RECIPES

Grimm AUDIO

www.grimmaudio.com
info@grimmaudio.com

In the eating

The cooking analogy is often put forward by audio designers to emphasize the artistic part of making good audio. Sonic colouration is a reality and a proper sense of balance and taste is required to build useful products.

But it extends further than that. The cook may not always use scales and beakers to measure out the ingredients, he knows exactly what he's adding, how much of it and most importantly, *why*.

Proof of the recipe…

All of the finest theory cannot predict how a human listener will experience music as processed by a particular circuit. As about everyone with practical audio electronics experience will attest, some circuits with vanishingly low distortion figures just fail to make music, whereas others that sound excellent have not much to offer in terms of numbers.

Luckily, the outcome is not completely random. Quite often, circuits with positively stellar transparency and neutrality have excellent distortion performance. Also, certain design techniques are more likely to produce good results than others.

The only way of discovering the relation between a circuit and its sound is trying out many circuits and testing them both by ear and by analyser.

… the ingredients…

To complicate matters, two circuits with absolutely identical measurements can sometimes sound as far apart as anything else when different (but equally spec'ed) parts are used in their construction. In such cases the only way out is to painstakingly test candidate parts from various sources, swapping them out and listening to the result with each one.

Capacitors, especially electrolytics are notorious offenders, but it turns out not much is exempt: resistors, active devices, wires, pc board materials… So far, the sonic differences between resistors have been easiest to correlate with measurement (on the individual part itself).

…and finally the pudding.

After having gone through these experiences, the designer will be able to put together a good sounding product without too many hassles. Even then, it would be foolish to take a new design straight to production without listening it through thorougly and collecting comments from selected potential users.

Recipes from Grimm's kitchen.

Short signal paths

An important way of minimizing colouration of audio signals is to limit the number of signal processing stages it goes through. Quite often we find it is possible to do with one circuit what is normally done in two or more steps, simply by rethinking the structure on a more global scale.

The AD1 is a case in point. AD converters normally use switched-capacitor delta-

sigma modulator ICs. These chips operate by charging caps at op amp outputs and discharging them across the inputs of other op amps. Thus they present to the outside world a very tough input to drive – input current is drawn in short spikes. This requires a very fast input buffer, stable into a capacitive load and of course with good audio performance.

In the data sheet of one of the best A/D chips, the manufacturer bluntly admits it is not possible to build an input buffer having both low noise and low distortion!

Instead of being the next company to try molly coddling the problem, Grimm decided to design a discrete converter with a benign, continuous-time architecture and a current mode input. The entire input section consists of two resistors. RFI countermeasures and input protections are unnecessary.

On a circuit scale, selecting the gain device most suited for a particular task (bipolar transistor, jfet, triode, transformer) often dramatically reduces circuit complexity, thereby improving sound quality (if not measured performance as well).

Application-specific analogue.

Keeping the signal paths short often precludes the use of the common "op amp" function block. One is reminded that the op amp, a voltage-controlled voltage source (VCVS) with two inputs and one output and very high gain is only one of a range of possible gain blocks.

On the input side, a gain block can have voltage or current control. On the output side they can be voltage or current sources and have one (unbalanced) or two outputs (balanced). Op amps only occupy one quadrant of this 2x2 matrix of current/voltage input/output function blocks. In the balanced mode, common mode and differential mode are controlled by two sets of inputs, which again of course may be voltage or current inputs. Voltage outputs can double as current inputs. A gain block can have multiple sets of inputs – only a few discrete parts are added each time, as opposed to entire op amps.

For unclear reasons, both the industry and academia have settled on "voltage thinking". Most audio IC development effort has gone into the design of op amps. For this reason, practical examples of the other options are few and far between and are never optimised for audio performance. As a result, non-op amp circuits are consistently dismissed by the engineering community as unsuitable for audio.

By now the reader must realise that a whole field of very versatile "building blocks" still lies open. Grimm Audio takes pride in having built up a substantial body of experience in designing and using these alternative circuit blocks.

Performance testing on the sub-circuit level

It is surprising to find how much the sonic performance of a circuit can suffer when hum or noise is injected into its power rails even when it has excellent PSRR and none of the noise supposedly finds its way to the output. Similar effects show up when circuits cross-couple electrically or magnetically.

When the design is measured as a black box, even the most detailed measurements struggle to point out such problems. Usually it's too late when they finally do. This is why all sub-circuits, including those that are supposedly not part of the signal path, are fully characterised before being applied in a product.

Shunt power regulators

Regulators hold an interesting position in the above. A normal regulator is designed such that it keeps the load from seeing disturbances caused by other circuits.

Shunt regulators go further than that: they prevent their load from inducing interference on the power line. The principle is simple: a current source is configured to pass a current to the load equal to the maximum current the load will ever draw.

This does not incur significant dissipation penalties: most signal processing circuits draw a relatively constant current to begin with. The actual shunt portion (an idealised zener diode) is placed in parallel with the load, as close to the load as possible. It will draw the excess current to keep the voltage across it fixed. Like a good decoupling capacitor does for HF, the shunt regulator will short out the AC current from the load to the local ground. The rest of the power circuit never get to see any of it.

Choke-input rectifiers

Manufacturers of electronic equipment are massively converting to switching power supplies in order to fulfil power-factor and mains harmonics requirements. In its current state, the art of low-noise SMPS design is “not very developed”, to be polite.

Ironically, one circuit trick used originally to keep rectifier tubes from getting overloaded offers good power factors and low noise at the same time: choke input rectification. The diodes work into an LC filter of which the inductor is chosen such that the peak-to-peak current ripple is less than the average current. This results in an input current waveform that cuts the middle between a sine and a triangle wave –rather better than the spiky current waveform found in inductorless rectifiers. The output waveform is also exquisitely noise-free.

The downside is weight and cost. Grimm’s products are not designed towards either cost or weight targets.

EMC from the ground up

All too often, EMC (Electro-Magnetic Compatibility) is seen as an unnecessary complication for product designers. We found something quite different: good EMC and sound quality go hand in hand.

Not, of course, when EMC is to be achieved by adding ferrite beads and ceramic capacitors to the I/O’s of badly designed gear just before going into production. When the chassis layout, board layout and circuit topology (in that order!) are chosen correctly, such measures can be made wholly redundant. On the sonic side, this means that all sorts of “rubbish at the noise floor” –supposedly mysterious sonic defects– are absent by design.

Now Serving: AD1

Exotic as it looks both on the inside and out, the AD1 is based on a solid core of theory, thoroughly planned, skilfully executed and critically tasted.

A table, bon appétit!

Bruno Putzeys, June 18th 2004.