

**An enlightening DAC-project,**  
the tubed output dac of Jukka Tolonen

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## **How it started**

This is a brief historical perspective on the proceedings of my project for a Digital to Analog Converter (DAC) up to the present (June 1998). If you are used to buy new, you might think twice before reading further. It can be boring. When you are the technician who does or could design his/her own DAC, at first sight there could be little to learn. However, I encountered several issues for further discussion among professionals. You are invited to bring forward your vision or experience. Reading might also be interesting for Do it yourself (DIY) persons who think about starting or upgrading a DAC. As for myself, my daily challenge as an economist is to advise companies on management and organization. In my spare time - apart from living with my wife and two kids - my two addictions are Neuro Linguistic Programming (NLP) and high end audio.

What you'll find here in this first part are the preparing activities, the steps to be taken before building: what design, what components, how to order via internet, etc. In my experience this is the most important part (that is if you know how to solder), a prepared start is half of all the work. This document is a compilation of knowledge and insight I only could have gathered from others as in 1997 I did not know anything on this matter. Most of the names you'll find below and I would like to thank them for their cooperation. I don't claim to be right, and there may be incorrect statements (please let me know). It is written inspired by the mission of the Audio Crafters Guild founded by Norman & Marian Tracy.

On one of my first trips on internet I encountered the site of Jukka Tolonen and his interesting audio projects (<http://www.megabaud.fi/~jtolonen/projects/projects.html>). One of these projects was a DAC design, based on the CS8412CP, SM5843a, AD1893 and PCM1702P/K. As I was looking for an upgrade for my CD-player, I thought: "Why not use this design?", and I did. For him jitter is an evil, so this chapter was taken care of. The idea of filtering the high frequencies at the beginning of the output stage was another strong argument. The main reason for choosing this one was the option for a tubed output, tube-adept as I am like Jukka. Moreover, another option is a balanced output mode which fits in with my plans for future expansion of my system. This prevented me from looking further for other excellent DAC-designs as I discovered later in those from ACG (<http://www.galstar.com/~ntracy/acg/acg.htm>), the Dutch 'Audio en Techniek' (<http://www.audio-nl.com>) and probably others. So here's my journalistic impression.

## **The DAC-project**

The upgrade I'll do in three steps:

- a. a digital output on my current CD-player. Here the ACG-site of Norman Tracy offered the articles of Erland Unruh ([erland.unruh@trab.se](mailto:erland.unruh@trab.se)) and Lars Erik A. Wedin ([Lars-erik.a.wedin@telia.se](mailto:Lars-erik.a.wedin@telia.se)) and a dedicated S/PDIF-output came within reach (The digital output one, DOO).
- b. an external DAC of a design where at least the pcb's are available (and if possible all parts included, because searching yourself is fun but consumes lots of time and often is hardly cheaper)
- c. replace the player, with modifications to be made by a professional

After checking if all the components could be ordered, I called for the pcb's which promptly arrived from Finland cash on delivery. I was impressed by the quality.

Then followed the ordering of the components. The simple components like resistors and capacitors can be had in my neighborhood. On the active components ACG is lending a helping hand with exact precision.

In ordering ic's it is important to specify the type with the exact extension following the type number, for the shape (in many cases plastic DIP) and often for the accuracy. Most of the data can be found on internet at the manufacturers. Erland Unruh and others state that it is important to choose at least the G-version of the CS8412CP (better noise rejection). This type is not stated in the name-code but it is found in the "manufacturing" code a row down. It's the letter just before the year+week digits.

In my case the component which was the hardest to get was the NPC-chip SM5843a. I was glad to be helped so carefully by Seiko Europe (thank you Gabriela Meyer-Delius respectively Andrea Huttenlocher of Channel).

At Klove in Holland (<http://www.klove.nl>) one can order precision crystals.

### **The match of output and input**

The CD-output with the DOO-design will be of the consumer format S/PDIF, but the input of the schematics looked like the professional AES/EBU-format. This looked like a serious mismatch. Don't be misled. Though these formats are of the same family, their characteristics don't match automatically! For serious applications the formats should not be mixed. In both versions holds true as Jukka said: "The most important thing in the digital signal transfer is to maintain constant impedance, also across the connectors." You can find here and there internet-articles explaining the differences. Then I discovered the switch of formats in the schematics of Jukka. In a reply to my question on this subject Jukka wrote: "Basically, AES/EBU and S/PDIF are the same interface with different cable and termination. Therefore, you can very easily convert the electrical interface to another format." Which can simply be done on his pcb indeed: by installing different components it is possible to choose one or the other format.

So that's it, I thought. Until Erland Unruh pointed out to me that it would (should, he meant as I understood) be wise to have the same shielded transformers on the input and the output side. RCA-plugs are no HF-interconnects. XLR-plugs with their balanced mode have the advantage of being less susceptible to interferences. When it comes to HF-stability a high-quality BNC (75 ohm type) could be more than a nice tweak. The technicians did fully agree on this last modification, thought Erland is setting new borders with, among others, his earth decoupled isolated BNC-suggestion. What he himself - a bit ironical, I think - calls 'low'-tech modifications are apparently driven by the thought of ensuring low jitter and noise at all stages. According to his measurements he is succeeding in this.

In all modesty one could pose two questions on this before his dedicated approach can be fully understood. First, why bother about tank-effects of capacitors when this effect is only significant at lower frequencies? Between the lines of his articles and in his solutions like the mix of capacitors you could make an educated guess. For his system-thinking attracts: the signal can be no better than the noise in the system allows it to be. Second, like Guido Tent ([gtent@ehv.sc.philips.com](mailto:gtent@ehv.sc.philips.com)) noticed, low noise is the best indicator for sound design? This however is a dispute I will leave to the technicians.

### **The power supply**

Some say audio is nothing more than a good modulated power supply. In my experience this is a premise which can be defended very good. An investment in a power supply is always paying. But investment in what exactly?

#### *a. The super regulator*

Although I had not yet read his articles the approach of Walt Jung seems to be of a super regulator. Design a regulator which can handle frequencies up to some 200 MHz and let all the active components have profit of it. This presupposes a craftsmanship where it comes to the pcb-layout. The pcb of Jukka Tolonen is based on this approach.

#### *b. The 'close to consumer' approach*

In the 'low'-tech approach of Erland Unruh you use regular regulators, provided they are placed in the neighborhood of the consuming ic's. And being decoupled properly. Keep it stupidly simple (or other linguistic options) and it will work out better, he seems to be broadcasting.

*c. The parallel approach*

Then there is the approach of the Dutch high end freaks from 'Audio en Techniek', where close to consumer only parallel regulators (TL431) are being used. This could have the advantage of a serial-impedance between the consumer and the power rail. This approach appears also to have more than good results.

*d. The tube-supply approach*

In power supplies for tube amplifiers you'll find after the rectifier a series of R/C-combinations. This leads to better sound than regulation is the adagium of purists like Mattijs de Vries. If you add a regulation it will interact with the tube, especially in critical designs like SRPP, in my experience and of others. However, if you add after the regulator another R/C then you might be able to include advantages of non-regulated and regulated (with the right Fc under audio frequencies).

In my case I like the result at least (more detail, dynamics, spacial precision). Now here's my free association of mind. Why would it not be possible to apply such type of solution to digital audio?

Now you can understand my question better: investment in what? How can you make priorities with so many well respected solutions? Or can approaches be combined? I hear you: no! But I repeat the question. For instance, the decoupling approach of Erland might be close to the tube-supply issue, if one looks at the pcb-traces as resistors. But how can you calculate/measure then if the Fc of the R/C-combination is well below the audible frequencies? Which professional technician will take the glove here?!

I have chosen for the solution at hand and will follow the pcb-layout for the super regulator as it is. Later on I could (and probably will) experiment further.

**Can ordering via internet be fun?**

In the past few month I heard several messages on the use of credit cards via internet. One says its ok. Others are confronted with abuse. So I asked myself: how can ordering via internet be fun? Here are some basic guidelines. They apply in the situation when parts are ordered outside the European Union (EU) and should be shipped to the EU, more particularly to the Netherlands. Other cases I did not check (ask your own Duty-authorities, you are invited to let me know the result).

a. Prepare your list of components in advance and in detail (like the exact type indication of ic's). It will make the quotation easier and it prevents misunderstandings.

b. When you ask for a quotation, also ask if the components are in stock. It will give you insight in how long it will take to get it all.

c. Confirm the order by fax (as soon as you get the message that all is ready to send). State the parts and the total amount on the fax. Here you can add the number and expiring date of your credit card. This is quick, cheap and safe. Faxing the specs of credit card has considerably less risk than E-mailing! I was told it is reasonable that the amount will be charged on the moment of shipping the order.

d. As soon as you place an order outside the EU this is subject for taxes. On parts of electronics usually no taxes of importation is to be paid however (tariff = 0%). You should pay VAT (17,5%) which is computed on the basis of the bill that is accompanying the parcel. There is for every Dutchman an amount of Dfl 65,- (\$ 32) which is duty-free. In special cases (so called monsters/samples) there is the amount of Dfl 120,- (\$ 60) duty-free. Then it is not allowed to have more pieces of the same part (it should be a sample), which the Duty authorities will check for by statistical sample.

The VAT of the country where the parts come from can usually be subtracted (depends on the duty rules per country). The taxes will have to be paid on the moment of delivery. When taxes of importation are to be paid normally the shipping company will contact you first (not in the case of normal air mail).

e. For transactions within the EU the VAT is already paid in the country where the parts are ordered. Here also the payment is more easy, with systems like cash on delivery, registered delivery of payment via Euro-giro. However, parts like special ic's are often hard to get or expensive within the EU.

f. So you ordered. But how can you be sure the parcel will arrive? Compare it to the things you buy in a shop. In a shop you can see if the delivered goods are ok. You pay, and you immediately receive what you asked for. In that case, you run no risk in the exchange of money for goods. How different it seems with ordering via internet. The moment of payment and the moment of receiving the order are separated then. Is this the responsibility of the transmitter or yours? May be neither. It is you who want to receive the goods and it is the internet-shop who wants you to come back.

Now in practice one should not worry too much. In my neighborhood I did not hear of parcels that did not arrive. And Norman Tracy of ACG said up till now all of the orders send by parcel post airmail arrived, although some of the delivery's were weeks late.

Is there an intelligent strategy to follow? Here are some thoughts. Do not send it surface mail (by boat). You pay few but will wait many, many, many weeks. There are several ways of sending parcels more quick: normal air mail, commercial transportation companies (like UPS, DHL, TNT), mail with registered delivery (you have to sign for it at delivery) and insured mail. These last two modes are common within Europe and with normal air mail between United States and Europe. Note that parcel post air mail can be insured, but it cannot be registered.

- Let the order sent by normal air post (United States Postal Services call it 'Parcel Post Airmail'). This is the cheapest possible shipment method and you'll receive the package in 5 to 7 business days. However, if the postman does not even ring once, you are stuck with only a small chance of claiming your cost. Most companies let the service explicitly end on the moment the postman takes over.

This option though might go along with the greatest chance for the lowest possible customs fees.

- Choose a way of sending with a system where you can track the parcel all along the route. This can be mail Express Mail (2 - 3 business days, with true tracking service) of United States Postal Services (USPS) or a respectable commercial transportation company (most of them can also track the parcel). In this way it is not likely the parcel will just disappear. Here you probably will pay extra for cost of delivery compared to Parcel Post Airmail.

Normally the bill will accompany the parcel, so the customs can check on the obligation to pay duty. Be aware that a commercial transportation company has to follow the standard Duty procedures.

- If the amount of the order is really high (you make an estimate for yourself), you can have it insured. It will cost some more but it will allow you to have a good nights sleep. In this case, the cost of insurance will also be visible for the customs. Insurance will be some \$ 1 per \$ 100,- . The Express Mail of USPS is standard insured for a maximum of \$ 500 (not for cost of delay). Some say it will be worth having the parcel insured, although not for the total amount of the shipment. This might look as a good strategy to pay the smallest amount of duty/tax. But this seems only be wise in those cases where it is sent by normal air mail with insurance. In the case of a commercial transportation company you run already considerably less risk of lost, while the accompanying bill probably still shows the full amount of payment. For DIY-ers insurance seems a cheaper way to prevent that sender and addressee have to start arguing in case of lost than mail with tracking service.

This all is theory. What is the right choice in practice? This depends on what you are looking for. Suppose you want to buy cheaper elsewhere than at home. Then you'll like to order more to get the most out of it, while minimizing the amount of transportation cost. If it concerns items that are not available in your neighborhood or are simply very expensive, you'll want to secure the delivery. Then some extra cost is not felt to be critical. Above that, the faster you want it, the more you will have to pay.

For an indication of the shipping costs in your case the company where you order can give an estimate.

You can also use the international rate calculator, an excellent service of the US Postal Service (<http://ircalc.usps.gov>). The modes of US government postal offices and their tariffs can be found in <http://www.usps.gov/postofc/postofc.html>.

If you order some physically small components (like ic's) you might think you'll receive a small package. I guess only Norman will succeed here. In my neighborhood I've seen some huge packages arrive. An example. Ic's sensible for static electricity are well packed in an anti-static plastic U-shield, put in an anti-static sack, covered in cardboard and put in a solid made paper box. In this way for some ic's of several tenth of grams you can end up with a package of one or two pounds just like that. This is of course a very safe way of packing and secure for industry, but for a DIY-er it will only add to the bill.

A package of two pounds send by USPS via Parcel Post Air Mail will cost you some \$15. By Express Mail (USPS) the same package the shipping cost is some \$ 26. The same package by a commercial company might cost less, the same or far more (mainly depending on the speed of delivery). So always ask and agree what is the way of shipping and the (estimated) cost of it. Some companies offer only one way of shipping.

g. Abuse of credit cards is always possible, even if you do the shopping in your own country. Via internet or fax no signature is needed. The company that sells the parts will be supervised closely, and runs the risk of loosing his license. Which he does not want, so here's where confidence ought to grow. Here the credit card company has a role to play (they introduce this means of payment and have a certain responsibility): at the end of the month (at VISA) you normally get the bill. After that moment you have at the most two weeks to let the credit card company know if there is something wrong with the bill.

It is advisable to contact first the company where you got the bill from, certainly if you intend to do business there more often (there could be just a mistake or this one employee who ...). But if the delivery is late, the components are wrong and the shipping company does not respond on your mails, then don't hesitate one minute.

How can you maximize the time between the date of ordering and the date of delivery before you get the bill from your credit card company at the end of the month? You could consider to confirm your order at the beginning of the month.

### **Quest for music**

Music has several meanings for me. First of all it is a way to 'find yourself again', for which I usually play my guitar. Then I like to listen to music when I'm reading or writing. This is a nice way of trying out CD's that are borrowed from the public library. There for example I noticed recently the music of the jazz/blues guitarist Ronnie Earl & The Broadcasters on his CD 'Still River' (a fine recording by Audioquest). My regular visits to concerts (De Doelen in Rotterdam or the Concertgebouw in Amsterdam) for classical music inspire also to quest for the 'right' recording. However, my first love for groups like The Who is hard to ignore.

After changes in my system I use only some musical fragments that I (by accident) happen to know well. The 'Szene am Bach' of Beethoven (Symfonie No 6 in F-gr, Pastorale Nimbus), the 'Firebird' of Stravinsky (Concertgebouw Orkert with Carlo Maria Giulini, Sony No SK 45935), 'Sonate h-moll' of Liszt (Ivo Pogorelich, Deutsche Grammophon No 429 391-2), 'Four seasons' of Vivaldi (Fabio Biondi, Opus 111, OPS 56-9120), 'House of the rising sun' of Cyndee Peters (Opus 3 No 7706), 'Nobody's Blues but mine' of Tomas Ornberg's Blue Five (Opus 3 No 9102), The Nightfly of Donald Fagan, Motion Music of Tony Overwater/Yuri Honing (The Dutch: Jazz in Motion) and the Swedisch 'Jazz at the Pawnshop' and 'Cantate Domino' (both Proprius) are such examples.

Finally, yes, there are these nice evening when the house is all quiet. Sometimes Laurindo Almeida, Ry Cooder, John Martin, Joni Mitchell, Hector Zazou (Songs from the cold sea, to experience really low frequencies), plain blues of John Lee Hooker, John Mayall or Mighty Sam McClain.

### **My current system**

A few words then about my system. I'm familiar with the vision of John van der Sluis at 'Audio and Techniek', who states that you cannot write for others about music without telling what you listen to and on what system.

There's this good old modified Thorens 160 turntable with Van den Hull MM2. The CD-player is a Nakamichi. The pre-amplifier is a SRPP-design with E88CC of the high end magazine 'Audio en Techniek', with tubed RIAA. The power amplifiers are - again a DIY-project from 'Audio en Techniek' - of a straight forward hybrid type with E88CC and four power Hitachi FET's (SK/SJ-types) per channel. This amplifier is unconditionally stable and able to deliver enough current even if the impedance of the loudspeaker goes low. It is a sound(ing) compromise between tube-advantages and driver power. The pre- and power amplifier are double mono and have an external, extensive R/C decoupled power supply (with lots of these fast 'oil in paper'-capacitors). The loudspeakers are the electrostatic Martin Logan Arius, with the power amplifiers placed near them. I made a kind of side table for this, with cabinets on each side to put the amplifiers in. For cables I use Monster and Audioquest types.

### **The building of the DAC**

Now the building of the DAC has started. This will keep me busy in my spare time for a while.

### **Where does it all lead to?**

For an in between evaluation of the project: at this time it is already an enlightening project in the positive meaning of the word. Where does it all lead to? Will it be like the Dutch audio magician Peter van Willenswaard recently said on a hifi-show: "Most of the commercial dac's have still got something somewhere what is not doing right what they should do."? The final judgment for me will be if there is coming better music out of the installation than at this moment.

When this is finished and sonic impressions are there, I hope to inform you further in part two. In the meantime, if you have questions or suggestions, do not hesitate to get in touch.

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