Systematic Approach Part 1 - General Theory

For many years now, we have used the expression 'Systematic Approach'. We use it in discussion with customers and dealers, with the press, at hi-fi shows, and also when we have detailed product development meetings here at Vertex. But what are we talking about? Is this a simple concept or a complex technical truth, is it marketing speak or a critical element of system setup technique? Well its all of these, and more.

In this part of the book we are going to take you through the major elements of the Systematic Approach in some detail, but first we thought we ought to try and characterize the meaning of this term.

Systematic Approach - a simple definition

- The Systematic Approach is a unified way of thinking. It means we consider all the influences on hi-fi performance in an integrated and balanced way, and we need to have all the information required to hand. It draws together the views that a system is both a set of discrete components and a whole entity built into an architectural framework. And then it considers how the system is affected by internal interactions and the environment within which it operates. The Systematic Approach enables us to make logical decisions that will take us in the right direction, towards an effective system performance, and not down the myriad of blind alleys that wait to trap the unwary.

Some Ideas about System Faults

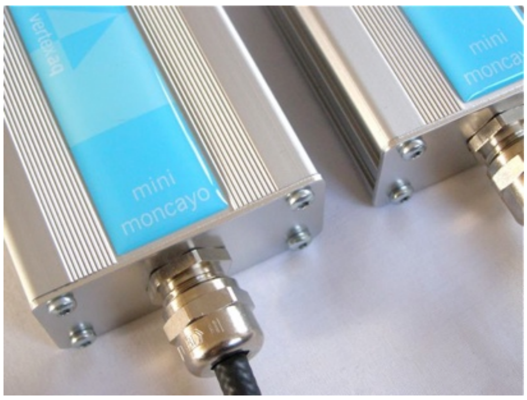
A complete system and its flaws

One of the first things to understand with the Systematic Approach is that it is firmly based in the idea that a system is a complete and interactive entity. And that complete entity includes your room, your mains, your music, your tastes, and, well, your brain. We all listen to music in surprisingly different ways, subconsciously, and this has a significant bearing on what we need to consider when managing the upgrading process.

So first of all lets look at some of the technical aspects of our systems. A conventionally set-up hi-fi system, as a complete entity, will suffer from some seriously debilitating effects. Some are external or 'environmental', others are 'interactive' in their nature. Looking closer we see that these effects have clear root causes and that some of these causes are constant, others are variable - and often a by-product of the constantly changing levels of energy that our systems generate (and therefore volume and music program dependent).

The root causes

We describe the root causes as follows:



Radio Frequency Interference (RFI):

- largely environmental, can be variable, but can also be interactive.

- RFI can come from many sources and be present over a huge range of frequencies. At lower frequencies things like poorly maintained electric motors can send significant levels of RFI back down power supplies. At high frequencies we have a myriad of digital equipment around us, throwing lots of noise onto the mains - and radiating the stuff too. Mobile phones of course are deliberately radiating significant amounts of RF energy. Finally, don't forget the hi-fi itself, which will generate a certain amount of noise itself. And that noise is right at the heart of your system (many digital components 'push' a substantial amount of RFI back onto the mains, polluting the supplies to other components in the system).

Acoustic (vibrational) energy:

- Within component structures (circuits and chassis). This can be environmental, interactive and variable. Vibration might get into your components from the ground (up through the supports). It may be internally generated by devices such as transformers and optical disc transports, or just picked up from high sound pressure levels in your listening room.

- Passed around the system by all the cables. Again this is a combination of factors. Transformers constantly send their vibrations around all the mains leads, vibration from speakers is fed back to the amplifier along the speaker leads. And, similar to ground-borne vibration being fed into your system through a stand, it can also be fed into your mains loom through the sockets in your wall.

- Note that when we say acoustic or vibrational energy we don't just mean the obvious low frequency thump of a bass drum, or foot fall. No, we mean vibration at frequencies all the way through the audio range and right through the ultrasonic spectrum too.

The effects

There are some other concepts to bring in here at this point, to aid understanding (we never said it would be easy!) - and these are the effects. Or in other words, what is it that the root causes actually do to damage performance.

RFI induced distortion:

- Unwanted RFI in analogue circuits raises the noise floor, losing fine detail and phase information (blurring the image), and it 'inter-modulates' with mid and upper frequencies causing a noticeable harshness and edge. In digital circuits, RFI raises digital distortion and effectively reduces the fidelity of the reproduced recording, making it sound significantly flatter and compressed.

Microphony:

- Unwanted acoustic vibration causes extensive damage to sound reproduction because almost all electronic components are to some degree 'microphonic' - that is, if they are vibrated, they will turn some of that vibration into a small unwanted electrical signal, which is literally added to the actual signal we want to process. They all act like mini microphones! Just vibrating a few of these components, or allowing this issue to effect the whole system, produces increasing amounts of damage, ranging from subtle loss of precision and detail, right up to gross blurring and distortion. The damage varies massively with level too, so usable headroom is curtailed and important timing cues from percussion peaks are lost.

If you have not heard about these causes and effects before, or seen these sort of descriptions, they can all seem rather complex, and perhaps not really plausible - after all surely, over the past 6 or 7 decades of hi-fi design, these things would have been fully explained and tackled. But, up until recently, they have been almost totally ignored. What we have done at Vertex is carefully identify and understand all these effects and designed techniques to counter the causes. And there's a very good reason why we have done this - when the causes described above are significantly reduced, the improvement in audio reproduction is truly massive.

Don't Think Components, Consider the System

Different thinking - lets get physical

System upgrades should always be taken with a balanced approach in mind, and with an awareness that its almost always the significant faults in a system that are the overriding factor with performance, and not the quality of your 'best' component. In other words, find the systematic faults and treat them before spending more money upgrading what might already be pretty good electronics.

To do that it really helps to start thinking about our hi-fi system in a different way. Let us consider a simple system setup being used in a normal domestic environment as shown below. This diagram represents how we think of the system conventionally.

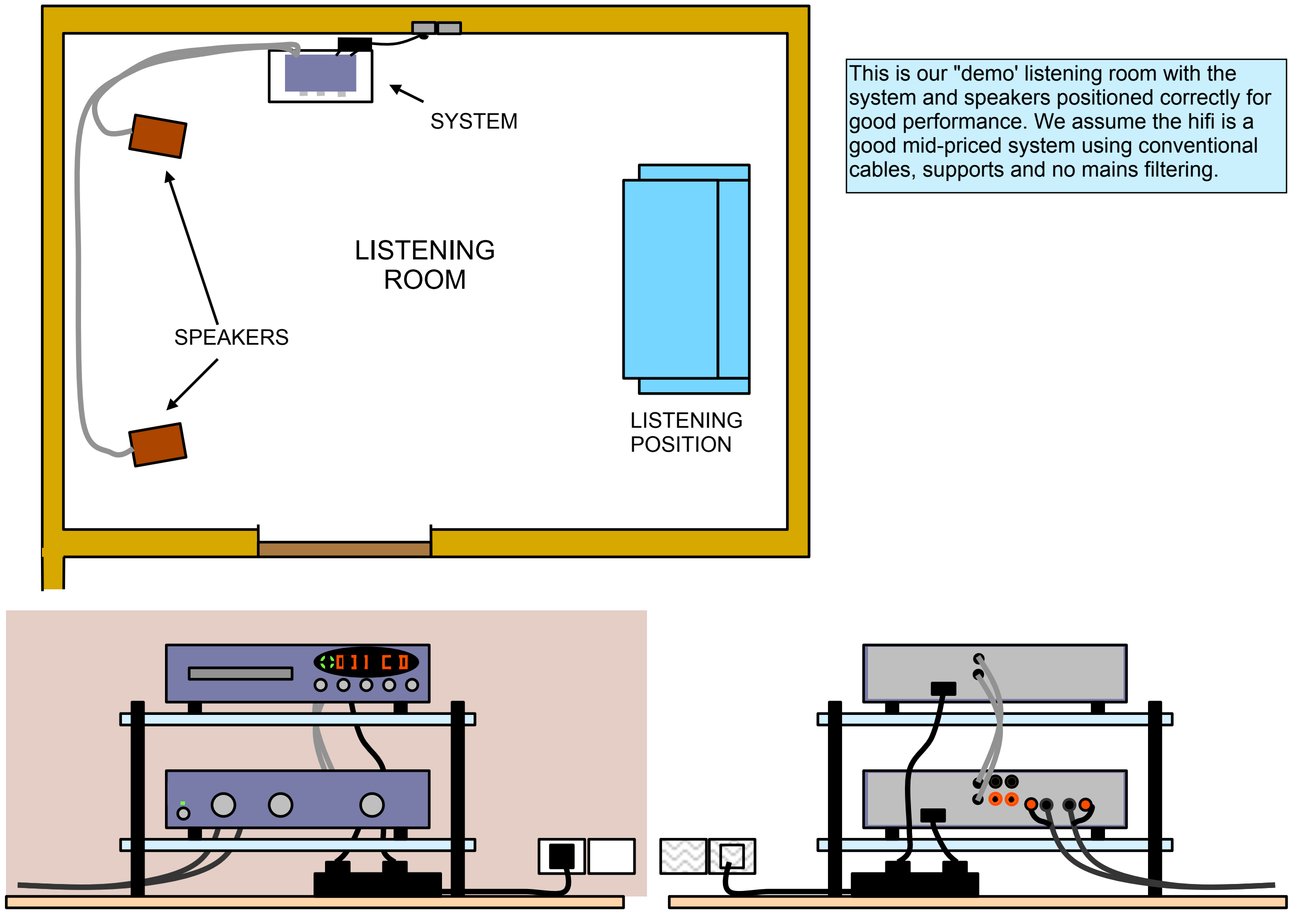


Fig 1 - system conventional view

But we must now consider a very different view, one based around the acoustic behavior of the complete system, as an entity of linked structures. Most critically, it is then the acoustic behaviors of these structural elements that we have to look at in detail, and to this we have to apply the following principles:

- Different types of solid materials conduct sound waves at vastly different speeds and efficiencies. Compared to the speed of sound in air, soft materials such as rubber conduct sound very slowly, about 1/4 the speed of sound in air. Very hard materials such as steel and granite conduct sound extremely quickly, about 16 to 18 times the speed of sound in air. Materials such as copper and silver (the metals used for conductors), which you could say are moderately hard, conduct sound at about 10 to 12 times the speed of sound in air. Commensurate with their speed, these materials 'lossy' characteristics follow a similar pattern - but note that whilst soft rubbers are very lossy, even moderately hard materials are only fractionally lossy compared to air, and very hard materials lose hardly anything in comparison to air. So for instance, a steel bar will conduct a moderate level of acoustic energy at very high velocities and over a very long way indeed, but copper or silver does not lose out much to steel.

- When you place 2 similar-characteristic materials into firm contact with each other, say steel against steel, sound energy in one will readily pass through into the other. There is a low acoustic impedance at the junction. When you place 2 dissimilar-characteristic materials into firm contact with each other, say steel against rubber, sound energy in one will not readily pass into the other, it will bounce off the junction and be reflected back. There is a high acoustic impedance at the junction.

- Take care not to confuse acoustic conduction with acoustic resonance. They are 2 completely different things. Resonance is a mechanical function. Take a steel rule and clamp it firmly at one end, flex and release the other end and it will spring back and forth at 3 or 4 Hz. Place a piece of plasticine on the end and the resonant frequency reduces. The characteristics of this resonance are set by the length of the rule, the springiness of the steel, the mass on the end of the rule and the air's damping effect. But place the end of the steel rule firmly against something that is vibrating at 10 KHz say, and the vibration will be conducted from one end to the other at approximately 12,000mph (speed of sound in air at sea level, 768mph x 16 = 12,288mph), and with extremely low losses too. This function is set by the material's molecular characteristics and the efficiency of the boundary at the source of the vibration.

- Our hi-fi systems are constructed out of many different types of materials, some of them soft, and some of them very hard, and therefore they exhibit the different acoustic characteristics we have described. But for the purposes of us keeping the description fairly manageable we categorize structure into 3 groups, high, moderate and low acoustic transmission, and color them red, orange and yellow respectively on the diagrams. We also treat cables as high acoustic transmission items. Whilst the metals of the cables might not be quite as efficient as say the steel of the casework, your cables link directly the circuits and components in each box and thus are considered pretty efficient in this context.

So we can now represent this system schematically as follows:

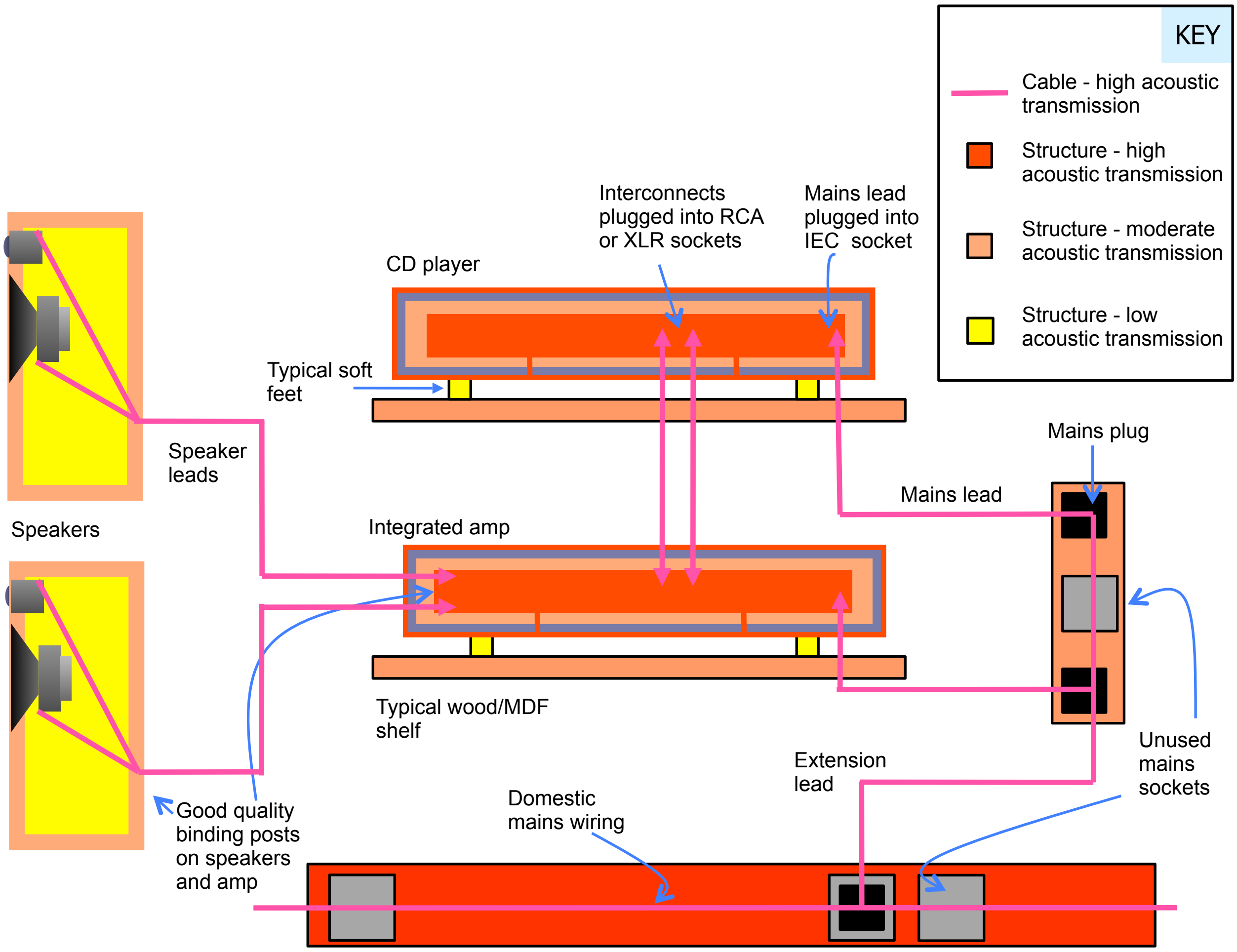


Fig 2 - acoustic structure schematic

In the diagram, the circuits and circuit-boards in the CD player and amplifier are represented by the central red block, with the 2 short vertical lines representing physical connection to the outer case, normally by mounting pillars or screws. Also, the red block behind the domestic wiring is representative of the walls within which the wiring is laid (which can be a significant issue that we'll discuss later).

Earlier we described the situation with vibration in the system, coming from transformers and motors, and the energy traveling all around the leads. But look at the diagram carefully, and consider where the acoustic impedances are minimal, where the vibration is going to travel too. The energy in the circuits is going to stay in and circulate around the casework, and its going to travel up and down the cables, in other words, it can only stay in the red structure or travel along the pink cables. It can't go anywhere else, such as through the player's feet as most players feet are usually made of plastic with felt or rubber, so there's a very big impedance mismatch.

So we can now show the routes of acoustic propagation in the following diagram.

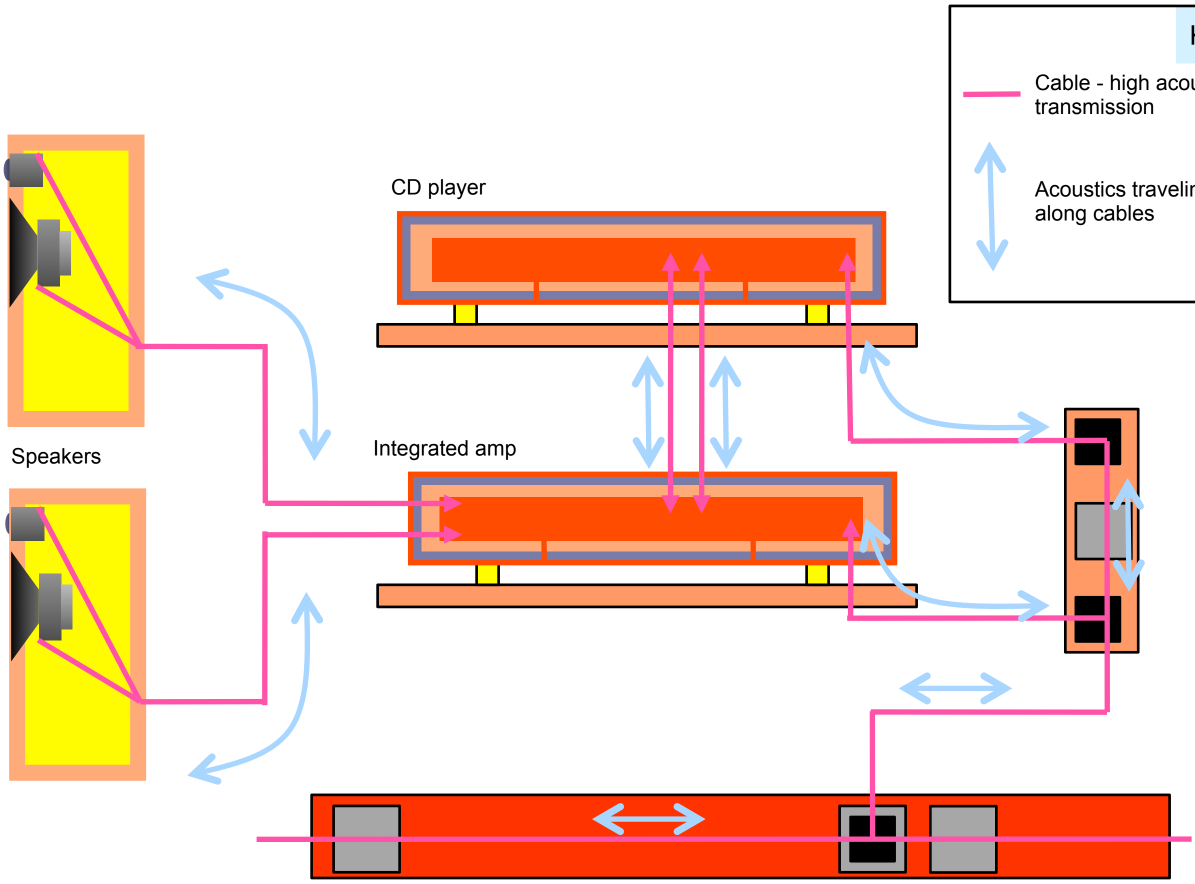


Fig 3 - acoustic propagation

Also consider that the speakers put a large amount of energy into the air, and whilst the air's contact with solid objects is not a particularly efficient union, very large objects, such as the walls of your room will pick up considerable energy and feed that straight back into the domestic mains wiring (especially at bass frequencies).

Different thinking - RFI management

We have of course, also talked about Radio Frequency Interference (RFI) as being another major culprit in the destruction of good performance. But again we need to get our thinking into the right form. One of the first myths to dispel, we think, is the idea that the mains is simply about getting our AC power out of the wall and into our hi-fi. Well that does happen of course, otherwise our hi-fi wouldn't work, but there is a lot more going on than that. Once we plug those leads into our system we have also provided a very efficient network to feed electrical noise (and that vibration!) in and around our system.

So let us look again at our system schematic, only this time consider where the RF noise is. Where the noise is doing the damage of course, is when it gets inside our boxes of electronics. And remember, that whilst we naturally think of the power going into our system on the live and returning back down the neutral, thats only one signal at 50Hz (or 60Hz). At much higher frequencies, the live, neutral and earth are all picking up rubbish (from computers, mobile phones etc) and transporting it around. One more thing to consider, the noise flows both ways - your boxes are noise generators in their own right and they output noise onto their mains cables, often polluting other parts of the system. A system with a lot of internal noise generators (CD players, DACs, amps with switch mode power supplies, or class D amps etc.) can be much more difficult to manage in RF terms than an inherently quiet system (such as vinyl front ends and analogue amps etc. (but that doesn't mean they can't suffer more from other issues!)).

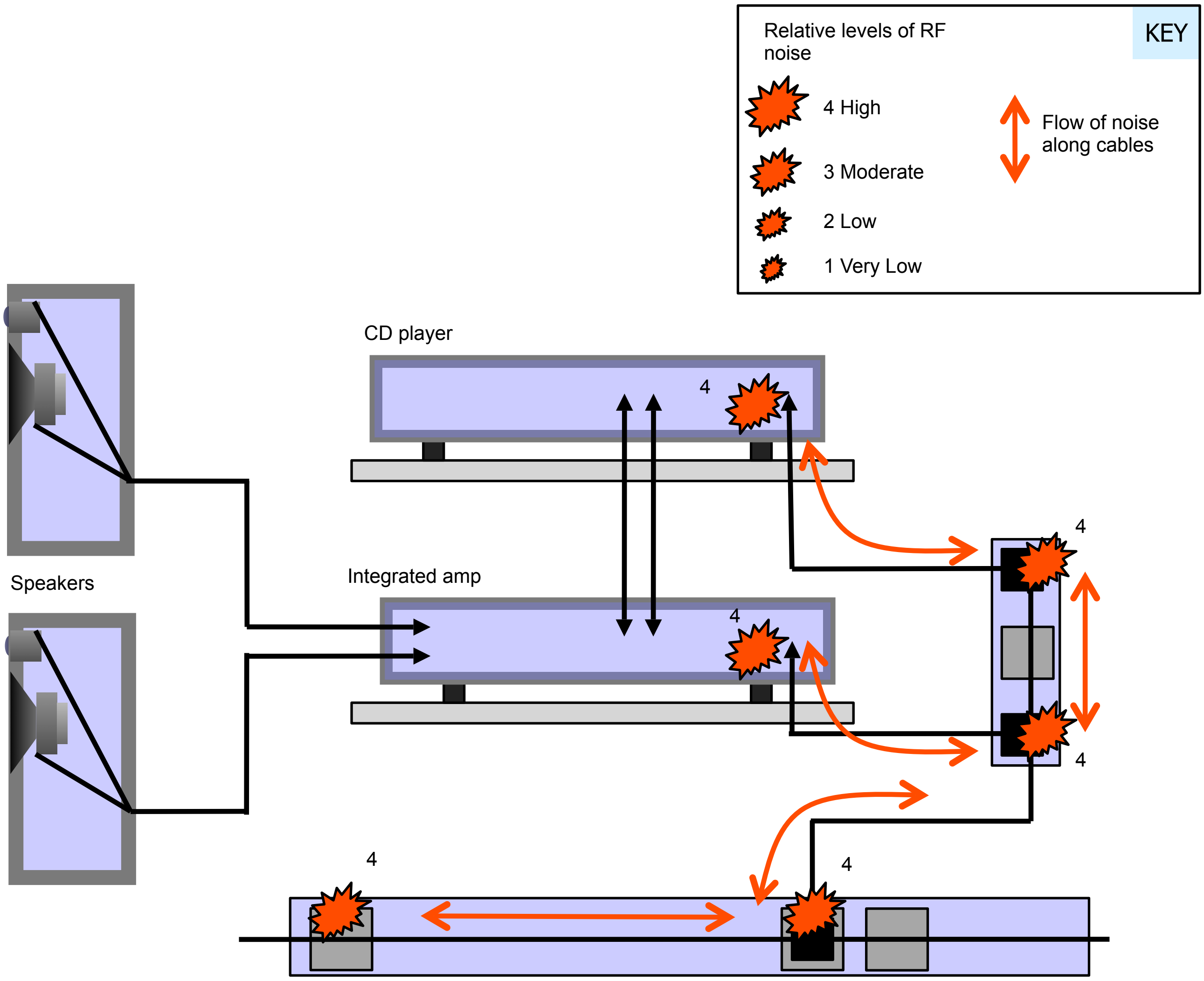


Fig 4 - noise in the machine

So in Fig 4 we have changed the emphasis of our schematic and now it represents what's happening with RFI in and around the system. At the moment in our system, we are doing nothing about the RF noise, therefore we are showing it at a high level throughout the system.

The sound of the untreated system

It is worth, at this point, describing briefly what a typical system will sound like when its left fully open to the ravages of vibration and RFI. It will sound bright, flat and 2-dimensional, heavier music will be fatiguing (limiting programme choice), bass will be lumpy and untuneful, tonal detail will be limited. Treble will be spitty with no subtlety. Timing will be poor, with different rhythmic elements of music seemingly disjointed. The system will not be transparent, so rather than the speakers and room disappearing, the listener is always aware that the sound is coming in a sense, off the face of the speakers.

Sounds a bit harsh this description perhaps. But ask any of our customers where they think their pre-Vertex system started from, and they'll pretty much agree with this.

Counter Attack!

The Kinabalu principle

So how are we going to deal with these problems? Well, you are probably aware that it's the Vertex supports and interconnecting equipment that we use to tackle all the vibration and microphonic problems. We'll come onto RFI and mains conditioning a little later.

Lets start with our supports, because the basic theories here are fundamentally the same in all the other products. The Kinabalu supports comprise an acoustically 'absorptive' platform with a hard granite top surface, a coupling tripod and a further 2 supporting feet (to keep things level). And on the underside of the platform are soft Sorbothane feet. The tripod is specifically designed to be a low acoustic impedance, and when correctly set up, the arrangement allows damaging acoustics to flow out of the box being supported, down through the tripod and into the platform. How? Well the tripod is a 'fast' steel object, directly supporting the 'fast' metal casework of the player, and its sat on the 'fast' granite surface of the platform - minimum impedance mismatches, maximum transfer! Its a case of taking the acoustic energy away from somewhere you don't want it (the electronics) and dumping it somewhere else, where it can't do any harm (into the platform). Note that we use the word absorption to give an indication that the vibration is taken out of the system, but in reality the absorption mechanism is a labyrinth and the vibration is actually 'nulled' by destructive interference. Soft feet underneath the platform prevent any vibration in the shelf or rack from passing up into the platform and player.

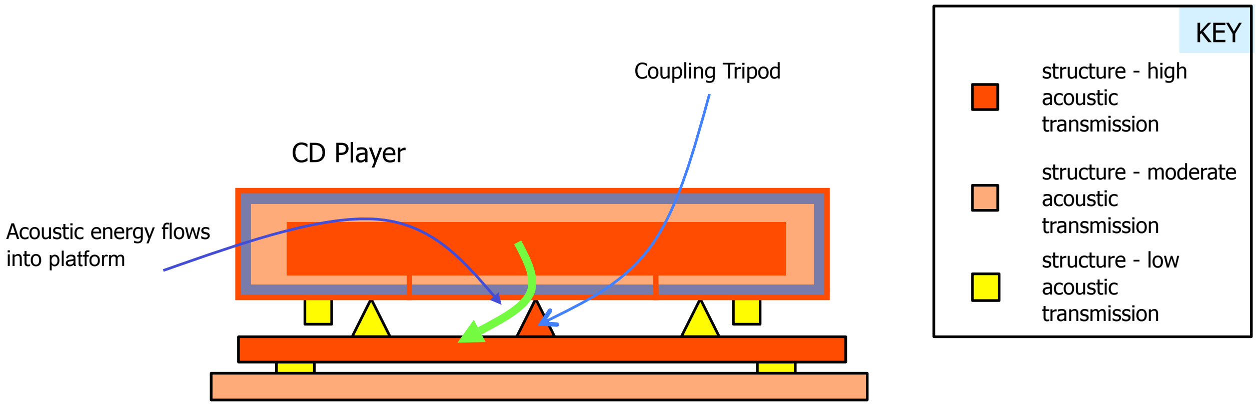


Fig 4 - the Kinabalu principle.

Hopefully you are beginning to get the idea with these diagrams now. If you see red in contact with red, you know its a good acoustic path, and if you see red in contact with yellow its a bad acoustic path. Note in this example we have shown the player's own feet as yellow - most manufacturers fit plastic feet with rubber and/or felt parts. The problem with this, as you can now see, is that vibration within the player is left there if you just stand the player on its own feet.

So if we now introduce 2 Kinabalu platforms into our system, this is what it looks like schematically.

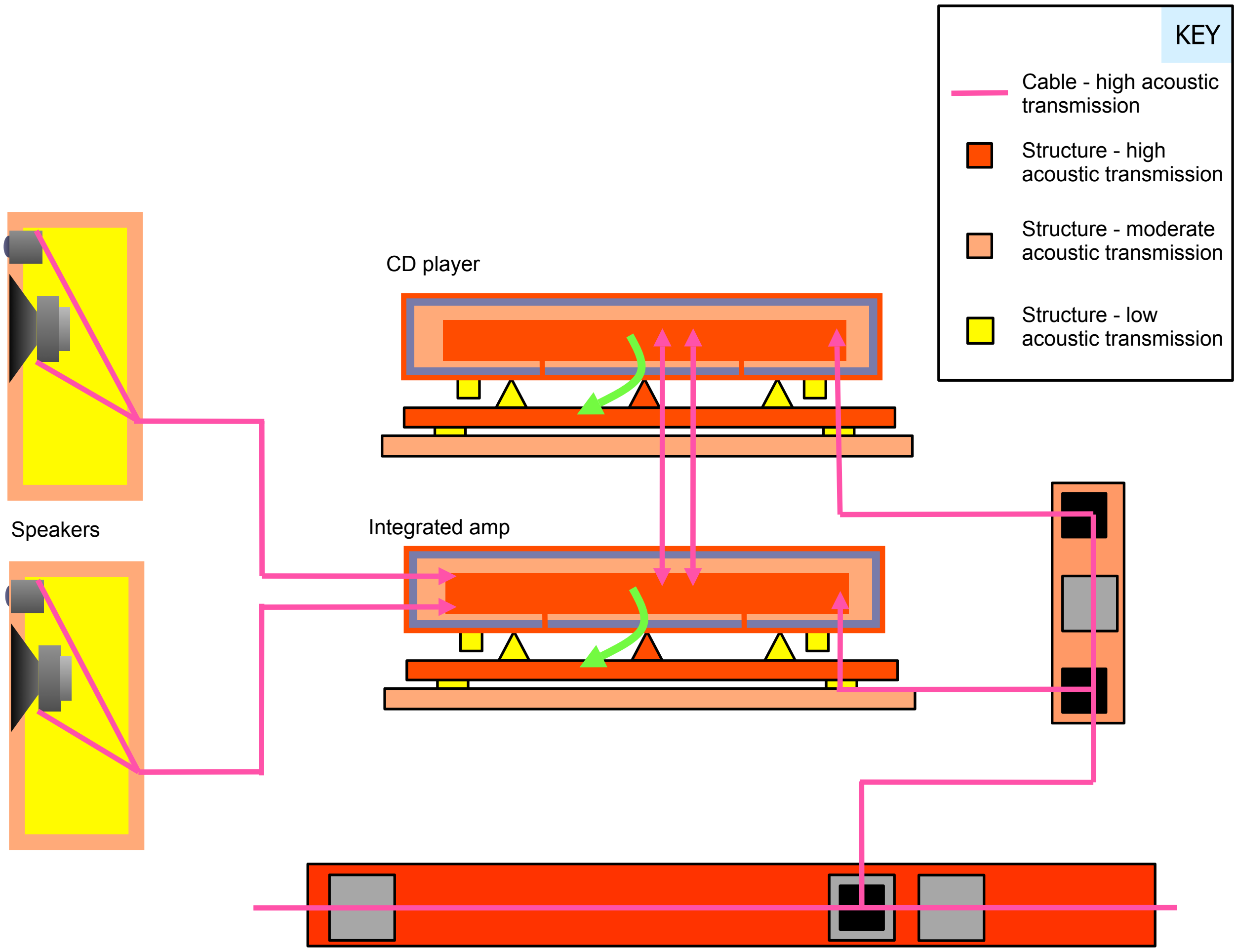


Fig 5 - draining from the electronics

So now we have provided 2 efficient drain routes to take a lot of acoustic energy out of the CD player and amp. If you have not yet had a demonstration of just how much this purely physical action improves performance, we suggest you hear it as soon as you can - it really is a revelation.

Our cables do it too

Now, if we get significant results by draining acoustic energy away from the chassis, then its logical that if we drain energy directly out of the circuits themselves, and prevent the vibration traveling around the system as well, we'll get further improvements. And this we do with the cables of course. You see, a Vertex cable, in acoustic terms, is similar to the Kinabalu system. Because of this, they don't look like ordinary leads, each Vertex lead has a large metal-cased module fitted some way along its length.

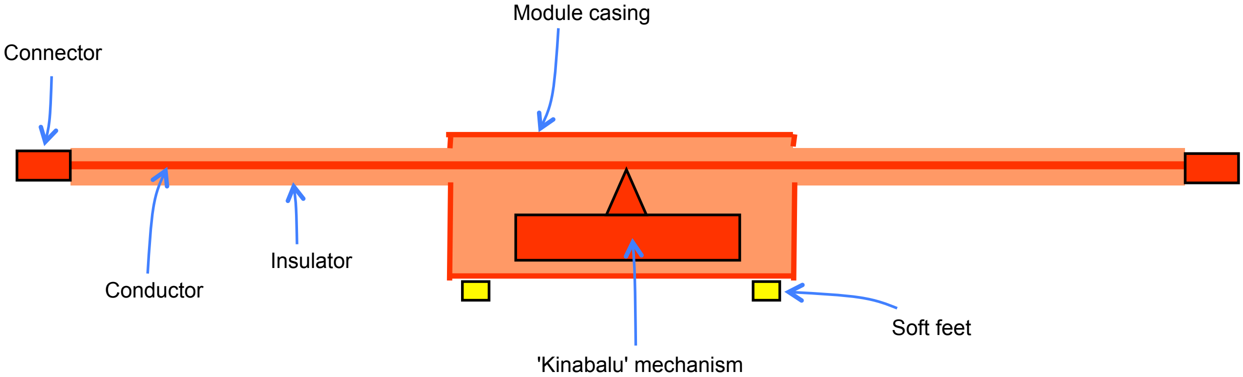
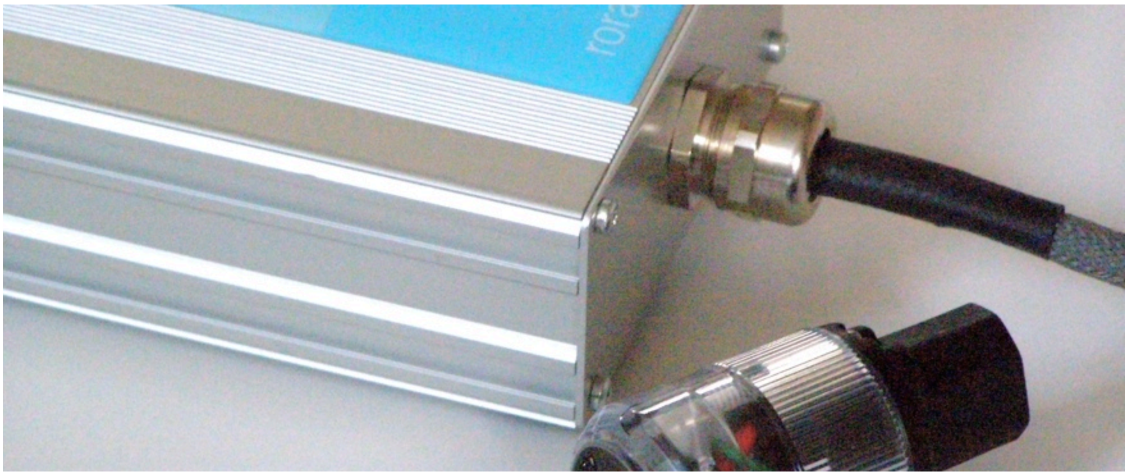


Fig 6 - schematic of a vertex cable

In this diagram you can easily see the that within the module, vibration is drained into a 'Kinabalu' structure. And this structure is similar to the labyrinth mechanism within the lower half of the Super and HiRez Kinabalu platforms. So now, when this lead is connected into your hi-fi, any vibration that is at the connector sees an easy route down the conductor (its hard metal remember) and into the acoustic absorption within the module. Now you might think that it would also carry on to the plug at the other end, but the destructive interference kills it. The same applies to vibration coming from the other connector. We do a very effective demonstration of this with a coin and a stethoscope - rub one connector with the coin on an ordinary lead and with the stethoscope you can clearly hear a considerable amount of sound at the other end. Do the same experiment on a Vertex cable and you hear nothing.

Finally, you will see the module sits on soft feet to reduce the risk of external vibration getting in from a shelf or the floor. However, note that we have shown the insulation as a moderate acoustic conductor - in order to preserve basic safety the insulator cannot be made out of a very soft rubber, there are inevitably some quite tough plastics used. That is why our setup instructions warn about allowing hard contact between the outer cable sleeving and structure such as walls or shelving uprights - this can feed a surprising amount of vibration into the cable.



So lets now go back to our system schematic diagram, the one showing vibration passing up and down all the leads. If we now replace all the mains and signal leads with Vertex leads, each with an acoustic absorption module, we make really huge changes to the acoustic behavior of the system. Remember also that, left unchecked, vibration can go down one lead, through plugs/sockets/connectors and up another lead. For example, vibration from a big power supply in an amp say, can travel down its mains lead, and up the mains lead to a sensitive pre-amp or phono-stage.

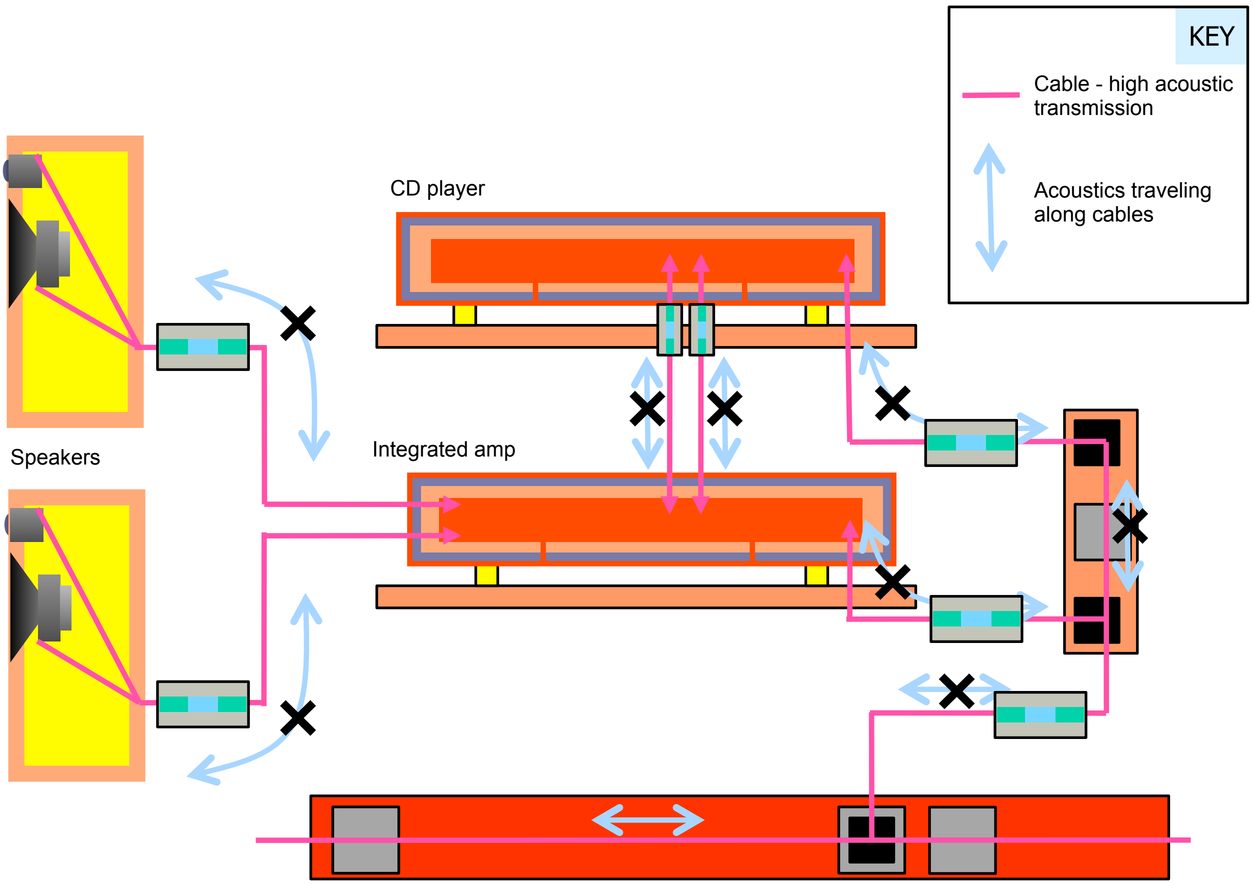


Fig 7 - killing vibration - in the cables and between the boxes

Next - lowering that RFI

The first, and in many ways, the most important part of our battle plan against RFI is a good 'shunt' mains filter. The word shunt means that the filter elements are not in line with the power being fed to your hi-fi - and this approach avoids the pitfalls of reduced current feed to power amps. In practical terms it means we can make a very simple plug-and-play product that you simply plug into an unused socket.

But hey, shunt filter circuits are just like any other circuit - they suffer badly from microphony. So guess what, we build the circuit on its own little Kinabalu platform!

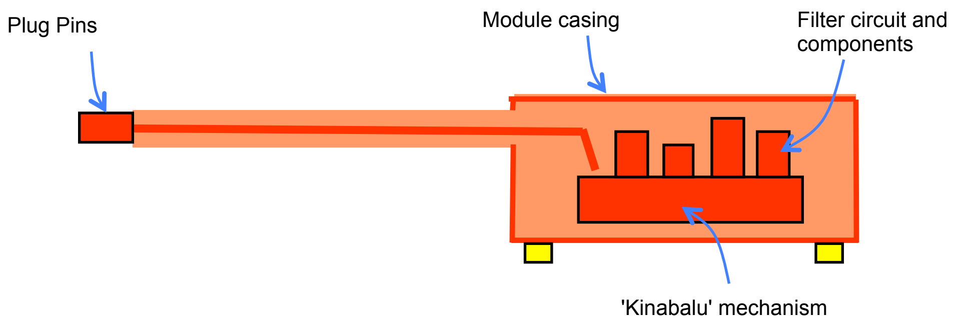


Fig 8 - schematic of a Vertex RFI filter (Jaya)

The electronic circuit in the shunt filter basically allows any high frequency noise which might be on the live, or neutral, to be 'shunted' onto the earth line and drained away from your system. Take a look at some of the photos of the Jaya mains filter to get an idea what these things look like. And now we need to look at our systematic view once again to get an idea of what these components will do.

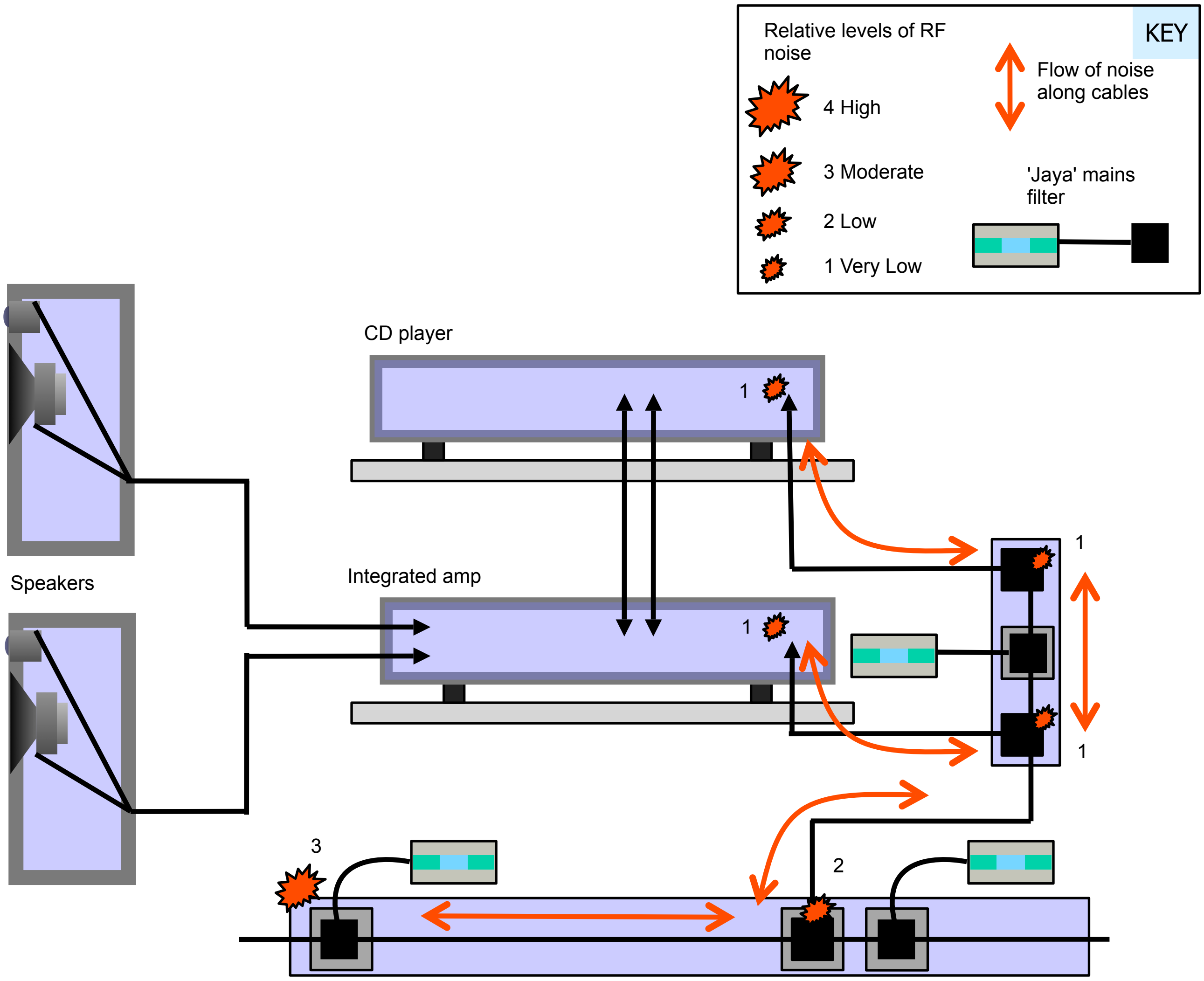


Fig 9 - the effect of 3 Jayas in our system

What we are showing here is the effect of installing 3 shunt filters into the system - because we can cover a few extra important points that way. First you should note that you can never completely remove RF noise. The ever present barrage of radio signals, particularly things like mobile phone nets and wifi, will be picked-up all around your wiring and if you try to reduce it at one point, it is still very much present just a few feet further down the wire. And of course the other big noise generator is the hi-fi itself.

So if we imagine we have put the first filter in the middle socket of the distribution rail, it would lower the RF there from 4 to 3 say, and from 4 to 3 in the electronics too - and you will hear a good improvement. But if you work back from the system, with 1 or 2 more filters, you get a cascade effect, and on the diagram we show how with 3 filters the noise at the electronics is reduced down to 1, very low. Now bear in mind that this example will vary in actual application from case to case - but the principle of noise over distance and cascade filtering is an important one, and one which has often been the key to lifting an otherwise disappointing system up to greatness.