By Claudio Negro and Valerio Russo

The Solid-State Duo, Part 2

The authors present the second part of this series, along with build instructions for the dedicated power supply and a soft-start circuit.

PHOTO 1: The finished UcD180

Our second amplifier **(Photo 1)** belongs to the switching family (named PWM, class D, class T, or simply "digital," based on the particular implementation). Mostly famous for its high efficiency, class D amplifiers entered the audio world at the end of 1964, with the X-10 Kit by Sinclair Radionics. Nine years later, Infinity Systems (now joined with Harman International) announced a switching amplifier to be presented during the 1974 CES in Chicago.

HISTORY

John Ulrick (Infinity co-founder and co-engineer, together with Arnie Nudell) relates that the prototype began to play just the evening before the CES opening, and with its display off because it was causing some glitches in the sound. In the end, the device was physically introduced in the Infinity booth just an hour before the show opened, nevertheless, it managed to play without problem for all four days of the event.

Soon after the CES, Infinity started to produce and sell it under the name of "SWAMP I": the first commercial class D audio amplifier was born, and it was able to produce 250W **(Photo 2)**. Ulrick left Infinity in 1979, and now he is the president and chief engineer of Spectron, an American manufacturer of (guess what?) digital audio amplifiers (www.spectronaudio.com).

Although a lot of water has flowed under the bridge since 1974, switching amplifiers were never largely accepted by audiophiles (forget about the T-Amp, a "phenomenon" which is now almost forgotten), mainly because of some limitations in the frequency response. In fact, as long as the load varies, the amplifier high-frequency response varies as well, so that class D amplifiers have been used mainly in active subwoofers or in the pro world, where the small dimensions, the reduced dissipation request, and the high efficiency are like manna from heaven. Nevertheless, the great revolution, in our opinion, came when Philips and Bang & Olufsen decided to enter the field.

In the year 2000, Frederiksen, Bengtsson, and Nielsen of B&O presented to the 109th AES (Audio Engineering Society) Convention a preprint in which they described a new PWM (Pulse Width Modulation) amplifier capable of 250 to 1000W of power: the ICEpower was born. The Danish circuit was innovative, because it showed off a frequency response within ±0.2dB from 20 to 20000Hz, no matter what the applied load was. That is one of the main limits the class D amplifiers overcame.

Great interest arose from the implementation of the ICEpower modules in power amplifiers of well-known brands such as Jeff Rowland, Rotel, Bel Canto, Martin Logan, Red Dragon, and Pioneer. Unfortunately, it's not easily possible for the end-user to buy the ICEpower modules, precluding their use in the DIY arena.

Meanwhile, at Philips, a young engineer named Bruno Putzeys, after eight months research, invented the Universal class D (UcD) amplifier, a module capable of great performance (even though many technicians saw some similarities with the ICEpower). The engineer solved the high frequency's load dependent drop, reduced the RFI emissions typical of all the switching amplifiers, and gained a frequency invariant total harmonic distortion.

This happened at the end of 2001, after which the UcD project remained one of the many unused patents. Fortunately, during a visit at Philips in 2003, the owner of the Dutch Hypex Electronics, Jan-Peter van Amerogen,

PHOTO 2: The first commercial class D audio amplifier, the Infinity Swamp I (1974)

met Putzeys, who demonstrated the UcD project. Immediately after, the manager contracted the authorization for its use.

Two years later, Putzeys quit Philips in order to take the lead of the Hypex research & development division. The result was that three amplifier modules (UcD180, UcD400, and UcD700) were put on the market, followed by a dedicated product line, made by power supplies, transformers, plate amplifiers with active controller, and a soft-start circuit. Basically, Hypex has in its catalog all the necessary components to build a class D amplifier. Between the well-known brands which adopted the UcD modules, there are the English *Meridian* and the American *Channel Islands Audio, Genesis*, and *Exodus Audio.*

UCD180ST

The model we bought was the standard (ST), the first one on the market since 2004. Later on, some alternative versions—the AD and HG series—were added to the Hypex catalog. In particular, the AD adopted an AD8620 buffer in spite of the evergreen NE5532, while the HG utilized the esteemed LM4562, which arranged to mount the optional voltage regulator HxR12, exploited some audio-grade capacitors and an improved version of the filter choke. Nowadays, only the ST and HG versions are available.

It's possible to tweak the UcD180ST with solder and a magnifying glass. You can change the input buffer with the AD8620, for example: in this case, you must replace the voltage regulating zener with a 12V one. Remember that these components are SMD (surface mount devices), so pay close attention during soldering. Tweaking the module will, of course, violate the warranty.

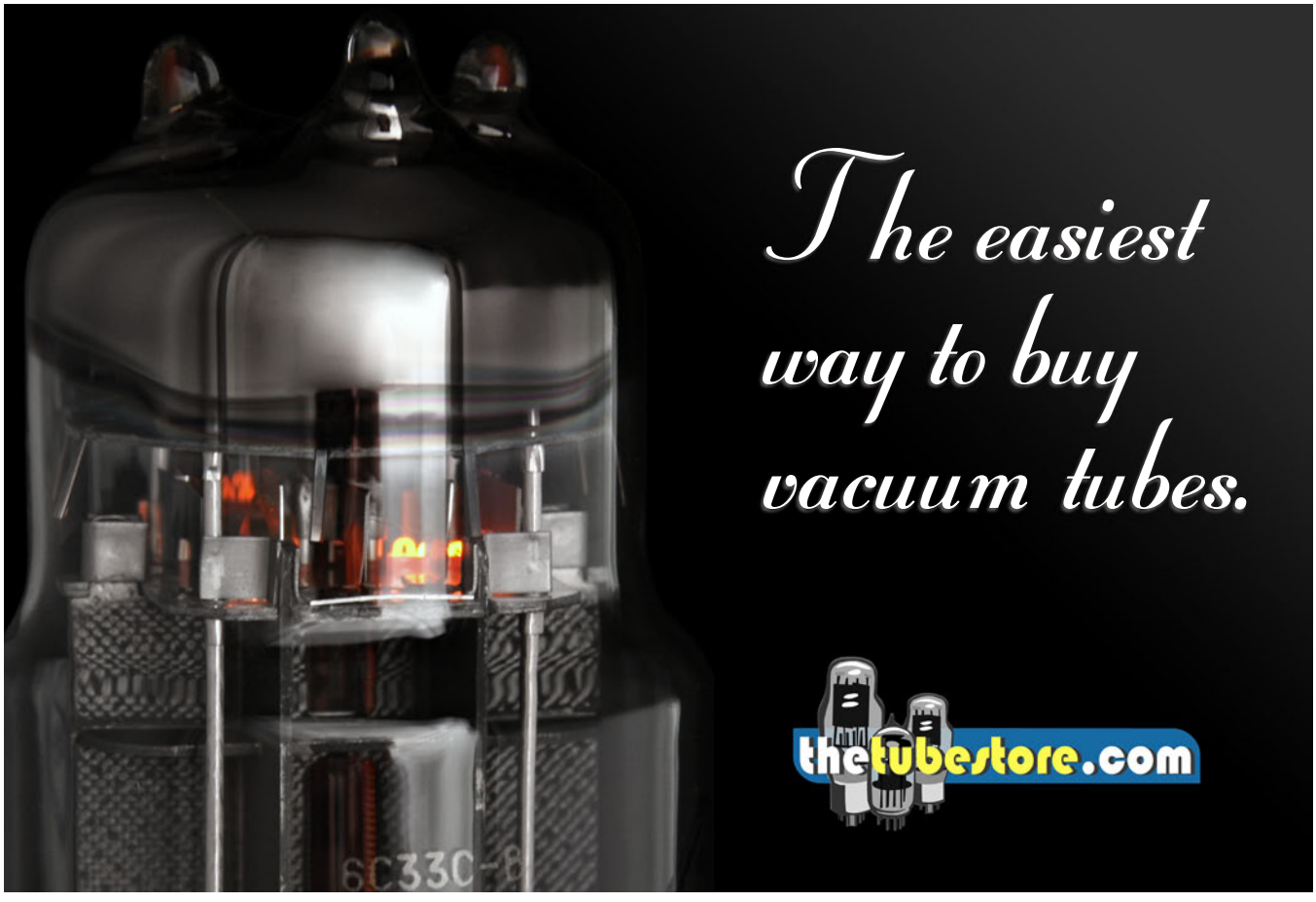
You can also substitute the coupling caps. Here you can satisfy your whims with whatever the market offers. We don't have suggestions for you (other than that some caps cost too much for what they offer, in our opinion), because we left everything as is, in order to test the original item. Last but not least, we recommend you not change the C35 and C36 caps with low ESR equivalent because the project requires some ESR.

The UcD180ST datasheet specifications are as follow, powering the module with ±45V and using a 4Ω load (where other conditions are not specified):

- Voltage gain: 26dB
- Frequency response (-3dB): 10-50kHz
- Input impedance: 100kΩ
- Output power (8Ω, 1% THD): 105W RMS
- Output power (4Ω, 1% THD): 180W RMS
- Damping factor (1kHz, 4Ω): 200
- Damping factor (20kHz, 4Ω): 26
- THD (20-20kHz, 75W, 8Ω):< 0.02%
- Efficiency: >90%

THE POWER SUPPLY

Although Hypex sells two models of power supply, we decided to build a PSU of our own **(Photo 3)**. We chose a dual mono configuration starting from the rectifier bridge; that is, one transformer with one secondary is used for both channels. This *pseudo*



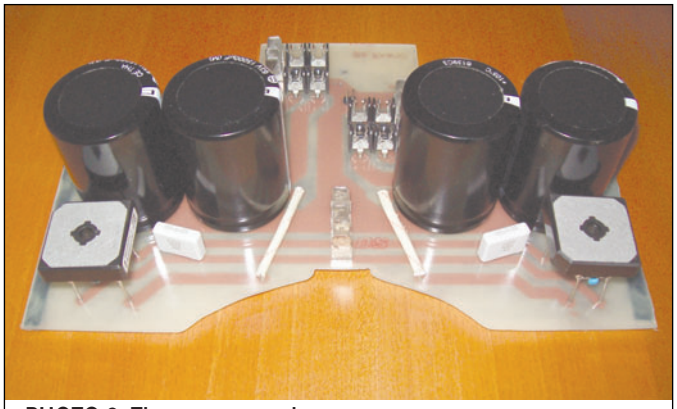


PHOTO 3: The power supply

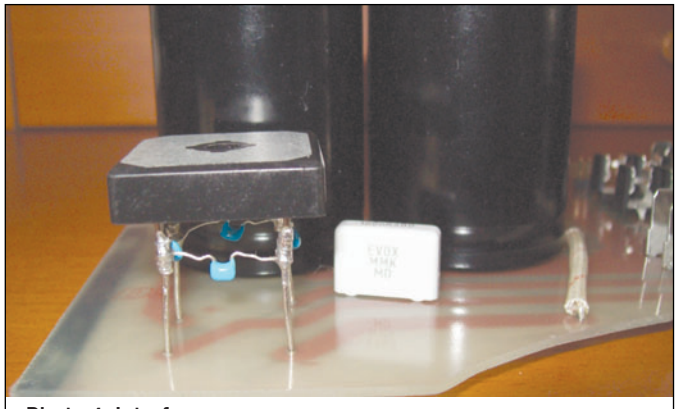


Photo 4: Interference suppressor caps

dual mono approach has some advantages over the single stereo PSU design (dynamic, channels separation, and so on), plus it saves you from needing to buy two transformers.

From the datasheet you can read the power requirement of the UcD180: the dual power supply ranges from ±30V DC to ±50V DC (there's an on-board protection for voltages over 52V), but it's suggested you operate at ±45V DC. Besides the thermal efficiency, the class D demands a bit less power than linear amplification, so the Dutch brand suggests a 160VA transformer per module. This turns into 320VA for a single transformer feeding two channels. Our need for continuous power on heavy loads led us to choose a *Nuvotem 0500P1-2-030K* encapsulated toroidal rated 500VA, which fits into the cabinet we wanted to use (a Galaxy GX288 from HiFi2000, www.hifi2000.it).

The full-wave rectifiers are rated 400V-35A, well above our needs; however, because the price difference for a smaller type was negligible, we preferred them. In parallel with each diode there is a 10nF 100V X7R ceramic capacitor, soldered directly to the legs of the bridge **(Photo 4)**, used as emission suppressor. In parallel with the transformer secondary, there is a 100nF 250V plastic film capacitor acting as a snubber.

The filter capacitors for a switching amplifier must be of very good quality. In fact, Hypex utilizes the *BHC slit foil* for their best PSU, and the *BC 056* for the cheaper one. We chose the Panasonic T-HA, for their quality versus cost (at least in Italy), their limited height, and good equivalent series resistance. To quantify the right capacitance value for our needs, Bruno Putzeys suggested this simple rule per module: C = 0.05/R, where C is the capacitance per power supply rail, and R is the heaviest load we intend to feed the amplifier. For example, assuming we must power a loudspeaker with a minimum impedance of 3.5Ω, from the above formula we get about 14mF, so we chose a 15000µF capacitor per rail (two in total for each UcD180 unit).

The power supply schematic and the PCB are shown in **Figs. 1 and 2**. Note the presence of fast-type fuses to protect the modules. The board's particular shape allowed us to shorten the power cabling. We made extensive use of faston terminals for quick and secure connections and tinned the copper tracks in order to increase the section and consequently improve the current flow.

The bill of materials needed to build this amplifier is contained in **Table 1**. As usual, you'll also find the product

TABLE 1: Amplifier components list

Reference	Description	RS-comp. P/N	Distrelec P/N	Digi-Key P/N	Mouser P/N
P1, P2	Diode bridge GBPC3504W, 400V, 35A	395-4360	600681	GBPC3504W-ND	844-GBPC3504W
C1	Capacitor X2, 0,33 microF, 275V	441-9650	820745	BC1613-ND	80-R463I333050M1M
C2, C3	Capacitor X2, 10 nanoF, 275V	616-7698	820729	BC1600-ND	80-R46KI21005001K1
C4, C11	Capacitor MMK, 100 nanoF, 400V, P15	192-203	821046	BC1849-ND	5989-400V.1-F
C5 to C8, C12 to C15	Ceramic capacitor X7R, 10 nanoF, 100V	211-5081	831606	495-3324-ND	581-SA101C103K
C9, C10, C16, C17	Elec. cap 15000 microF, 63V,	358-1883	P10638-ND	667-ECE-T1JA153EA	
	snap in, D 40 mm, P 22,5 mm				
S1	Illuminated switch, DPST, 250V, 10A	468-5374			
	230/30+30 Vac, 500 VA				
T1	Toroidal encapsuleted transformer,	223-8904			
F1	Fuse 2,5A, Slow, 5x20 mm	537-1486	280099	486-1220-ND	693-0034.3121
F2 to F5	Fuse 4A, Fast, 5x20 mm	563-481	281093	486-1239-ND	693-0034.1522
2 Hypex UcD180 ST					
1 power inlet IEC with fuse		815-830	110251	708-1329-ND	161-PF0001/63
10 Faston, male, PCB mount., 6.3 mm		534-834	450280	1287K-ND	534-1287
2 XLR female connector		405-736	111132		568-NC3FD-LX-B
2 Neutrix Speakon, 2 poles		2508451169	159574		568-NL2MP
4 PCB fuse holder, 5x20 mm		417-098	271136	F1504-ND	422-FX0321
Cabinet Hi-Fi 2000 GX288 -					
http://www.hifi2000.it/					

codes of four online suppliers, Distrelec (www.distrelec.ch), Digi-Key (www.Digikey.com), Mouser (www.mouser.com), and RS-Components (www.rs-components.com).

THE SOFT-START CIRCUIT

On some occasions, to preserve the rectifying diodes from a premature failure, it's wise to use a soft-start circuit before the transformer. This will reduce the switch-on current peak. By using the following formula you can calculate the diodes capabilities: Ip = Vp/Rt, where Ip is the current peak, Vp is the voltage peak, and Rt is the total resistance. Using the PSU components datasheet, you can see that the used transformer secondary Vp = 42.3V AC, while its resistance is equal to 0.13Ω.

The electrolytic cap has an ESR of 0.027Ω, while you assume for this example that the PCB traces and the connection cable add 0.07Ω. Thus, you have Ip = 42.3/(0.12 + 0.027 + 0.07) = 195A. Actually, you didn't compute the diode resistance, but you can use it to have a wider tolerance area. Back to your rectifying diodes needs, you need to choose those with a I_{FSM} > 195A.

However, keep in mind that those current peaks are capable of giving some hard work to the transformer as well as to the filtering caps. Therefore, it's wise to preserve the power supply components by employing a soft-start circuit anytime you use a power transformer with more than 400-500 VA and huge filter capacity.

Because we used a 500VA transform-

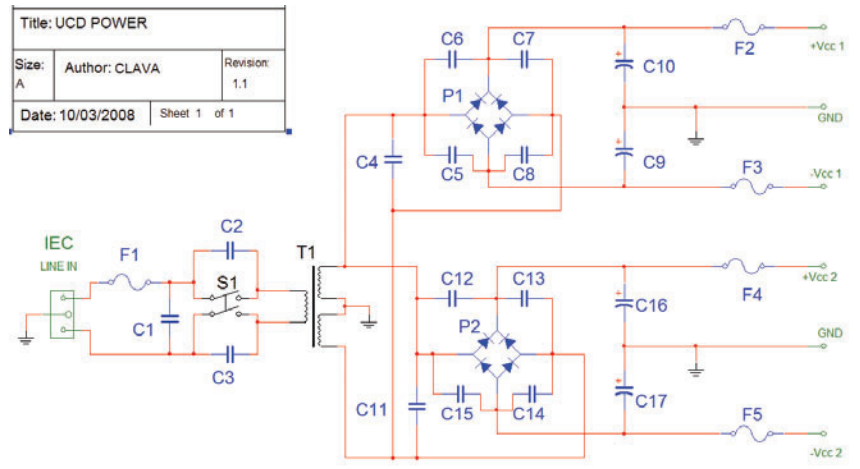


FIGURE 1: PSU schematic

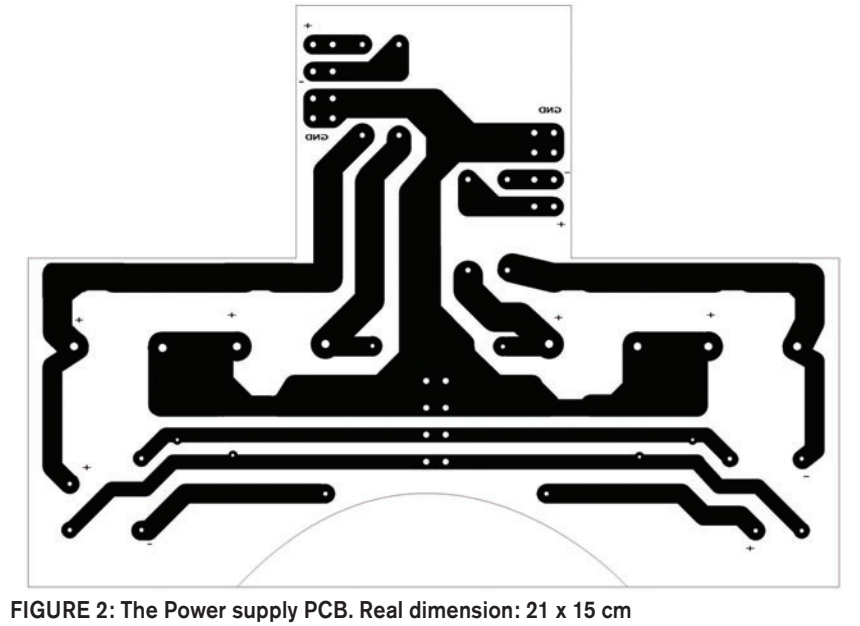


FIGURE 2: The Power supply PCB. Real dimension: 21 x 15 cm

SOLEN Électronique Inc.
4470 Av. Thibault
St-Hubert, QC J3Y 7T9
Canada
Tel.: 450-656-2759
Fax.: 450-443-4949
Email: solen@solen.ca
http://www.solen.ca

Solen is bringing you the first audiophile grade two-way monitor amplifiers for the DIY market. Using all Polystyrene or Polypropylene capacitors in the signal path, gold plated RCA socket, removable IEC power chord and a high output power transformer.

AP-016

$94.50

The AP-016 is available in three versions. The AP-016A crossover point is at 2Khz, the AP-016B is at 2.7KHz and the AP-016C is at 3.5KHz. All of them are 4th order Linkwitz-Riley crossover.

Specifications:
HF Power Output: 30Wrms
LF Power Output: 80Wrms
THD: 0.03%
S/N ratio @ rated W: 90db
Input sensitivity: 1V
Input impedance: 22Kohms
4th order X-over: 2KHz AP-016A
2.7KHz AP-016B
3.5KHz AP-016C
Weight: 2.6Kgs (5.7lbs)
Dimensions W x H x D:
W: 137mm (5.4")
H: 218mm (8.6")
D: 81mm (3.2")
Cut-Out W x H:
W: 108mm (4.25")
H: 190mm (7.5")
AC Voltage: 115V / 230V

MAKE YOUR SPEAKERS ACTIVE!

er, we decided to employ a soft-start circuit. Here are three different options.

First, a simple solution to the switch-on current peak is called an NTC thermistor, which, placed in series with the transformer primary, offers a resistance (a value between 5 to 10Ω is adequate) when cold. Once the current starts to flow to the component, the NTC thermistor becomes hotter (Joule effect) and its resistance diminishes. NTC stands for negative temperature coefficient, as opposed to the PTC type in which the resistance increases as the temperature rises. A wide variety of inrush current limiter products are available at Ametherm (www.ametherm.com), where you will also find more information on how to properly choose the right thermistor for your specific needs.

However, "every rose has its thorn," as the rock band Poison used to sing! The first hitch is that as the amplifier changes its power request, the thermistor changes its resistance; that is, the supply voltage is modulated by the requested current. This is not a problem if your amplifier works in class A; otherwise, it's better to avoid this type of inrush current limiter.

Another limitation is due to the component thermal time constant, which simply means that after you turn off your amplifier, protected by the NTC thermistor, you will need to wait a minute before turning it on again safely. Last but not least, the thermistor reaches high temperatures (>200° C), so be careful where you place it in the cabinet and don't try to touch it.

The second solution (easy and cheap) to solve the first two thorns would be to use a switch, activated after powering on the amplifier, to bypass the thermistor. We don't like this option very much.

The third soft-start circuit we suggest is another project of the Italian designer Mauro Penasa (www.webalice.it/mauro.penasa/Soft_start.html), author of the My_Ref. amplifier in part 1. **Figure 3** shows the circuit schematic: the parallel of two resistors (R4-R5) limits the inrush current, and after around a second they are bypassed by a relay. The recommended value of R4-R5 is 100Ω when using a power transformer till 400VA, while the value can drop down to 47Ω when a bigger transformer is implemented, as in our case.

Notice the presence of a Metal Oxide Varistor to filter voltage spikes. We sug-

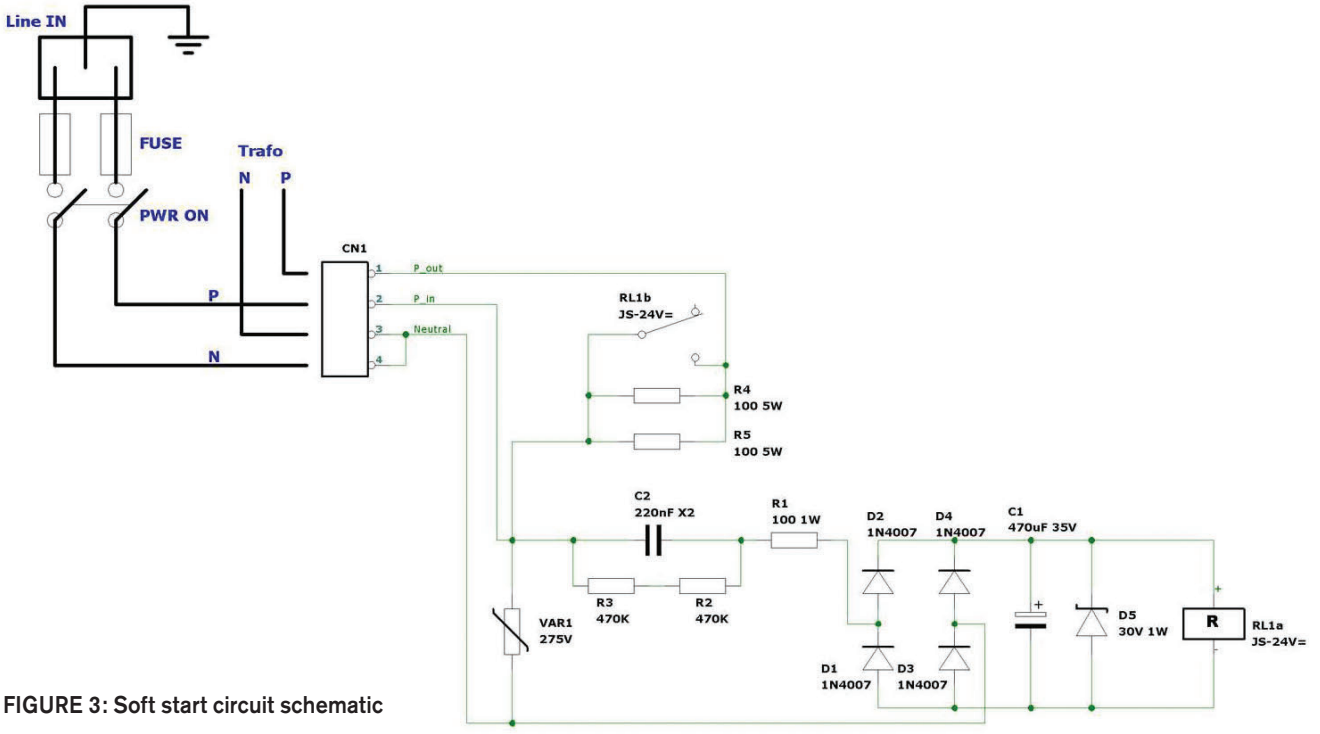


FIGURE 3: Soft start circuit schematic

PHOTO 5: The soft start circuit inserted in a plastic box

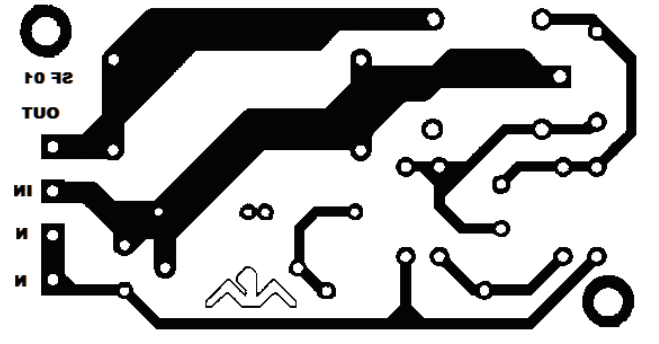


FIGURE 4: Soft start circuit PCB. Real dimension: 8 x 4.5 cm

gest, for security reasons already discussed in the article "ezDAC" (*audioXpress*, May '09, p. 12), the fused type TMOV. The completed circuit is visible in **Photo 5**, glued in a plastic case, which is a mandatory procedure since no galvanic isolation is available. The PCB layout is illustrated in **Fig. 4**, while the components list is in **Table 2**.

ASSEMBLING THE AMPLIFIER

The arrangement of the components inside the UcD180 amplifier is similar to what you have already seen inside the My_Ref; that is, starting from the front panel of the case, you find the transformer followed by the power supply and end up with the amplifier sections. The two Hypex modules are the first ones bolted to the side panels of the GX288 **(Photo 6)** thanks to the blue T-shaped wing. It's mandatory to use a heatsink and, to accomplish it, we used the cabinet aluminum panels. We noted, after several hours of listening at high levels, that the sides remained cold to the touch. The two outer screws are almost invisible, tak-

TABLE 2: SOFT START COMPONENTS LIST

Reference	Description	RS-Comp. P/N	Distrelec P/N	Mouser P/N
R1	100 OHM, 1W, 5%	131-772	712008	594-5073NW100R0J
R2, R3	470K OHM, 1/4W, 1%	149-149	714173	660-MF1/4DCT52R4703F
R4, R5	56, 5W, 5%, wire wound		722466	71-CP000556R00JE14
D1, D2, D3, D4	Diode, 1N4007	628-9546	600099	512-1N4007
D5	ZENER Diode 1N4751, 30V, 1W,	812-572	600941	78-1N4751A-TAP
RL1	Relay, 24Vdc, 5A, 250V, JS1-24	171-8796	402526	769-JS1-24V
C1	Elec.Cap. 470 microF, 35V, D 10 mm	228-6795	802595	647-UHD1V471MPD1TD
C2	Cap. X2 Class, 220 nanoF, 250V, P15, 91x182 mm	622-5047	820743	BFC233820224
VAR1	Varistor 275V	543-5108	730007	576-TMOV14RP275E
CONN1	PCB terminal block, 4 poles	548-7250	141261	651-1935187
Plastic enclosure		493-5988	300733	546-1591B-BK

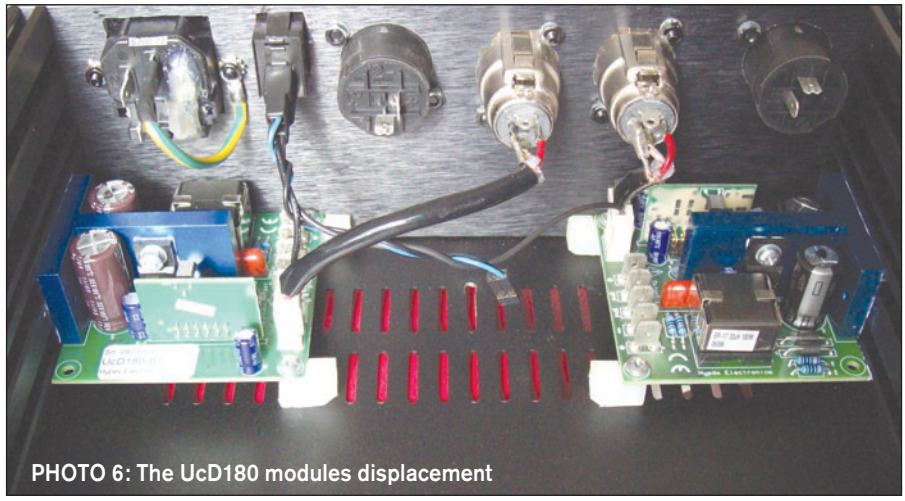


PHOTO 6: The UcD180 modules displacement

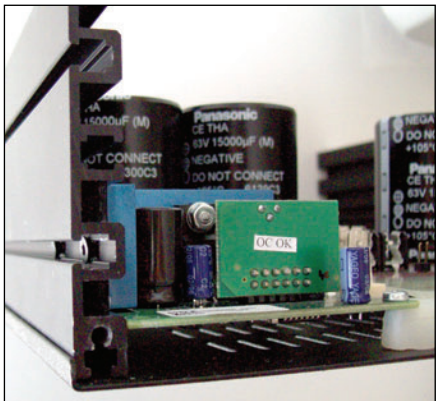


Photo 7: Blocking the UcD180

Photo 8: The PSU and modules displacement

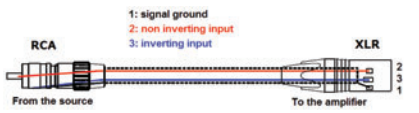


Figure 5: Balanced to unbalanced adapter cable

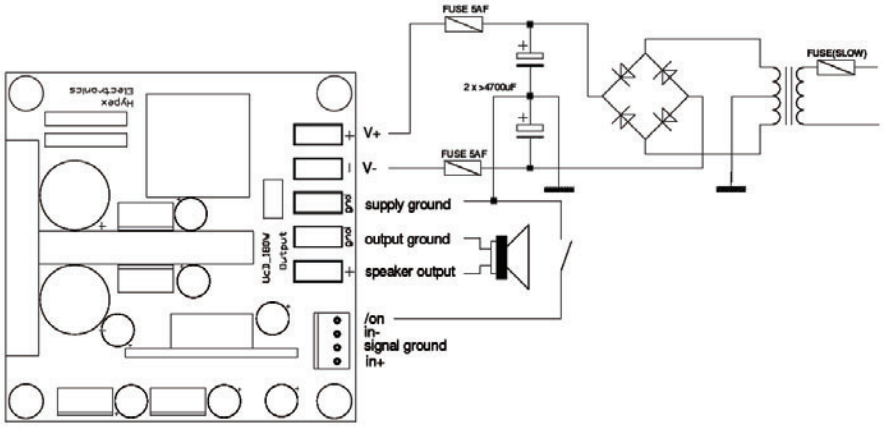


Figure 6: UcD180 connections

ing advantage of the slots on the external side **(Photo 7)**.

The power PCB slipped into the cabinet side slots is shown in **Photo 8**; other support points were produced using some plastic spacers. To lock the PCBs we used silicone glue along the slots and a bolt through the case bottom.

The transformer is blocked to a 3mm thick Bakelite plate by an 8mm bolt with washer; between them there are some strips of neoprene. The board is stuck in the usual hollow side of the GX288 and therein fixed with silicone glue. Some holes were made in the Bakelite plate to permit the passage of the power cables. The plastic black box that houses the soft-start circuit is glued to the Bakelite and the side panel.

For the power connections, we employed female faston, crimped, soldered and isolated with a heat-shrinkable tube. On the IEC socket, C1 is glued and soldered between phase and neutral (see the schematic) with the function of RFI filtering. The earth is connected to the frame by a yellow-green cable screwed through the same IEC socket bolt. Please note that anodized aluminum is not electrically conductive, so you must scrape it and interpose a toothed washer.

The phase and neutral wires (brown and blue) are linked to the two poles of the front panel switch (please use caution with these mains line connections!) The capacitors C2-C3 (arc suppressor) are soldered parallel to the switch terminals. The remaining two terminals of the switch are connected to the soft-start box, passing below the transformer, whose primary winding is also linked to the soft-start. All cables carrying mains voltage have a 1.5 square mm cross-section and the proper isolation. We suggest you twist the transformer primary and secondary cables.

For the signal connections, the output connectors are speakon, while the input ones are XLR, as the UcD has a balanced input. If you wish to use an unbalanced connection, we suggest you build an adapter cable like the one in **Fig. 5**.

In the previous **Photo 6** you can notice two thin cables (black and blue) departing from a switch on the rear panel. These implement a mute function when the /ON header (UcD module) is not

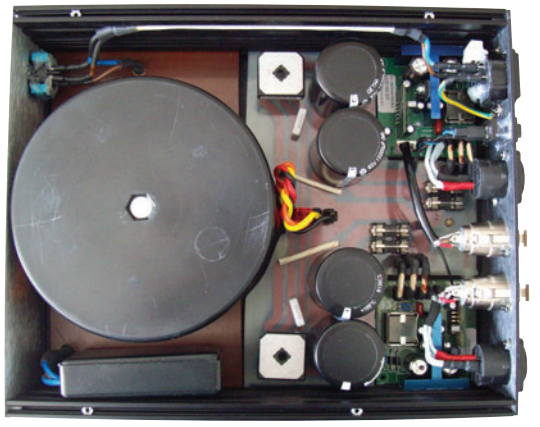


Photo 9: Internal view of the completed amplifier

Photo 10: Amplifier rear view

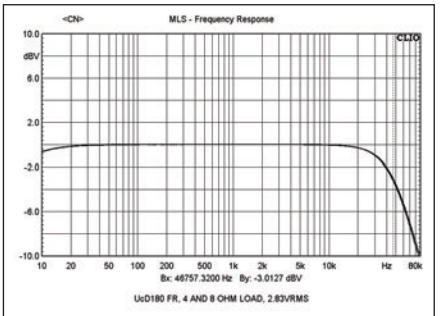


Figure 7 : Frequency response: at 2,83 Vrms, 8 and 4 ohm load

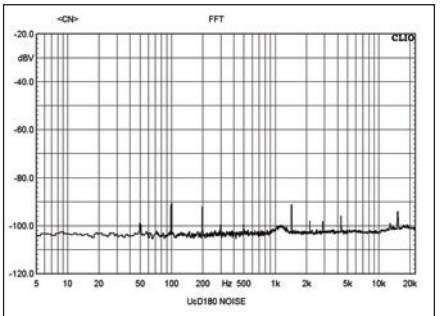


Figure 8: Noise level, input terminated with a 620 ohm resistor

connected to the supply ground (PSU PCB). In **Fig. 6** the connection diagram is visible. Keep in mind that if you don't choose to ground the /ON header, the amplifier will not play any kind of music. You can see the completed amplifier internal view in **Photo 9**, while the case rear is shown in **Photo 10**.

UCD180 MEASUREMENTS

The test setup included the Audiomatica Clio 10, Picotech 212/3 oscilloscope, and Protek B8011 function generator. To check the output DC offset, we terminated the input with a 620Ω resistor and measured 3.4mV in the right channel and 3.6mV in the left one. The input impedance at 1000Hz resulted in 94.500Ω, while the output damping factor, referred to 8Ω, is equal to 240 at 1kHz.

The frequency response in **Fig. 7** shows a quite flat line from 20 to 20kHz, with the -3dB frequency located above 46kHz. More important, changing the load doesn't cause early rolloff at high frequencies, as we used to see when testing class D amplifiers. In the entire audio band, the 4 and 8Ω curves are coincident.

The measured noise spectrum, obtained closing the input with a 620Ω resistor, is below -100dBV **(Fig. 8)**. We then fed the amplifier with a square wave at 1kHz, using a 7Ω load, and the result is what **Fig. 9** illustrates, clearly showing the switching frequency, which is typical of this kind of amplifier. Mr. Putzeys told us that the UcD family is a self-oscillating amplifier, thus the switching frequency is not fixed using a separate oscillator. Instead, the control loop itself causes the amplifier to oscillate at a certain frequency.

A side effect of this (all self-oscillating amplifiers do this) is that the switching frequency is variable. Close to clipping, the switching frequency becomes lower and more visible on the oscilloscope, while at clipping the switching frequency actually becomes DC (no switching). To get rid of the switch-

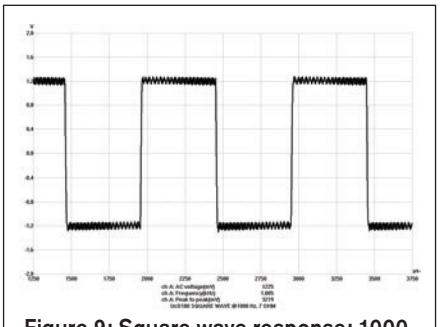


Figure 9: Square wave response: 1000 Hz, 2,5Vpp, 7 ohm load

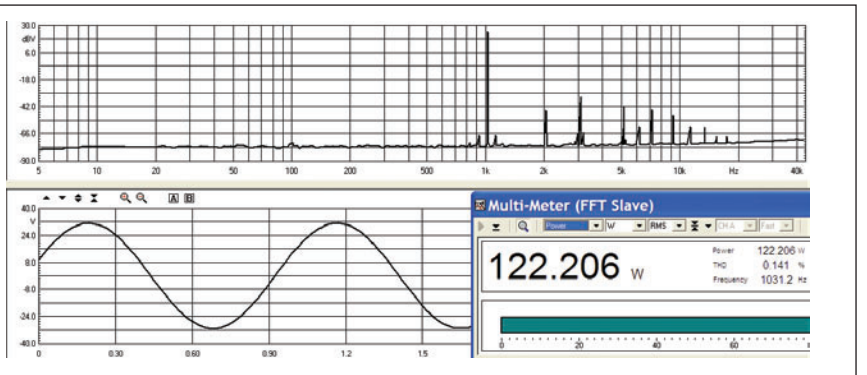


Figure 10: FFT and wave response: 1000 Hz, 122W, 4 ohm load

7052PH
Phantom Powered
Measurement Mic System
NOW 4Hz to 25+kHz
<18dBA >135dBSPL
IEC61094-4
Compliant
1dB/div
30 kHz
Titanium
Diaphragm
www.acopacific.com

Linear Audio
your tech audio resource
Jan Didden
editor
Volume 1
bigger-better-still no ads
- Green class-A
- The F-word
- R & C distortion
- X-over X-roads
- DIY adventures
- Low noise design
- More....

order now at www.linearaudio.net
discountcode **AXA** for 10% off

The Invisible Switch

The Switch Is Connected With The Shortest Possible Leads. The Wired, Battery Driven Selector Is Placed Anywhere.

KAB
Preserving The Sounds Of A Lifetime
www.kabusa.com

ing frequency in the measurements, you should adopt a low-pass filter. Bruce Hofer of Audio Precision wrote a related white paper titled "Measuring switch mode power amplifier," available for download from their site www.audioprecision.com.

Next we fueled the amplifier with a 1kHz wave to check its FFT: with a load of 4Ω and an output power of 122W, the UcD180 has mainly odd order harmonics with a linear decay **(Fig. 10)**.

With the Clio linearity & distortion analysis, we made some more measurements: THD vs. power **(Fig. 11)** and the IMD vs. power **(Fig. 12)**, with the common 4 and 8Ω load. Finally, **Fig. 13** is the THD vs. frequency at 1-10-70W, with an 8Ω load.

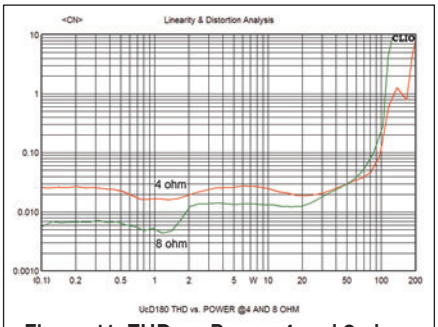


Figure 11: THD vs. Power, 4 and 8 ohm load

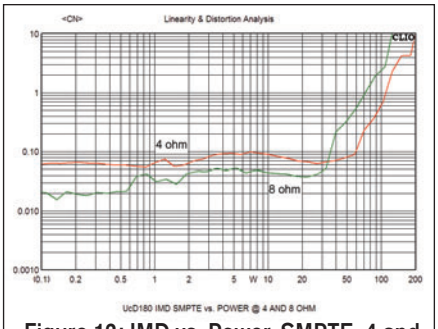


Figure 12: IMD vs. Power, SMPTE, 4 and 8 ohm load

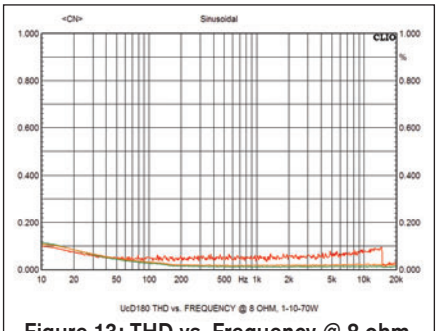


Figure 13: THD vs. Frequency @ 8 ohm, 1-10-70 watt

COMPARATIVE LISTENING

The listening session took place at Claudio's home, and lasted three months. During this period, many listeners took part. The listening setup for the solid-state duo included: the Teac CDP3500 CD player; the Marantz 6100 turntable with a Stanton 881S stylus; the Hegeman Hapi 2 preamplifier; Straight Wire Maestro II line cables and Straight Wire Encore II power cables; and PS Audio Ultimate Outlet mains filter. The loudspeakers were a DIY project by Claudio (a Coral woofer and a Sipe tweeter in a reflex configuration) and the model one_08_3 by Sound&Design (http://www.sound-design.it). The music we listened to is included in **Table 3**.

The first song we played was by a great vocal artist, Pat Benatar. The sound from this four-time Grammy Award winner belonged to 1940s music hall, assisting a big band concert. With the UcD there's no listening fatigue, but with the My_Ref. the music becomes warmer and sounds more bluesy. We changed CDs to listen to Joe Satriani, in a song (*Down, Down, Down*) full of intensity where Satch's Ibanez guitar seems to be cry-

TABLE 3: REFERENCE RECORDINGS

Pat Benatar	**True love,** Chrysalis CCD1805. *Song 6*
Jeff Buckley	**Grace,** Columbia Sony 475928. *Song 2, 5, 10*
Cheap Trick	**At Budokan,** LP Epic records. *Song 5*
Chesky Records	**The ultimate demonstration disc,** UD951. *Song 5, 7, 9, 11, 15, 17, 27, 29*
Litfiba	**El diablo,** Warner CGD 9031. *Song 3*
Yngwie Malmsteen	**Concerto suite for electric guitar and orchestra in E flat minor OP.1,** Dream Catcher RIDE 16C. *Song 4*
Massive Attack	**Mezzanine,** Virgin 45599. *Song 1,3*
Ted Nugent	**Spirit of the wild,** Atlantic 82611-2. *Song 6*
Robert Plant	**Dreamland,** Mercury 586962-2. *Song 2*
Joe Satriani	**Joe Satriani,** Sony 481102-2. *Song 3*
Sister of mercy	**Vision thing,** Merciful Release-East West. *Song 7*
Patti Smith	**Horses,** LP Arista records. *Song 1*
Starz	**Coliseum rock, LP.** *Song 8*
Tchaikovsky	**The Nutcracker, Valery Gergiev director,** Philips 462114. *Song 1, 8, 19, 20, 24*

ing. Definitely both amplifiers played this music very well, transmitting beautiful sensations; however, the UcD put too much emphasis on the cymbals, in our opinion.

Another great guitarist, Ted Nugent, played a song written for his lifelong friend Fred Bear: a fantastic song with the Detroit artist playing a great long solo with his Gibson Byrdland. Both amplifiers returned the right band dislocation, and the palm muting sounded very realistic.

We next played songs to emphasize voices. The scenic representation was similar when we played the gospel choir of Livingston Taylor, placing the UcD and the My_Ref on the same level. Robert Plant started to sing the apocalyptic *Morning Dew*, and we closed our eyes to let us fly with the song crescendo, where rock and Indian sonorities melted together. It was difficult to find differences between the two contenders, because both returned a natural and rich sound. The same happened when we turned on the turntable to play the first studio record of Patti Smith, with that superb remake of Van Morrison's *Gloria*. Instead, when letting Sara K. sing, we noticed that the scene moved back with the My Ref. *aX*

Added listening impressions, not available in the published article:

When doing all this listening, we found important to see what happens when playing a live concert recording, and to accomplish it the stylus touched the grooves of *Cheap Trick at Budokan* (a re-mastered version, including the concert video, is now available on CD). *Need your love* it's a blues-rock song, with the rhythmic always in evidence and Zander voice transmitting all the song love-hate binomial, while Nielsen's Hamer Explorer glues the parts to end up with an enthralling solo. The Ucd returned a deeper stereo image, with the fans crying more in evidence in the background, which caused some disappointment. Instead the My-Ref excelled when reproducing Petterson's eight string bass, as well as the total timbre balance and the details. We were almost capable to see Rick throwing to the crowd his picks: OK, OK our imagination was traveling too fast!

It's time now for Valery Gergiev to start conducting *The Nutcracker*: both the amplifiers were able to show us the orchestra, with every instrument in the right place of the stage. The characteristic brass in the Intrada was well suited under the strings, a little higher, better focalized with the My_Ref, which played very well the beautiful timbre of brass. We also felt a better control in the bass region (timpani at the end of the Intrada) with the MyRef. The scenic reconstruction was deep and large in both the amplifiers.

Let's resume the characteristics of the two.

My_Ref: well controlled, especially in the bass region, and good contrast; beautiful timbre, well balanced, and good precision in the scenic presentation. A perfect mix.

UcD180: a surprise! We would never expect such a power with such a quality, from this little digital circuit. A bit less controlled than the My_Ref (but we feel that this is a peculiar characteristic of the Italian) but with more dynamic. This leads to have more punch, a better sense of rhythm, and so a more intense involvement with pop, rock and electronic genres. The only drawback is some lack of grain, with certain recordings, in the high frequencies region. Focalization is not as good as the My Ref, but it shows a perhaps larger scenic dimension.

Conclusion

We can end up with a question: can all this quality, and also all this power, cost only 350 euro? The answer is not just "yes": it's simply the UcD180ST we were proud to build.