and we'll be applying for two or three more patents in the next three months. As you can understand, I can't comment precisely without making problems for myself. But there's still a lot out there.

MIT