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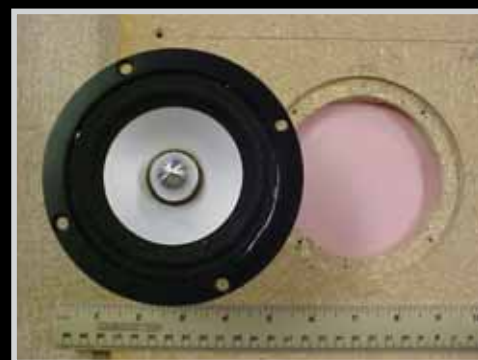
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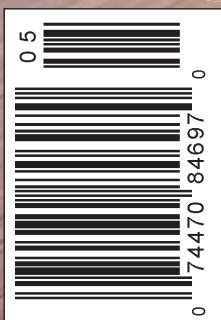
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CONTENTS

VOLUME 41 NUMBER 4 MAY 2010

"The peculiar evil of silencing the expression of an opinion is, that it is robbing the human race; posterity as well as the existing generation; those who dissent from the opinion, still more than those who hold it." — JOHN STUART MILL

FEATURES

TANG BAND FULL-RANGE SYSTEM

This simple two-way speaker achieves near-zero phase with a pair of TB drivers.

By G.R. Koonce.....4

GLASS AUDIO SECTION

VISITING THAILAND'S DIY TUBE ENTHUSIASTS

Tube audio is a growing concern in Thailand.

By Karin Preeda.....9

THE OPTIMIZED SRPP AMP, Pt. 1

Discover how to use this simple circuit in tube audio design.

By Merlin Blencowe.....13

AMPLIFIER COMPARISON USING OSCILLOSCOPE WAVEFORM PLOTS

Tube and solid-state amps square off.

By Kent Smith.....20

RELIABLE REVIEWS

TDL TECHNOLOGY'S TUNEABLE RUMBLE FILTER

Reviewed by Don Walizer.....27

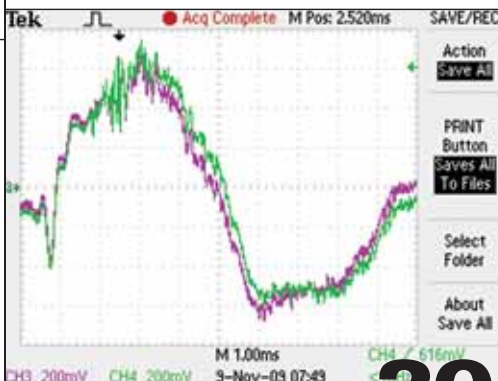


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YARD SALE30



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Tang Band Full-Range System

The author puts Tang Band drivers, which are available from Parts Express as TBspeakers, through their paces.

Bob Wright and I first investigated Tang Band drivers back in 2002 when we obtained them through Canada. At that time we were looking for a “full-range” driver for small satellites; that is, a driver that would cover the frequency range 100Hz to 20kHz and thus with a subwoofer could cover the full audio bandwidth. We tested many small drivers—some by Tang Band (TB), and designed some into small satellites¹. We later studied the 8” TB subwoofer driver, using it in small vented-box subwoofers². This article examines the use of some of the leftover TB drivers from that 2002 study.

SATELLITE DRIVERS

In the drivers-for-satellite testing, the

only drivers that truly covered the desired frequency range were two-way units not made by TB. We tested TB drivers from 2” up to 5” nominal diameters, and some of them did come close to “full-range.” Note that in 2002 TB drivers were generally somewhat larger in diameter than their listed nominal diameter. The nominal 2” driver was good at high frequency, but did not go low enough. The nominal 4” and 5” drivers would go down to 100Hz, but did not go high enough.

The nominal 3” TB drivers came closest to “full-range” with a bottom end near 150Hz and going to 20kHz. Clearly the power capability at low frequency was rather limited, and they were not always as smooth at high frequency as

you would like. The driver we chose to build into satellites was the W3-871S, which we believed was the best of the 3” TB units we tested. Note that testing of more recently purchased W3-871S units showed considerably different characteristics, so don’t expect to match our 2002 results today.

Since 2002 I had built two good systems with the leftover TB nominal 4” and 5” drivers combined with various tweeters in two-way systems. The work for this article started when I decided to see whether I could do anything with the remaining TB drivers on hand. I had pairs of the 4” W4-657S and the 3” W3-881S and W3-879S models. I liked the measured response of the W3-881S better than the W3-879S and decided

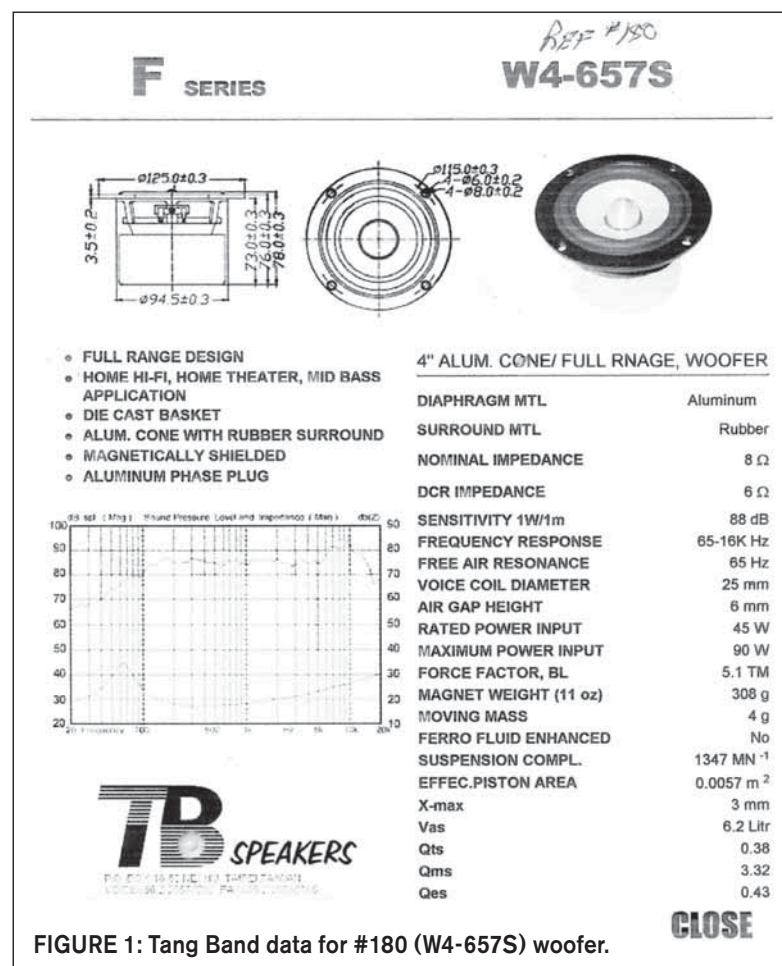
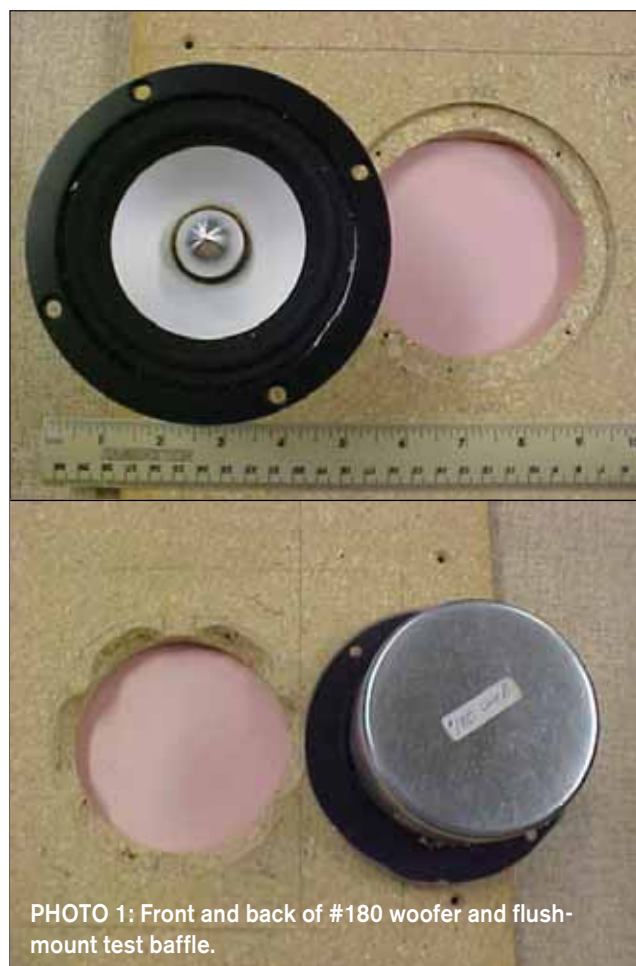


FIGURE 1: Tang Band data for #180 (W4-657S) woofer.



to investigate a two-way system with the W4-657S (as woofer) and W3-881S (as mid/tweeter) drivers. Note that the 4" driver is not listed in the 2009 Parts Express catalog.

I assign a reference number to drivers to avoid the need to write their full model number. The W4-657S is referred to as #180 and the W3-881S as #187. Thus the title of the project for this driver pair is P180 187.

THE P180 187 SYSTEM DESIGN

Figure 1 shows the TB data for the #180 4" woofer back in 2002. **Photo 1** shows this driver and the special flush-mounting test-baffle insert built for it. This is an aluminum-coned driver with a die-cast basket and fixed-mounted phase plug. The apparent diameter in **Photo 1** is an illusion, with the driver-mounting rim being closer to the camera than the ruler and test baffle, so it seems well over 5" in diameter. It is, in fact, 5" in diameter and fits into the hole! This is still a bit large for a nominal 4" driver.

But note that the TB's die-cast baskets have mounting-screw holes containing a recess for the screw head as visible in **Photo 1**. The difference in diameter between the throughhole and the head recess is very slight, sometimes as low as 0.12". This means the screw head has a metal lip of only 0.06" width to "hold" the basket. You must carefully select mounting screws to properly mount these drivers. For a woofer you might resort to larger screws that stay on top of the cast basket.

Figure 2 shows my test results for the #180 woofer both surface and flush mounted. This metal cone driver shows the

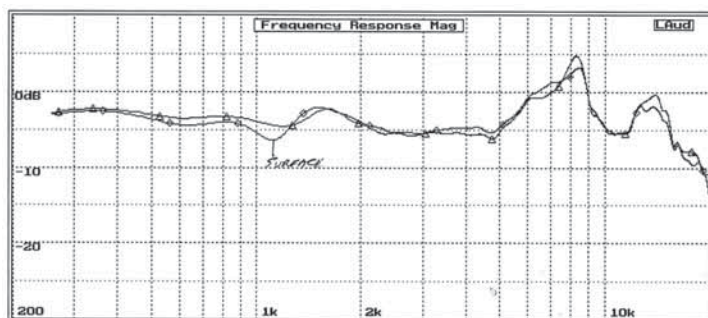


FIGURE 2: Measured response of #180 woofer surface and flush mounted.

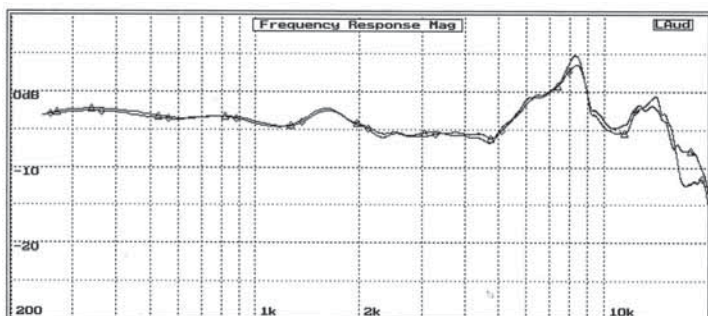


FIGURE 3: Measured match for pair of #180 woofers.

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LF Power Output: 80Wrms

THD: 0.03%

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Input impedance: 22Kohms

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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

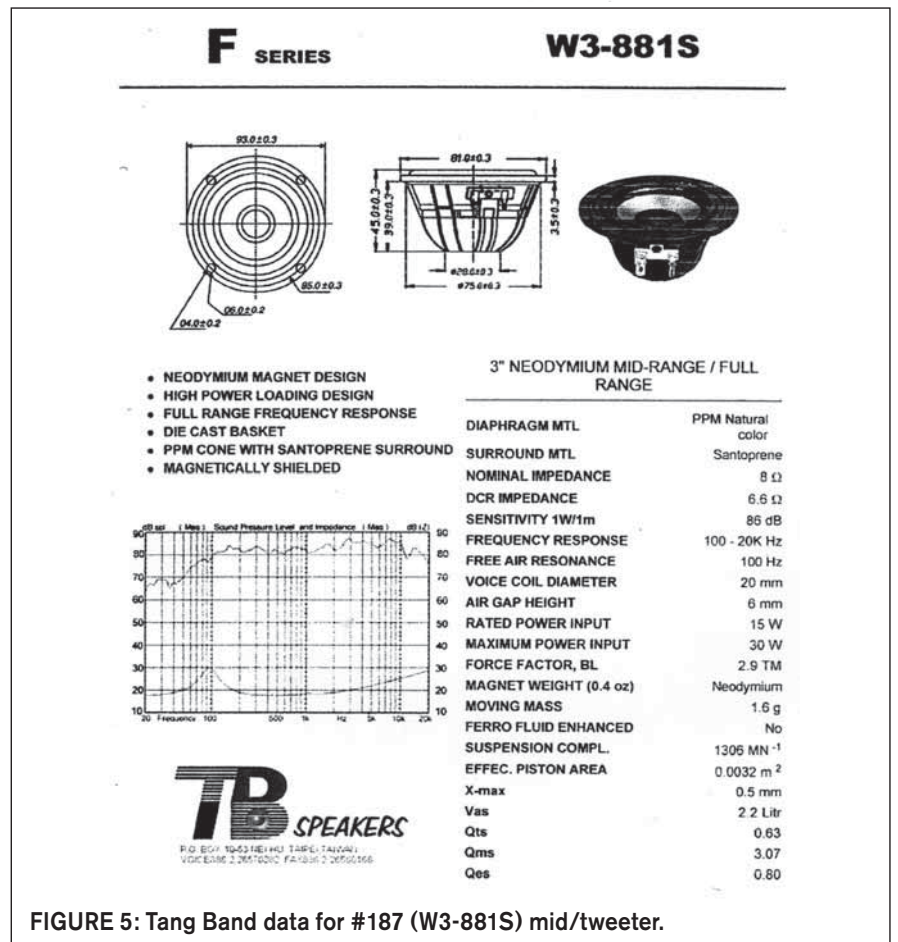
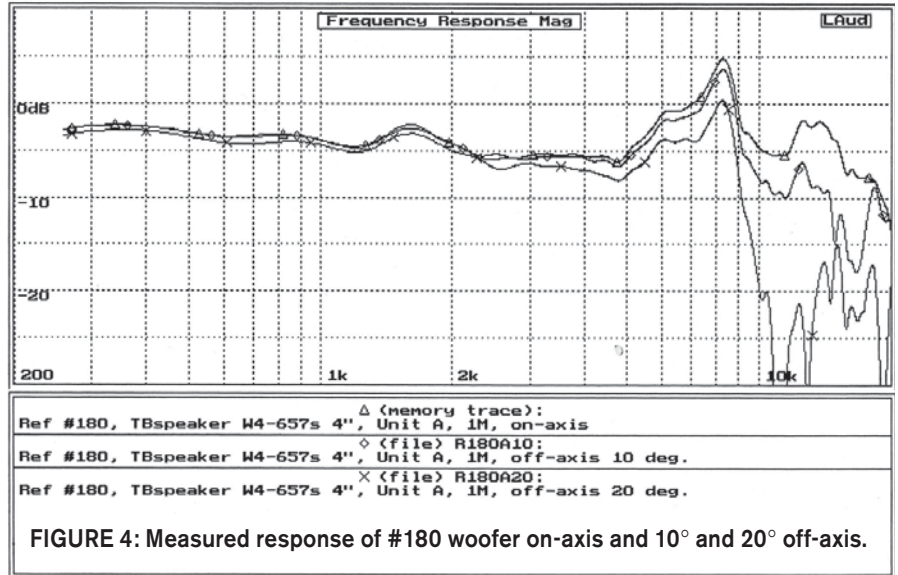
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same response peaking and roughness at high frequency I have observed with most metal cone drivers I have tested. **Figure 3** shows that my two #180 units matched well to their usable limit of about 5kHz, while **Fig. 4** shows the off-axis response flush mounted.

Figure 5 shows the 2002 TB data on the #187 W3-881S, my mid/tweeter. **Photo 2** shows front and rear views of this driver, again with a die cast basket

requiring careful mounting-screw selection. **Figure 6** shows the response and unit match for my two #187 drivers. They look very good up to about 8kHz and then become a bit rough. This is an amazingly wide response for a single driver. The on- and off-axis response for the flush-mounted #187 driver is shown in **Fig. 7**.

My intent was to build a two-way system with a rather low crossover (CO)



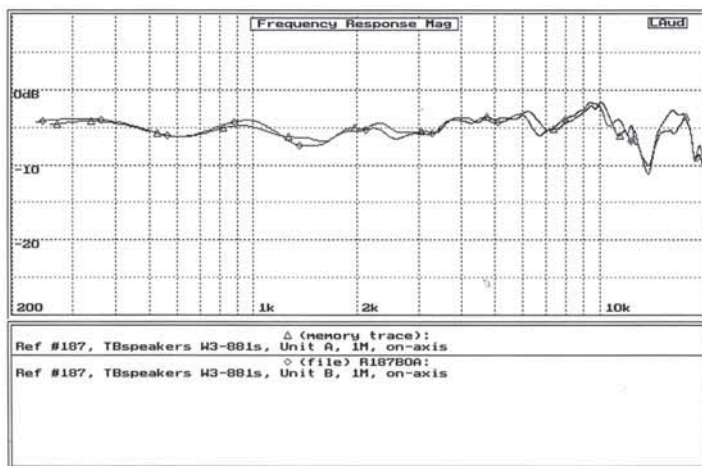


FIGURE 6: Measured response and match of #187 mid/tweeters.

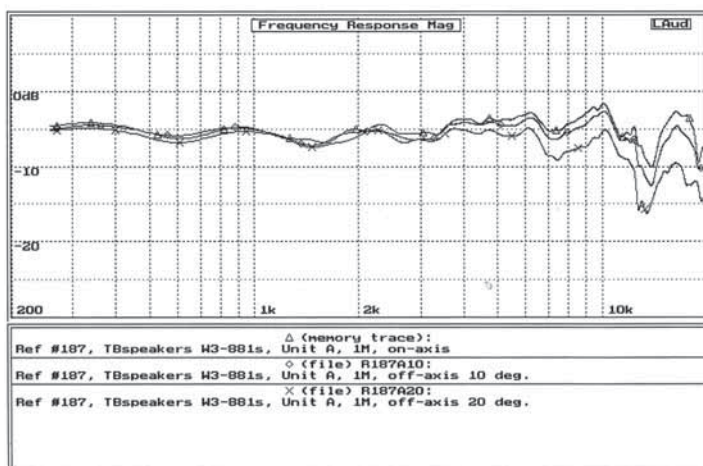


FIGURE 7: Measured response of #187 mid/tweeter on-axis and 10° and 20° off-axis.

frequency. This was accomplished by entering the necessary files and data for the two drivers into a CO modeling program and developing an acceptable system response.

The surprising result of this work is shown in **Fig. 8**. The top-left response plot shows each driver's on-axis response with its CO section. The acoustic CO point is about 800Hz. The center response plot shows the system magni-

tude response at a listening angle of -5° (i.e., 5° off the mid/tweeter axis toward the woofer). The bottom response plot shows the system phase shift at the same listening angle and was the surprise. From 300Hz up to where the mid/tweeter response starts to become rough, the system is zero phase!

I had worked very hard a few years ago to build a system that was zero phase from 200Hz upward. That sys-

tem used five drivers in a symmetrical WMTMW configuration with steps in the front panel to properly align the drivers and a first-order CO³. The top-right polar plot in **Fig. 8** shows that lobing is not a problem and that 5° to -10° is the optimum listening-angle range. I elected to use -5° because it improved the high-frequency response. Finally, the bottom polar plot shows the zero-phase nature of the system holds

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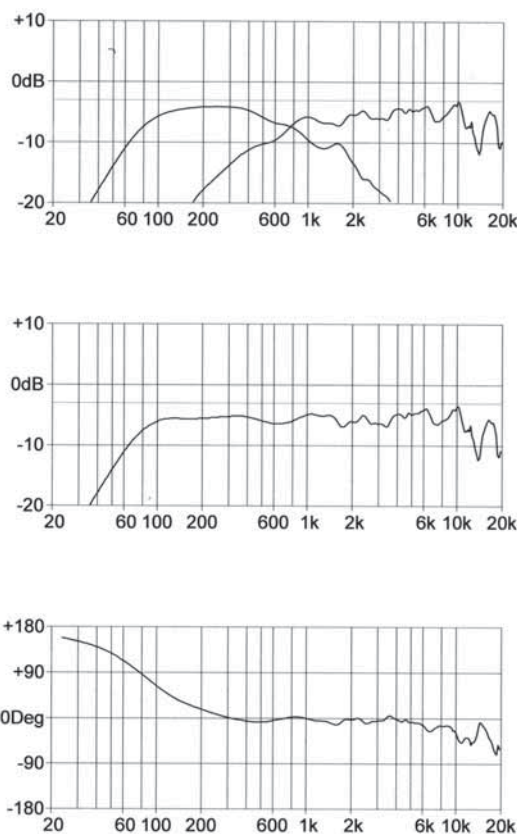
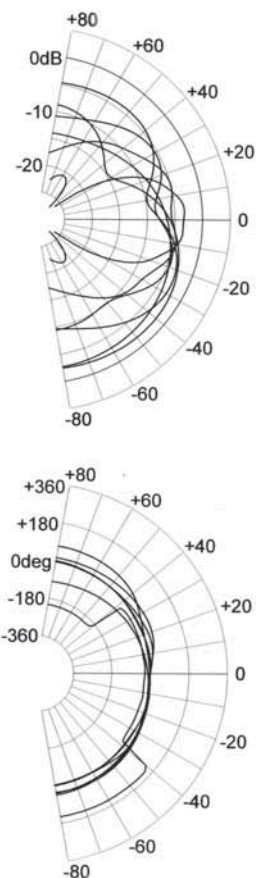


FIGURE 8: Performance of modeled P180 187 system.



over a reasonable vertical-listening-angle range.

Figure 9 shows the CO developed for the P180 187 system. The woofer low-pass is first-order with an odd zobel and a network to cancel the 8kHz response peak in the #180 driver. The mid/tweeter high-pass is second-order with a small inductor (50μH) to tame the high-end and an L-pad. Both drivers are wired with positive polarity. Here we

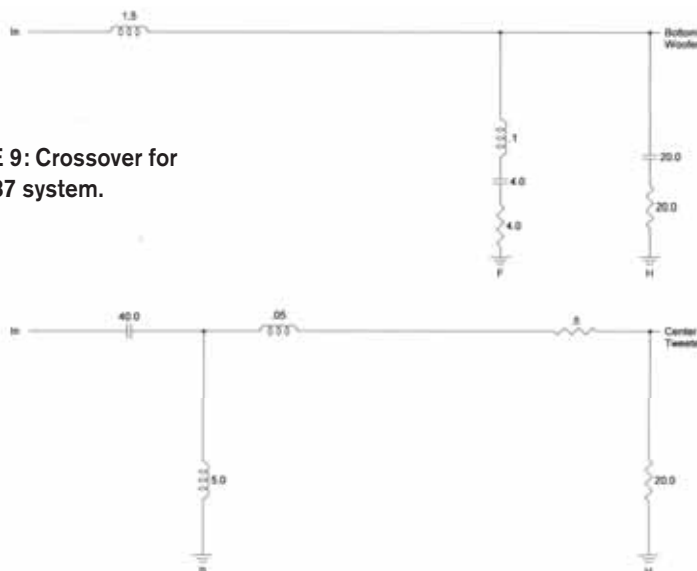
have a zero-phase system, above 300Hz, that has the following features:

1. The front panel is flat with flush-mounted drivers.
2. Only two drivers are used, not a symmetrical array.
3. The CO is not fully first-order.

How is this simple system able to produce a zero-phase response? It appears to be a zero-phase system, above 300Hz, that has the following features:

Continued on p. 25.

FIGURE 9: Crossover for P180 187 system.



GLASS AUDIO

Visiting Thailand's DIY Tube Enthusiasts

An active—and growing—community of audio DIYers is thriving in Thailand.

By Karin Preeda



PHOTO 1: Wooden turntable, aka "Little doggy," by Traipot Chunlawong.

The audio DIY scene in Thailand started at least 40 years ago, when, like in other places in the world, DIY enthusiasts used tubes in their gear. Because Thailand doesn't make tubes, it imported them from all over the world. Therefore, when looking for tubes at flea markets or at some NOS tube dealers in Thailand, you will see tubes from Europe, Japan, and the US. You will also find some big US transmitting tubes here because the United

States once had military base camps in Thailand in the Vietnam War era. So, at least some of those tubes avoided being scrapped (a friend of mine witnessed thousands of GE VT-4Cs smashed by a backhoe some years ago).

In the 80s Thai DIYers focused more attention on solid-state equipment. Therefore, several big lots of audio tubes were exported to foreign countries. Hundreds of household tubes such as EL34, EL37, 6CA7, 6L6, and 7591A were sold very cheap. So, what was left here were radio, TV, and some military transmitting tubes.

TUBES ON DISPLAY

Ten years later, with the advent of the Internet, which made information exchanging much easier; many DIYers went back to tube audio. There were several groups of Thai DIYers who gathered for DIY activities, such as www.thaidiysaudio.net. The website went online in 2007, and its members meet regularly for DIY activities, such as a low-cost power amp contest and the unlim-

ited power amp shootout, and the exchange of ideas about topics such as the low-watt amp and the full-range speaker.

LOW WATT

At this year's special event—held last November in Bangkok—members exhibited low-watt amplifiers and DIY electrostatic headphones. The DIY wooden "doggy" turntable and CD transport/non-oversampling DAC were used as sources. The main preamp was a



PHOTO 2: The EL84 (by Suwan Jaruki-attikul) integrated amp that has no sharp edge.

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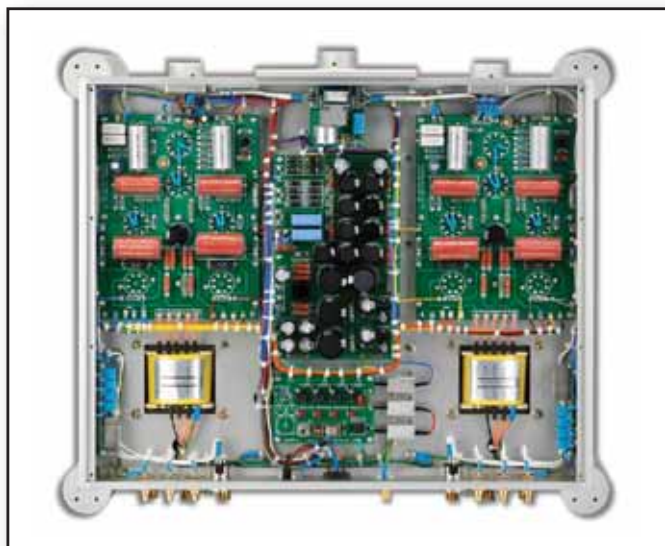
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PHOTO 3: Last year's champion in low-cost power amp contest. Built by Wachirachai Chawanonthakit, this mini keg Heineken looks good under dim light!

6SN7 Aikido (www.tubecad.com) with remote-control input selector and volume. The loudspeaker was a Lowther DX-2. The Firstwatt F5 clone, which was the only solid-state power amp in the room, demonstrated a high degree of clarity in its music reproduction.

HIGH WATT

Another room was filled with high watt tube power amps, some of which were the contenders in the group's "Unlimited Power Shoot-out"—held the previous month—for driving the B&W 801. The preamp was a 6SN7 Aikido, non-remote-control version, and the loudspeaker was an Aurum Cantus

Leisure III SE. Because the NOS 833A, 805, and 450TL are available here at reasonable prices, users chose them instead of the 211 or 845 for those big amps. Many audiophiles very much enjoy listening to big transmitting amps. The highlight seemed to be 833A and 450TL power amps, which impressed almost every listener.

The event drew an enthusiastic crowd, many of whom were eager to get started in DIY audio. Currently, over a thousand registered users are included in the group. Average daily online users number around 30-50. This bodes well for a continuing active DIY community in Thailand. *ax*



PHOTO 4: Electrostatic headphone with amplifier.



PHOTO 6: High watt room, featuring hi-power transmitting tube power amps.



PHOTO 5: Lowther DX-2 for low watt room.



PHOTO 7: 450TL power amp (by Prapas P) plays music while 833A (by Pratan Pakdee) is waiting for the next round.

The Optimized SRPP Amp, Part 1

Some deceptively simple circuits explained for the audio amateur.

By Merlin Blencowe

The SRPP is a most enigmatic circuit (**Fig. 1**), and seems to cause bewilderment and inspiration in equal measure among many valve enthusiasts. It is frequently confused with other, vaguely similar-looking circuits, and its practical uses are not immediately obvious. This article looks briefly at the history of the circuit, its operation, and how you can optimize it as an *output-transformerless power amplifier*. This article also examines a couple of circuits that aren't SRPPs at all!

WHAT DOES SRPP STAND FOR?

The first peculiarity of the SRPP is that no one seems to be sure where the name came from! The earliest reference to the circuit (that I could find) is a 1940 patent by Henry Clough of the Marconi company¹. Most surprising is that although the patent mainly describes its use as a modulator, it does acknowledge that it could just as easily be used as an audio amplifier. Yet it would be many years before it appeared in a commercial audio application.

In 1943 the SRPP was patented again in slightly different form, by Artzt at RCA². Still, it does not appear to have been widely used or given a particular name for many years, and is rarely found in radio textbooks of the time. Occasionally it does appear under rather generic descriptions like "two-tube series arrangement...sometimes useful as a power amplifier"³ or "totem-pole amplifier"⁴ (Artzt preferred to call it a "series-balanced amplifier").

In 1951, Peterson and Sinclair⁵ finally adapted the SRPP for audio use, ambitiously calling it a "distortionless audio amplifier" in their patent granted in 1957. In this patent they expand it into a μ -follower and finally produce what they called the *single-ended push-pull amplifier*⁶, or SEPP. The SEPP,

then, is related, but not identical to, the SRPP as we know it now.

By the late 1950s, textbooks on television circuits routinely referred to the SRPP as a shunt regulated amplifier^{7,8}, which at least explains the initials S and R. However, outside the world of television it was generally referred to as a *bootstrap amplifier*^{9,10} (which also covered circuits such as the μ -follower and White cathode follower) or SEPP. Of course, we now use the term SEPP for the more specific circuit arrangement by Peterson and Sinclair.

From the 1960s onward a variety of transistor versions appeared^{11,12,13,14}, but *still* without the name SRPP applied. However, by the 1990s we suddenly find the valve version routinely referred to as the SRPP^{15,16} (although not always correctly), but exactly who bestowed the initials remains a mystery (do you know?). Nevertheless, the name *Shunt-Regulated Push-Pull* amplifier is

now sure to stick, and we at least have some sense of standardization.

BACK TO BASICS

If audio electronics magazines are anything to go by, the operation of the SRPP seems to be routinely misunderstood as involving a cathode follower. Therefore, it might be useful to quickly review the operation of a simple resistance-loaded valve, to avoid the same confusion.

Figure 2A shows a conventional, common-cathode gain stage. The input happens to be supplied from an isolation transformer that removes any problems with ground referencing, and the grid is biased negative using a battery. If you input a positive pulse, the valve will conduct more anode current. The voltage drop across the anode resistor R_a increases, so the signal voltage at the anode appears inverted.

If you draw a Thévenin equivalent

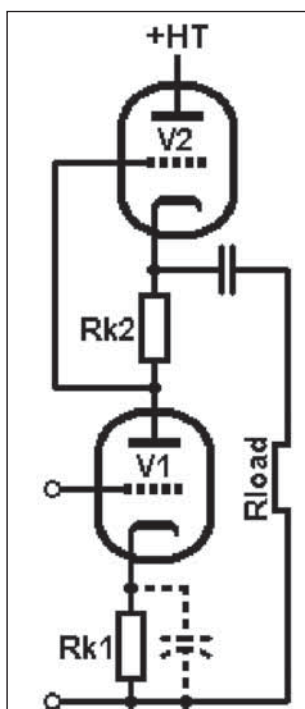


FIGURE 1: The humble SRPP seems to inspire and confuse in equal measure.

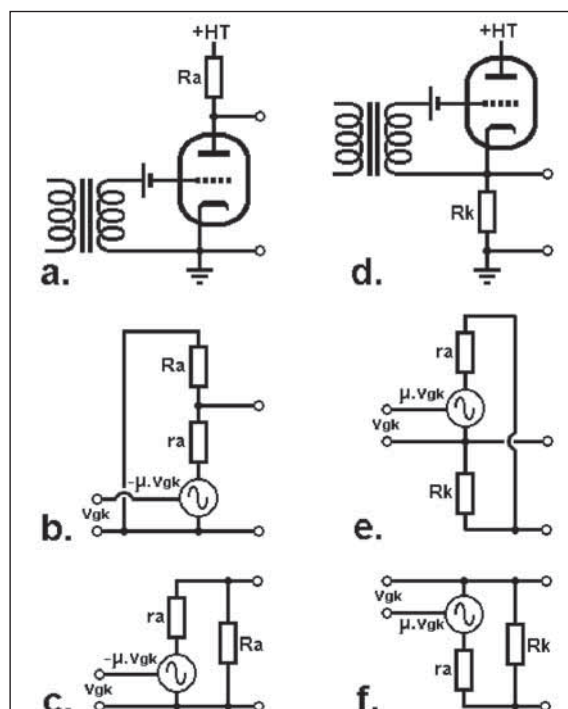


FIGURE 2: The common-cathode gain stage and its equivalent circuit (A-C). The common-anode gain stage and its equivalent circuit. Not a cathode follower in sight! (D-F).

circuit for this, remembering that ground and the HT are shorted together by the large power supply smoothing capacitors, then you arrive at **Fig. 2B**. You can adjust the diagram again as in **Fig. 2C** to show more clearly that, as far as AC signals are concerned, R_a and r_a form a potential

divider whose gain is $R_a/(R_a + r_a)$. If you make v_{gk} equal to 1V, then you can express the gain of the whole stage as:

$$A = \frac{-\mu R_a}{R_a + r_a}$$

And the output impedance is:

$$Z_{out} = R_a \parallel r_a = \frac{R_a \cdot r_a}{R_a + r_a}$$

where

R_a = the anode resistor (plate resistor)

r_a = the internal anode resistance (plate resistance) of the triode

μ = the amplification factor of the triode

Now consider the circuit in **Fig. 2D**. At first glance it may look like a cathode follower, and even some experienced builders will mistake it for such. However, the secret lies in the fact that the input signal is still connected directly between *grid* and *cathode*, just as it was before, so all you have really moved is the load resistor, which is now called R_k . With a true cathode follower the input is applied between grid and ground and, because the cathode tries to follow the grid, the actual signal appearing between grid and cathode—which is what a valve amplifies—is very small, so you get very little voltage gain. But not so in this case!

The input signal appears *directly* between grid and cathode, no matter what signal appears at the cathode. Again, if you input a positive pulse, the valve will

conduct more anode current, so the voltage across R_k increases and so the output voltage is not inverted this time. If you draw a Thévenin equivalent for this circuit, then you arrive at **Fig. 2E**, and, if you adjust the diagram yet again, you come to **Fig. 2F**, which is exactly the same as that in **Fig. 2C** except that it is flipped! Therefore, this circuit operates *exactly* as the previous one did, except that the output signal is not inverted; it is a *common-anode gain stage*. The gain is simply:

$$A = \frac{\mu R_a}{R_a + r_a}$$

(note the minus sign is missing) and the output impedance is the same as before.

A true SRPP is built by stacking one of these common-anode stages (V2) on top of a common-cathode stage (V1), as in **Fig. 1**. The signal current flowing in V1 must flow through R_{k2} , so a signal voltage appears across it and forms the input signal for V2. Because R_{k2} is connected between grid and cathode of V2, the signal voltage appears directly between grid and cathode, so V2 is not a cathode follower! When you input a positive pulse to V1, it conducts more, causing the voltage across R_{k2} to increase. V2 therefore receives a negative pulse and is forced to conduct less. Thus the two valves conduct in phase opposition; it is a push-pull amplifier with its own built-in phase inverter.

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WHY SHUNT REGULATED?

Considering the two valves are in series, it might seem a little odd that it is called *shunt* regulated, which implies a parallel connection. The explanation is provided by Amos and Birkinshaw (1958): In television circuits it was often necessary to drive very capacitive loads without gross distortion or signal loss at high frequencies. However, for reasons of economy, it was not desirable simply to use one or two ordinary class-A

stages because they would need to idle at high current, even though the actual current demands might be only small most of the time.

The solution to this is shown in **Fig. 3A** (for AC only), and consists of an ordinary, low current amplifier stage V1 which handles the signal most of the time, and a sort of auxiliary valve V2 which provides the heavy current demands, when necessary. By placing a current-sensing resistor R in series with

the load Z, if the load current increases (i.e., the signal frequency is increased), the voltage drop across R also increases, and if this signal is delivered to V2, it will, in turn, deliver the extra load-current demand. It is obvious that V2 is in parallel with the load and maintains or regulates the signal against a falling load impedance at increasing frequency.

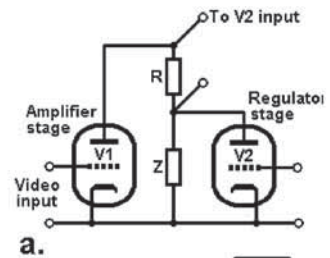
From this principle it is a short step to the SRPP in **Fig. 3B**. An important point to recognize about the SRPP

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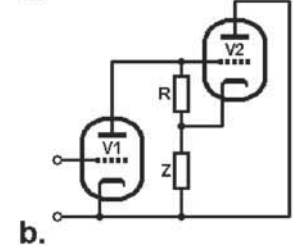


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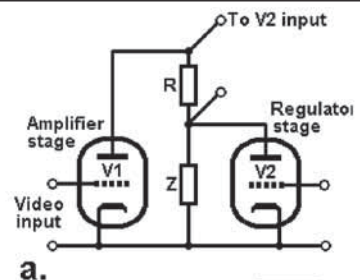


a.

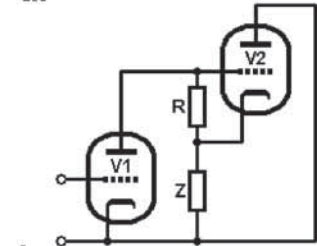


b.

FIGURE 3: Shunt regulation of a video signal (ignoring DC conditions). After Amos and Birkinshaw.



a.



b.

FIGURE 4: With an infinite load the circuit is not an SRPP at all, but an actively loaded triode (A). By moving the output to the anode of V1, you obtain the half-mu stage (B). Bypassing both resistors reduces the output impedance, though distortion will be greater.



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is that it can only operate in Class A, because the valves are in series. If one valve cuts off, then the remaining valve can no longer conduct either. The White cathode follower is also a type of strictly-class-A shunt-regulated amplifier, and was similarly popular in television and computing circuits.

WHEN IS THE SRPP NOT AN SRPP?

Whether the SRPP really *is* an SRPP depends on the load. If there is no load on the valve (e.g., it is DC coupled to another stage), then there is nowhere for current to go but straight through both valves, and so the stage is entirely single-ended, as in **Fig. 4A**. This is *not* an SRPP but a common-cathode gain stage with an active load, and the maximum peak current flow is then equal to the quiescent current, as it always is with single-ended operation. Such a circuit is obviously intended only for voltage gain, and is not widely used¹⁷. Nonetheless, if you move the output to the anode of V1, then you obtain some useful properties¹⁸. V2 appears to multiply or boot-

strap the value of Rk2 by a factor of $\mu + 1$, so the total load on the lower valve becomes $r_a + Rk2(\mu + 1)$ (which is much too low to be considered a constant-current source).

If both resistors are bypassed, then the voltage gain would be:

$$A_{(\text{bypassed})} = -\mu_1 \cdot \frac{r_{a2}}{r_{a1} + r_{a2}}$$

Or if they are unbypassed, then it is:

$$A_{(\text{unbypassed})} = -\mu_1 \cdot \frac{r_{a2} + Rk2(\mu_2 + 1)}{[r_{a1} + Rk1(\mu_1 + 1)] + [r_{a2} + Rk2(\mu_2 + 1)]}$$

where:

Subscript 1 indicates the lower triode

Subscript 2 indicates the upper triode

However, the magic really happens when you use identical triodes and also make Rk1 equal to Rk2, because the above equations then simplify to:

$$A = -\frac{\mu}{2}$$

So bypassing both resistors does not affect the gain; only the output impedance is reduced (though the distortion will be much greater). For the bypassed version:

$$Z_{out(\text{bypassed})} = \frac{r_a}{2}$$

And for the unbypassed version:

$$Z_{out(\text{unbypassed})} = \frac{r_a + Rk(\mu + 1)}{2}$$

Consequently, this circuit—which you might call a “half- μ ” stage—is very useful indeed, because the gain and Miller capacitance remain quite constant despite aging of the valves, or the use of valves of varying provenance, because μ is the most consistent and stable parameter of a triode. It should also be quite immune to changes in heater power and supply voltage. On the other hand, the main disadvantage is that the PSRR is only 6dB.

THE OPTIMIZED SRPP

If you attach a finite load to **Fig. 4A**, then you produce an extra path for current to flow. When the lower triode is driven to cutoff, V2 reaches its maximum conduction and this current flows into the load. When V1 then conducts fully, V2 reaches its minimum conduction and current flows out of the load and down the lower triode. You see that current is actively pushed into and pulled out of the load; the load receives the difference in current draw between the two valves, hence it is push-pull operation and you have a true SRPP. Obviously, if the load impedance is very high—like a 1M Ω resistor—then the current delivered into it is tiny and you have a pretty pathetic example of push-pull operation, but it is push-pull nonetheless.

In old TV circuits it was usual for V2 to deliver more current to the load than V1. However, for audio purposes you are more interested in making both valves contribute *equally* to the load current and to maximize that current, and this is what I call the “optimized SRPP.” A few authors^{19,20} have already observed that you can obtain a deep null in the THD with the right combination of Rk and R_{load} , and the values correspond (almost) exactly with those of the optimized circuit. This is unsurprising, for a perfectly balanced push-pull amplifier will cancel all even-order harmonics, resulting in minimum THD.

However, the SRPP does not have truly push-pull input signals, because the input signal to the upper triode has

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already been amplified by the lower, and so will contain some extra distortion. As a result, the value of load which gives the deepest distortion cancellation is usually 10-20% lower than the value found by calculation, and will also vary rather unpredictably according to the manufacturing variations between samples. However, it is worth noting that it is better to use a load which is slightly too large than one which is too small, because the distortion rapidly increases below the critical value.

NEXT MONTH

If you were hoping to see a little more of the SRPP in this article (and not the half- μ amplifier), then part 2 in the June issue will satisfy your expectations. I show how to calculate the optimum resistor values for the SRPP, and examine a couple of the common circuit variations and their uses. *aX*

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Amplifier Comparison Using Oscilloscope Waveform Plots

Testing the differences between tube and solid-state amps.

By Kent Smith

This article is the result of my getting back into audio after the year 2000, and deciding to build my own amplifiers. I had attended many classical concerts, but noticed that bass drums never sounded right on my home system, no matter what the speakers or placements were. I tried building a tube amplifier a few years ago, and suddenly became less impressed with both my homemade LM3886 amplifier, and the Yamaha receiver.

A good push-pull tube amp seemed to have more natural-sounding drums, along with better overall clarity, given the same speakers and CD player. I recently was able to verify this with my percussionist son, who pointed out and explained subtle differences that I had not noticed. I once knew a pianist who claimed that recorded piano never sounded right. I was never sure that I believed him, but now I do. I have become familiar enough with some instruments that I can hear the difference in reproduction.

Unfortunately, I have not been

able to find any technical information about why a tube amplifier could sound better than a modern “chip” amp. Most people who couldn’t believe it would just write it off by using the highly technical and undefined term “Euphonic.” For some reason, this term actually works in the audio market, even though it doesn’t actually mean anything specific. But there must be some way to show the difference, or it would not exist. So, I decided to tackle the investigation myself.

TEST SETUP

I was recently able to borrow a Tektronix TDS 2024B oscilloscope, which can easily give plots through its USB port. The plots are limited to time domain, but it’s a start. I decided to employ an uncompressed recording (rare these days) of a real-life drum and cymbal (almost as rare). I chose this because the audible differences of these instruments were most notable between amplifiers. The recording I used is Sheffield Lab’s Crème De La

Crème, Track 5, the second drum beat that also has a cymbal on top of it.

I connected each amplifier directly to a Sony SCD-CE595 CD player, which is a very good yet inexpensive unit. I connected the output to a simple 4” full-range in a compact vented box.

The Amplifiers. Tube amp: Based on the Dynaco ST-35 with following exceptions: 12AU7 input, 12AQ5A run in triode mode (not UL), no negative feedback. Cost less than \$200 to build using NOS tubes and Hammond transformers. LM3886 amp: Circuit derived from the datasheet. Cost well under \$100 to build.

PROCEDURE

First I connected oscilloscope Channel 3 to the output of one side of the amplifier, and channel 4 to the input of the same side of the amplifier. Then, I adjusted the gain and scope scaling so that the amplifier played at a typical moderate low loudness level, and readjusted the amplifier gain so that the plots overlay

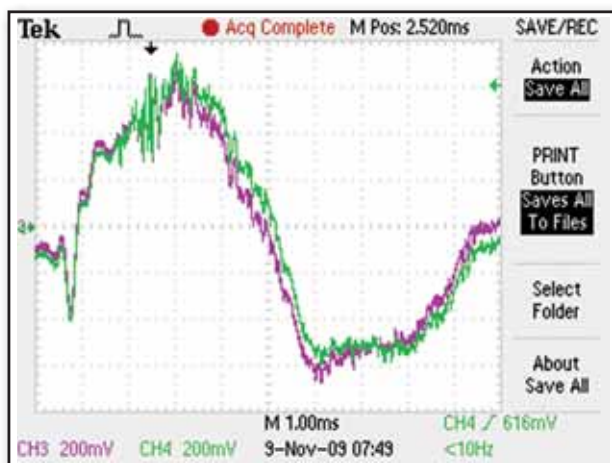


FIGURE 1: Tube amp results.

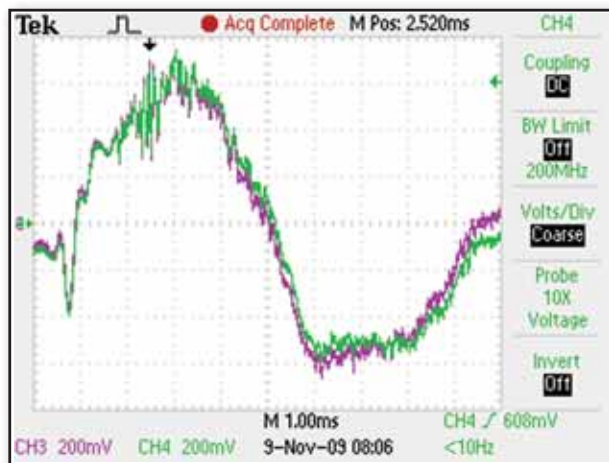
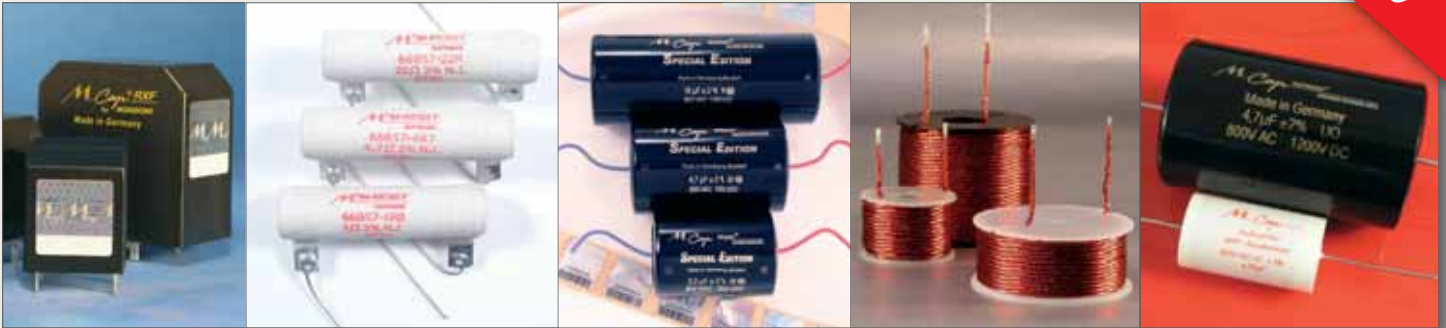


FIGURE 2: Solid-state results.

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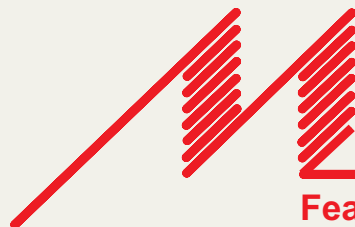


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closely as possible. I used a sine wave from a function generator to set the gain on each amplifier.

I assume that in a perfect amplifier, the output waveform would match the input. Each plot is 1ms per division for a 10ms total time (Figs. 1 and 2).

RESULTS

The plots speak for themselves. The output of the tube amplifier is closer to the input signal. The chip amp plots show significant differences in both amplitude and time, especially on the downward side of the drum peak. Time errors are bending in the pitch, which I consider worse than amplitude differences. There is also some loss in dynamic amplitude peaks, except for the overshoot on the negative peak.

To verify that there was not a problem with the LM3886 amp, I tried the same test on a Yamaha receiver. The results were exactly the same.

Looking at these plots, I think I could see how negative feedback, if delayed slightly, could cause the observed problem. But I don't know how to prove or disprove that.

While testing the LM3886, I also tried changing to a resistive 8Ω load, then a 150Ω load, but it made no significant difference. Therefore, I don't believe that reactive load impedances are a problem.

To me, these plots do not resolve the issue of what the differences are, just that there are actual differences, and that the chip amplifiers of today fail to perform as well as a good tube amp. I also think that there must be more differences than what this data shows. Because the waveform differences seem more acute at low frequencies, I suspect damping factor may be involved. Recent work by Nelson Pass also seems to make high damping factors an issue.

These results seem to support what my ear hears, as well as that of some other music lovers. I am not saying that the chip amplifiers are bad; I enjoy listening to my Yamaha receiver in the bedroom for background music. Chip amps also seem to do a good job with today's compressed and processed recordings. I guess there are some things that tube amps just cannot fix. But I personally can no longer accept a chip amp as an audiophile product; it simply cannot follow a complex waveform very well.

The good news is that, while you can't buy an inexpensive amplifier that does not use a chip amplifier, you can build one, even with tubes, at very low cost. I would love to see this test done on a Pass amplifier (as a viable alternative to high voltage tubes), and I would like to see other types of tests done with a spectrum analyzer, especially intermod. I would also like to see my tests done by other people, both to verify these tests and possibly to learn more. *aX*

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PHOTO 2: Reference #187 mid/tweeter front and rear views.

Continued from p. 8.

pears that if you use two drivers with a very large overlapping frequency-response range such systems are possible. Part of the answer was called to my attention by George Augspurger.

While the mid-tweeter CO was basically a second-order, **Fig. 8** shows that the mid/tweeter response with its CO section looks like a first-order response. George did some investigation and found that a second-order CO designed with a Q of 0.25 and a 4:1 overlap simulates a first-order CO around the CO frequency. The 4:1 overlap means that the low-pass is designed for four times the desired CO frequency and the high-pass is designed for one-quarter the desired CO frequency.

Figure 10 shows the performance of this CO, which, indeed, yields a zero-phase response except at very low frequency. I really like this CO because eventually it will go to 12dB/octave slopes, helping to hide the mid/tweeter resonance, which can be a problem with a first-order CO.

IS ZERO-PHASE RECOMMENDED?

My work to date has shown that zero-phase is not a characteristic that provides a superior-sounding system. Others have agreed with this^{4,5}. Most people agree that you want to limit the system phase shift across the audio band, but zero phase is not required. The best approach may be to design for a minimum-phase system. The current feeling is that with music a phase shift variation that causes a time dispersion less than about 2.4ms is all that is required⁶.

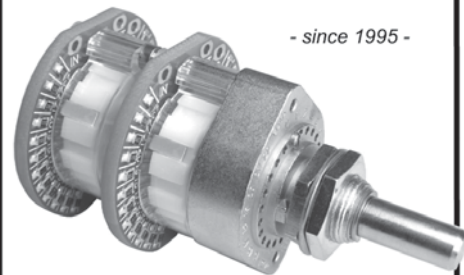
No practical speaker system will hold zero phase down to the lowest frequencies because the woofer does not

go down to DC and the low-frequency rolloff will cause phase shift. Dennis Colin, among others, believes that the low-frequency phase shift is important^{7,8}. This is a topic outside the range of this article.

So while zero phase is not required for a system, trying for it will get you a minimum-phase system which is worthwhile. A small, simple two-way near-zero-phase system was developed with a pair of TB drivers. Can this in general be accomplished with other driver pairs?

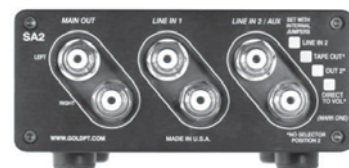
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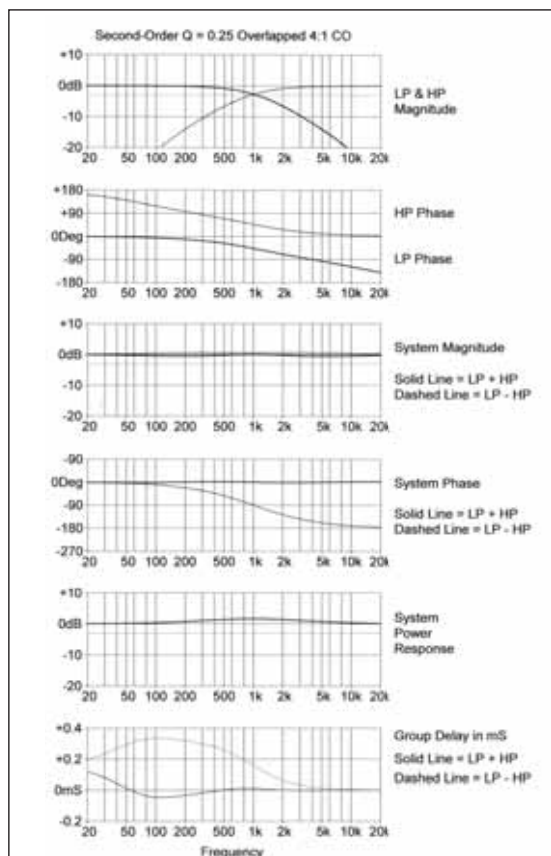


FIGURE 10: Performance of second-order crossover designed with $Q = 0.25$ and 4:1 overlap.

CONSTRUCTION

Building this small system turned out to be more of a problem than it seemed it should. The woofer would be in a damped vented-box enclosure. The mid/tweeter would be in a highly damped closed-box enclosure. It was the -5° listening angle that caused the problem.

The design was for a floor-standing enclosure. A stand-mounted design would want more diffraction spreading loss compensation than I could obtain. Built with



PHOTO 3: Front and side views of the constructed P180 187 system.

the conventional mid/tweeter above the woofer layout meant that the floor-setting boxes had to be tipped an unrealistic amount to get the listener on the proper axis. The only cure was to build with the woofer at the top and the mid/tweeter below the woofer.

It may seem like such a system would not image correctly, but I have used this approach in the past and you can't identify the inverted driver order by listening. I wanted the vent to exit at the bottom of the box and looked at all sorts of ways to get the woofer port to pass through the mid/tweeter box and still be available to cut for tuning. I finally gave up and went to a rear-mounted port. **Photo 3** shows the front and side views of the small boxes indicating the required tip angle. Note the front panel has been covered with $\frac{1}{2}$ " thick fiberglass to reduce box-edge diffraction.

Because this driver pair appears to no longer be available,

there is no reason to document the construction of this system.

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TDL Tuneable Stereo Rumble Filter

By Don Walizer



PHOTO 1: The 603A.

Model 603A
TDL Technology
5260 Cochise Trail Las Cruces, NM 88012
575-405-7289
http://tdl-tech.com

For years I've enjoyed the benefits of using a variable "rumble" filter when playing or recording 78 rpm records. Both my venerable OWL 1 Restoration Module and the TDL 4010 Restoration Preamp that replaced it have such a filter. Acoustical (pre-1925) records have no usable output below about 150Hz, and electrically recorded 78s are dominated by noise below the 40-70Hz range. The variable rumble filter is a very effective tool for removing noise in this highly audible 20-150Hz range, and adds greatly to the enjoyment of vintage 78s. Unfortunately, until the advent of TDL's Model 603A Tuneable Stereo Rumble Filter, the vast majority of audio systems that are capable of playing 78s with the proper equalization have not had this capability.

In my case, I have two casual listening systems for 78s using the old and new versions of the Esoteric Sound RE-EQUALIZER (www.esoteric-sound.com), respectively; and I use a modified TDL Model 407 Stereo Phono Preamp when grading 78s for resale. Neither of the re-equalizers has any provision for low-frequency (LF) filtering, and the TDL Model 407 has only a 20Hz Rumble Filter switch. I was therefore very interested when I learned

that TDL decided to make a variable stereo rumble filter that can be inserted just about anywhere in the audio chain. I procured one of the first units and looked forward to putting it through its paces.

My first impression of the 603A was that it is a typical TDL design—highly utilitarian with an emphasis on function rather than visual esthetics. The 603A is a simple 7" × 5" × 2½" aluminum box with a rotary dial in front for selecting the desired low-frequency rolloff in 5Hz increments from 15 to 65Hz. (I understand that TDL will customize the 11 rolloff frequencies at the buyer's request.) The purpose of the aluminum box is, of course, to provide shielding from extraneous RFI and EMF influences. In back are RCA right and



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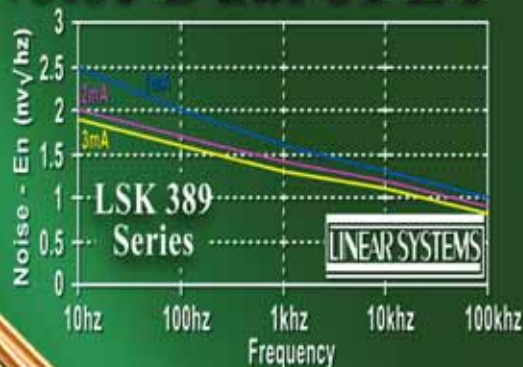
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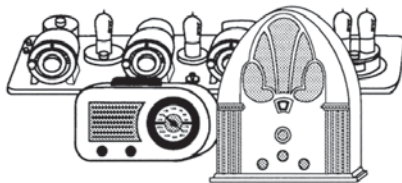
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left channel inputs and outputs and a jack for the included power adapter.

Of course, I immediately had to open it up and take a look inside. As expected, the layout was clean and uncluttered with obvious attention to detail throughout. What I did not expect was to see another aluminum enclosure inside! As it turns out, this enclosure within an enclosure houses TDL's amazing power purification circuitry, which allows the 603A to operate as quietly as a battery-operated unit. I have since learned that TDL has discontinued its battery-operated units such as the Model 407 Stereo Phono Preamp because there is no longer an advantage to using a pure DC (battery) power supply.

I was beginning to suspect that the 603A was something special, so I decided to see how much noise it would add when I inserted it into my recording system consisting of an Adcom GFP-555II preamp (www.adcom.com), KAB Broadcast Standard Turntable (www.kabusa.com) with Ortofon Super OM 30 cartridge (www.ortofon.com), and Event ALP5 Direct Field Monitor speakers (www.event1.com) augmented with a 10" Dayton Titan-ic subwoofer (www.parts-express.com). I used a spectrum analyzer to measure the quiescent noise level of my system at the tape out jacks without the 603A inserted, and then placed the 603A between the tape out jacks and the analyzer. The result was—nothing! The *only* difference between the two graphs was the reduction of the noise floor below 15Hz, which is the minimum setting of the 603A.

I couldn't believe it. I've never inserted any active device into the audio chain without some effect on noise level. Now I'm thinking audiophile-grade and then some.

QUESTIONS

The 603A had to add some harmonic distortion, right? Throw in some test tones and there was no difference. This was becoming serious. I just wanted my 78s to sound good, so who cares about a *little* noise or distortion? I decided to perform the acid test.

I use the Events as my studio monitors because of their spectacular sound field imaging. I can pinpoint on the millimeter where an instrument or voice is coming from. I figured that adding the 603A be-

tween my preamp and powered speakers and playing a high-quality stereo LP will collapse the sound field. But there was no difference, just pinpoint accuracy, with or without the 603A.

So I figured it's overkill for my 78s, and my preamp has an infrasonic filter for LPs, so who needs an audiophile-grade variable rumble filter? I could probably get by with something much cheaper, if there were something much cheaper out there. But I had a lot to learn.

In order to help gauge the sonic effectiveness of the 603A in normal use, I inserted it between the phono stage and preamp of one of my audition systems consisting of a KAB-modified Technics SLBD20D turntable (www.panasonic.com) with a Stanton 500 cartridge (www.kabusa.com), Graham Slee GRAM 2 phono stage (www.gspaudio.co.uk), Adcom GTP-502 preamp, Onkyo WRAT M282 200W/channel power amp (www.us.onkyo.com), and Monitor Audio Bronze BR2 speakers (www.monitordaudio.co.uk). I removed the grilles from the BR2s so I could both see and hear the effects of LF noise. Listening to a wide range of 78s, I confirmed that the 603A is, indeed, a great tool for the removal of unwanted LF noise. I was a happy camper.

THE REST OF THE STORY

I left the grilles off my BR2s and eventu-

ally listened to an LP—"Darkness on the Delta" by Wallace Davenport. As soon as I placed the stylus on the record, the LF speaker cones began oscillating wildly! The Technics SLBD20D isn't audiophile-grade, but it has pretty respectable specs. You could see, though, that the record had some weird warps at the beginning and it was driving the speakers nuts.

I quickly turned the 603A knob to the 40Hz position and the oscillations disappeared. Not only that, the sound quality improved, and the bass actually sounded stronger. Was this a fluke?

I started carting out LPs and found that almost all benefited from a setting of 20 or 30 on the 603A; and many, such as the Davenport, required a setting of 40 or higher. In all cases, the extraneous cone oscillations disappeared, and the sound was cleaner with no noticeable effect on LF extension. Sound quality improved because the "real" LF tones were not being modulated by the noise LF tones; and the amps weren't being robbed of power by LF noise.

I have since confirmed the following with different audio systems, including several with "zero" rumble turntables:

1. Almost all LPs improve with the use of the 603A. You will be hard-pressed to find audible information below 40Hz on 99 percent of LPs, but about 90 percent will include audible noise in this range. My default

setting on the 603A for LPs is 30Hz.

2. There's not much that a rumble filter can do for a poor quality turntable. Get the best turntable you can afford and let the rumble filter work on the record.
3. The "infrasonic" filters that are found on many preamps are virtually worthless. You need to work higher in the audio spectrum to deal with record warp/pressing/storage issues. If your preamp has an infrasonic filter, disable it and use the 603A unless you a) have a "zero" rumble turntable; b) have a "zero" warp record recorded on a "zero" rumble cutter, and c) are trying to reproduce a 20Hz or lower tone.
4. Bass freaks will particularly love the 603A. Not only will it protect their speakers, but it will also produce cleaner, more powerful bass. Jazz and classical fans will also be surprised and pleased when they hear really clean tones from cellos and string bass, and the powerful whacks on bass drums.

So, do you really need a rumble filter? Well, I want to get myself a couple more 603As.

603A REVIEW ADDENDUM

Acting on my recommendation, when I placed my order, I asked TDL to customize the cutoff frequencies to better accommodate the reproduction of acoustical recordings. I wanted to keep the original 5Hz incremental settings from 15 to



PHOTO 2: The 603A, back.

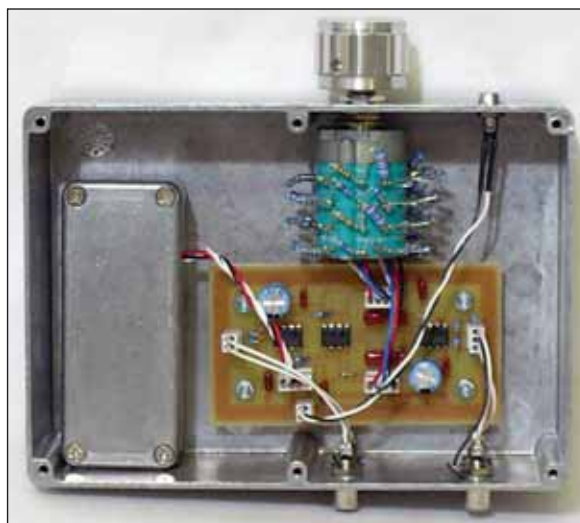


PHOTO 3: Inside the 603A.



Reliable Reviews

40Hz and add the following frequencies: 50, 60, 80, 100, and 120Hz. "No problem" was the response from the good folks at TDL; so I'm now the proud owner of three 603A Tuneable Stereo Rumble Filters, two with customized settings.

I'm happy to say that the new units are of the same high, audiophile-quality build as my first; and especially appreciate the added cutoff frequencies when playing my acoustical recordings. I found, for example, that a cutoff frequency of 100Hz really cleans up the voice quality on my Caruso recordings; and 120Hz seems to work especially well with vertically cut recordings such

as Edison Diamond Discs.

The modified 603As have also proven to be quite useful with the rest of my 78 collection. The 80Hz setting improves the playback of many of my older electrical recordings, such as Victors, which used a 500Hz or higher turnover in lieu of the original Western Electric turnover of 250Hz. With these recordings, the required additional preamp boost can accentuate LF noise from the recording process. As a rule, my default setting for electrically recorded 78s is 40Hz.

My original 603A, which has been in service for several months, is functioning as smoothly as when I got it. Based

on my experience with other TDL products, I expect it to provide years of enjoyable, trouble-free performance.

Manufacturer's Response:

Mr. Walizer has written a highly complimentary and very informative review of our model 603A Tuneable Rumble Filter—I can find nothing to dispute! He is correct in stating that we will customize the 11 cutoff frequencies at no additional charge. Because of component size limitations, please keep the range of frequencies between 5Hz and 150Hz.

Ron Tipton

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Ad Index

ADVERTISER PAGE

ACO Pacific Inc	25
Antique Radio Classified	28
Audience	26
Audio Amateur Inc.	
audioXpress Digital	31
Goldpoint Level Controls	25
Jantzen Audio Denmark	5
KAB Electro-Acoustics	26
Liberty Instruments, Inc.	31
Linear Integrated Systems	27
Madisound Loudspeakers	8
Mouser Electronics	28
Parts Express Int'l., Inc.	CV4
Solen, Inc.	6
Tang Band Industries Co.,Ltd.	7
Triad Magnetics	CV2
Xerocomm, Inc.	27

GLASS AUDIO SECTION

Audio Transformers	18
Avel Lindberg	16

Hammond Manufacturing.....	11
Jantzen Audio Denmark	10
JJ Electronic	17
Metasonix	14
Mundorf EB GmbH	21
New Sensor Corporation	15,23
Parts Connexion	24
Serious Stereo	14
The Tube Store, Inc.	19

GLASS AUDIO MARKETPLACE

Billington Export Ltd.	22
Dynakit Vacuum Tube Audio Products	22

CLASSIFIEDS

All Electronics.....	30
Audio Classics Ltd.	30
Billington Export Ltd.	30
Borbely Audio	30
Design Build Listen, Ltd.	30
Tempo Electric	30

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We Interview Nelson Pass



From LP cutter-head electronics to car amps, from the 1kW/ch X1000.5 to the 10W/ch FirstWatt series, from open-baffles to giant pipe speakers, Nelson Pass has designed them all. . . and successfully so. Let's meet this man who chooses his own direction, and gives generously to the audio DIY community.

Jan Didden (JD): Mr. Pass, most readers will be familiar with the audio product line that bears your name, from Pass Labs. Some might also know that before Pass Labs you founded Threshold Corporation, known for among others, the Stasis amplifier series. Less people know that before starting your own company you designed amplifiers for others. Can you talk a bit of that history?

Nelson Pass (NP): Threshold was successful for about eight years before other companies showed interest. For the record, my ownerships have been Threshold, Pass Labs, and General Amplifier (First Watt). I have collaborated with 13 other brand names that I can remember. A couple of these I should not name, several do not deserve to be

named, and the following are ordered chronologically:

I worked at ESS, where Peter Werback designed the amplifiers. When I gave up my little side business building car amplifiers (back in the days of Craig and Kraco), I offered Peter my small customer base, and the resulting company, Linear Power, was quite successful until he died in a plane crash. So I filled in part time for a couple years, helping out with amplifier design work, an accounting system, and a subwoofer with motional feedback.

After this I was introduced to Rob Ain and Alec Chenin of Adcom, where I designed the GFA555 amplifier and its relatives. These products were very successful commercially, teaching me to charge more money for my work.

These amplifiers used bipolar transistors in a simple four-stage circuit. The input and voltage gain stages were biased by constant current sources, which drove Darlington emitter-follower output devices. It had an interesting clip detector which sensed feedback overload in the voltage gain stage and lit an LED. It also had a very effective bias circuit which fixed the bias voltage at the output of the driver transistors through local feedback, giving the amplifier improved thermal stability.

JD: The Adcom amplifiers were quite successful, weren't they? They had and still have a very good reputation, and still command a good price on the used market. Your reference to feedback bias circuit is intriguing. Can you give

some more details about that?

NP: It's pretty simple. For production convenience, you want to make the bias current of the amplifier output stage easy to adjust and you want it to stay at that value forever, so I made up a simple self-adjusting bias circuit. Here are two diagrams, the first showing a simplified version of the GFA555 (**Fig. 1**) and the second another version which I later patented (**Fig. 2**). In the GFA555 circuit, the bases Q7 and Q8 see the voltage across R1 and begin conducting when that voltage is enough to bias up their PN junctions (about 1.3V).

This controls the voltage across the bases of drivers Q3 and Q4 with a lo-

cal feedback loop and biases output devices Q5 and Q6. The loop eliminates the thermal drift of Q3 and Q4, which improves the output stage bias current stability. This still leaves the thermal drift of output devices Q5 and Q6, but the thermal characteristic of the PN junctions of Q7 and Q8 tend to compensate for this if they are in thermal contact with the output stage. The second circuit is similar, but uses an optical isolator, which eliminates any electrical connection between the current sensing and bias control parts.

Of all the collaborations, Adcom was the most personally enjoyable. I enjoyed working with

Rob and Alec, and we had a good relationship up to the sale of the company. I still talk to Rob occasionally.

The relationship with Nakamichi was more profit oriented. Around 1985 we were approached for a patent license and design work, which resulted in the Nakamichi versions of the Stasis amplifiers. Actually, we did not have to do a lot of work—they took our existing schematics and rendered them into their own version of the product. At the end of the process, they brought one up to Foresthill to have it tweaked, and there we were.

Nakamichi also led to design work

FIGURE 1: Simplified version of the GFA555 bias generator.

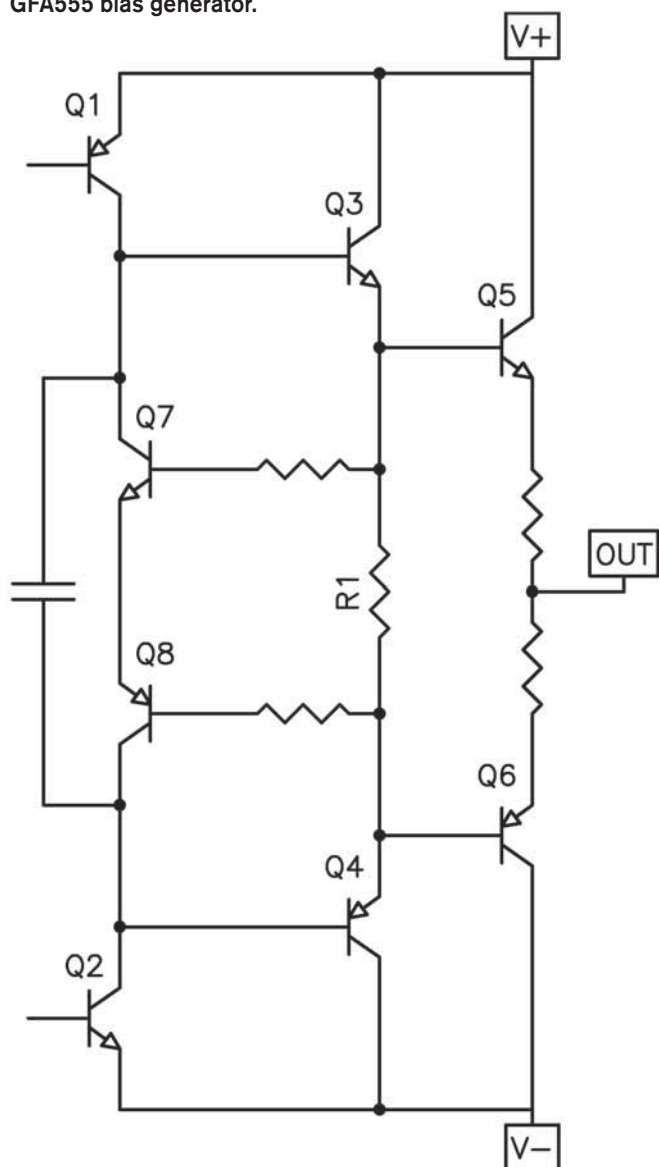
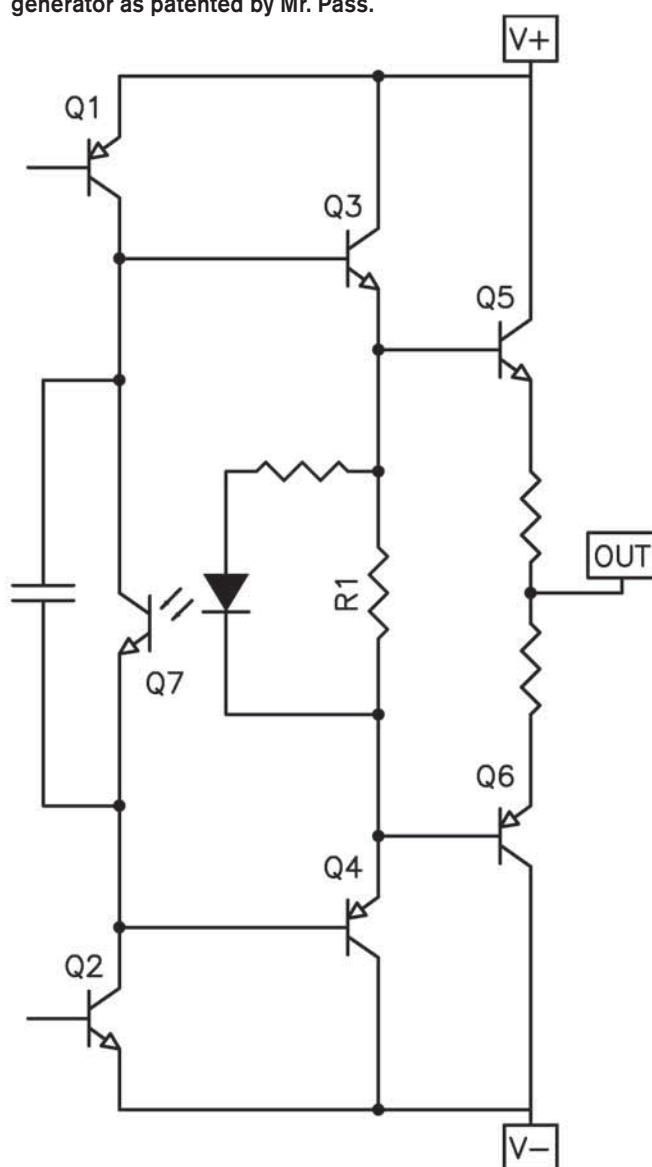


FIGURE 2: Opto-isolated feedback bias generator as patented by Mr. Pass.



for several car audio amplifiers by Soundstream. This project was a lot more work, but ultimately resulted in a product line that included the D200, D100, A100, A50, and so on. There wasn't anything groundbreaking in the circuits, but it was my first commercial experience with switching power supplies.

JD: In the 80s switching power supplies were relatively new and didn't have a very good reputation. The Sony TA-N86 and 88 come to mind. When they failed it was difficult to find a repair service that actually understood enough about these circuits to be able to repair them. What was your experience at the time? Now that the technology for

switched supplies has matured, would you use them for power amplifiers?

NP: This is not really my area of expertise. As a concept, I would consider using them, but it would take a considerable investment in time and energy that I don't have available at the moment. I would be far more likely to use them in low power equipment, where they can be made to have lower capacitive coupling to the AC line and where noise issues are a little easier to deal with. But for the time being my attention is elsewhere.

So, shortly after founding Pass Labs in 1991 I did some work for Mobile Fidelity, replacing the Ortofon electronics driving their cutter-head. This was a particularly challenging project, as the original electronics were very complex, with tons of ancient op amps in the circuit. The goal was to create a better-sounding system by simplifying the active circuitry as much as possible. The functions included balanced inputs, reverse RIAA equalization (full and half speed), additional equalization, feedback, feedback equalization, and balanced outputs. The outputs went to balanced Class A power amplifiers which drove the cutter-head, and feedback from the cutter-head came back to the control unit.



PHOTO 1

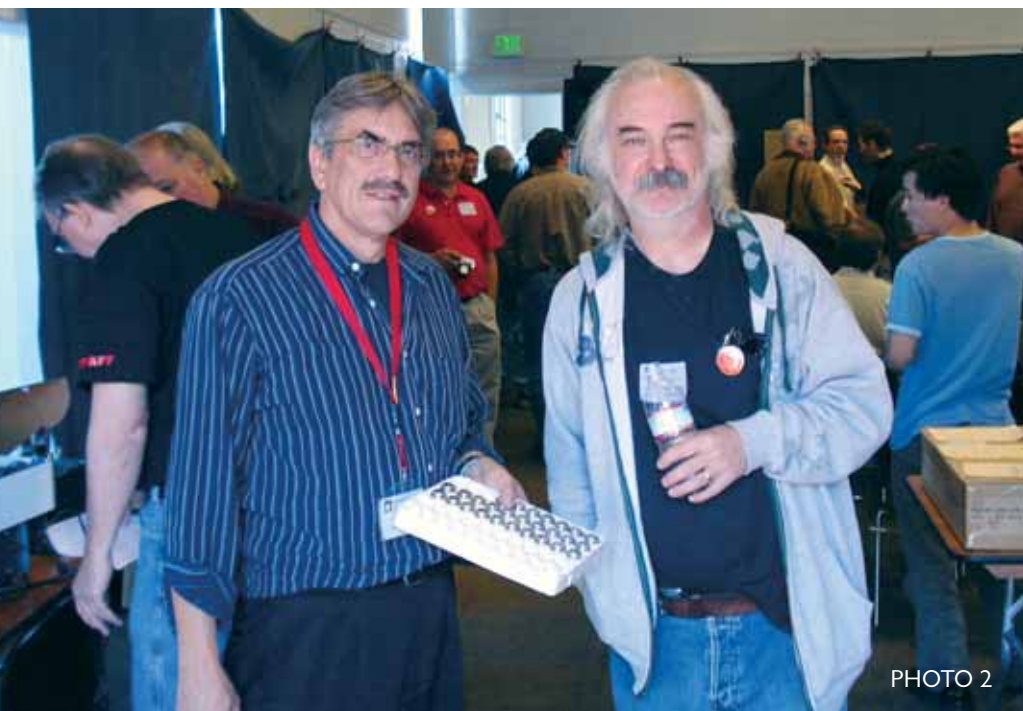


PHOTO 2

PHOTO 1: Nelson's Kleinhorn experiment, not an exercise in modesty.

PHOTO 2: Nelson (right) and the author (left) at the first Burning Amp Festival in 2007.

Because cutter-heads are very delicate and expensive to repair, there were numerous delicately adjusted protection circuits. The cutter-head drive coils were cooled by helium and monitored for temperature by running a very small amount of DC current through them. A circuit sensed the DC voltage across the coils and interpreted this as temperature. The protection needed to respond quickly, so the filters were quite sharp to avoid being triggered by the AC drive signal.

To accomplish all this, I first measured all the characteristics of the electronics and the cutter-head as precisely as possible and created a model of the system that I gave to a simulator (an early version of MicroCap). Then I began simplifying the active electronics by consolidating as many functions as possible into a few active stages. In

the end I was able to get all the gain, equalization, and feedback folded into one active stage which still delivered the same “objective” performance. The power amplifiers were cousins of the A75 design and predecessors of the later Adcom MOSFET designs. The project was successful, paid well, and broadened my experience in vinyl production and circuit simulation, but it was a tremendous amount of work over a couple years.

JD: You mentioned the A75. I believe that was a successor to the A40 which you published in *Audio Amateur*. Still mostly bipolar, if I remember correctly. At what point did you go to mostly or all-MOSFET designs? And what was the main reason for it?

NP: I cut my teeth on bipolars in the late 60s, and with the exception of

JFET inputs, followed occasionally by small MOSFETs, the Threshold products were bipolar. In 1980 I took a small leap with the power MOSFET version of the HK Citation 12 for an *audioXpress* DIY project, and after that my DIY pieces, including the A75, were MOSFET. Threshold continued to make bipolar, but when I left in 1991 to form Pass Labs I had by then decided to concentrate on Class A FET design.

There were two reasons for it. First, I found the FETs easier to work with in terms of obtaining equivalent or better performance with simple Class A circuits. Second, I liked the sound of the FETs better than bipolars, and still do. Now that some decent power JFETs are available, I am getting more interesting results, and I look forward to working with them more in the future.

Speaking of MOSFETs, in 1992 Ad-



com came back to the table for a new series to replace the GFA555 family, which had grown long in the tooth. This became the GFA5800, 5500, and so on. The circuits are familiar by now: three stages of MOSFETs, using an input differential pair biased by a constant current source, this driving a P channel VAS, also current sourced, and followed by complementary MOSFET followers. I also delivered a simple line stage preamp design, the GFP750, which was vaguely similar to the Aleph P preamp, but also incorporated a switch for active versus passive operation.

I designed the Adcom car audio products, the GFI 4702, 4600, and other amplifiers. These were circuits based on the MOSFET designs for the home audio equipment, and they were pretty unusual for the car audio market. They seem to still have a good reputation today.

JD: Is there a principle difference in designing car audio amplifiers or home

stereo amps, apart from the obvious 12V nominal supply in cars?

NP: It's a very different aesthetic—that is to say that the customer has very different expectations. When I did the Adcom car series, I applied “high-end hi-fi” sensibilities to the design. It sounded great in the living room, but did not particularly impress the customers, and the product was only nominally successful. I think the same is true of home theater. The customer is more focused on dynamics and articulation, and some of the traditional high-end two channel qualities fall by the wayside.

JD: I don't want to open a whole can of worms, but you seem not to be overly concerned about getting very low distortion. For your First Watt amps you have made the point that at the low levels where most listening takes place, the distortion is very low. Yet, at high-level peaks (especially with low- to medium-output power amps), distortion does rise considerably. But people

like your amps. Does it have to do with the way the distortion rises, or with the spectral make-up of the distortion?

NP: The characteristic I get is the result of simple FET circuits running in Class A. This means minimal or no feedback, low-order harmonic characteristic, and monotonic but pedestrian distortion numbers.

That approach usually (not always) delivers the sound that I like, and apparently my taste matches up with a portion of the buying public. The only magic involved takes place in the neural networks between our ears. What happens there is still poorly understood and varies between individuals. Whatever the deal is, ultra low distortion doesn't seem to have much to do with it.

JD: I know you have been involved with speaker design as well; can you tell us a bit more about that?

NP: I started out building speakers, and found myself at ESS about two weeks before Oskar Heil arrived. I spent the next couple years working up all manner of enclosures and crossover networks, sharpening my electronics skills, and soaking up all there was to know about a start-up manufacturing operation.

Subsequently I spent a year running the service department at the local Sun Stereo—more valuable experience poking around inside the broken amplifiers of McIntosh, Phase Linear, Sony, Pioneer, and JVC, while I worked on my own designs at night until it was time to launch Threshold in 1975.

But the speaker bug never leaves you, and so I have always maintained a tablesaw and a router. We have always kept a few examples of commercial speakers so as not to lose touch with the marketplace, but most of the time my listening space has been graced with unfinished plywood boxes. I met my wife Jill at ESS—she was the Heil dia-

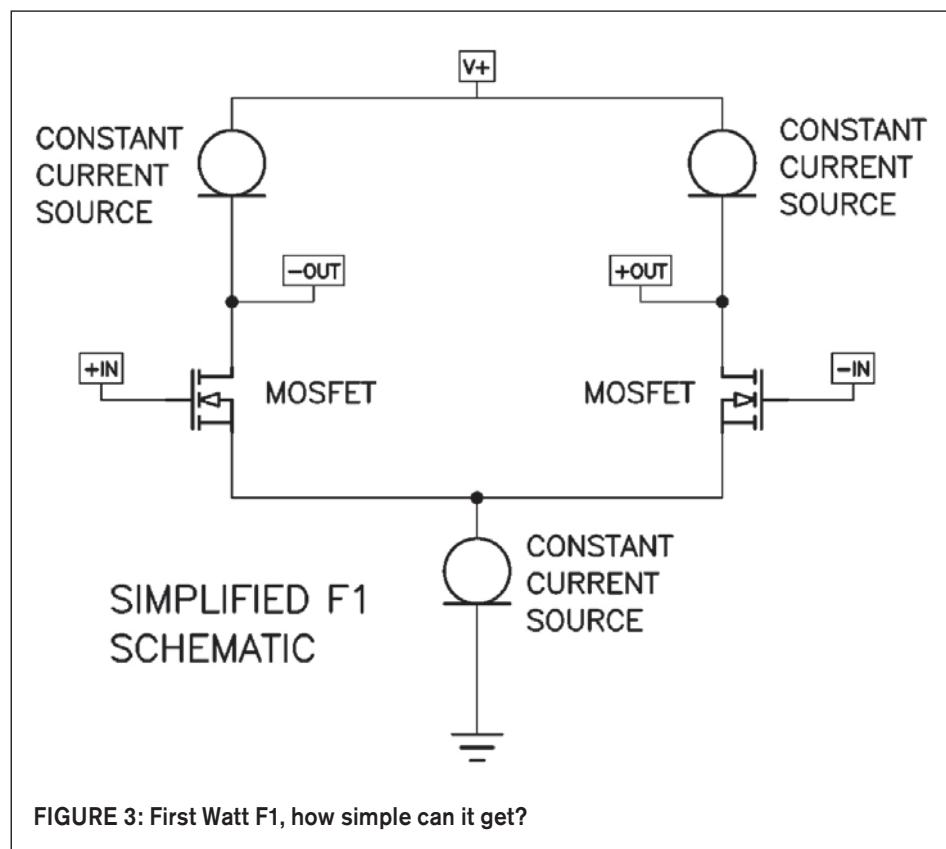
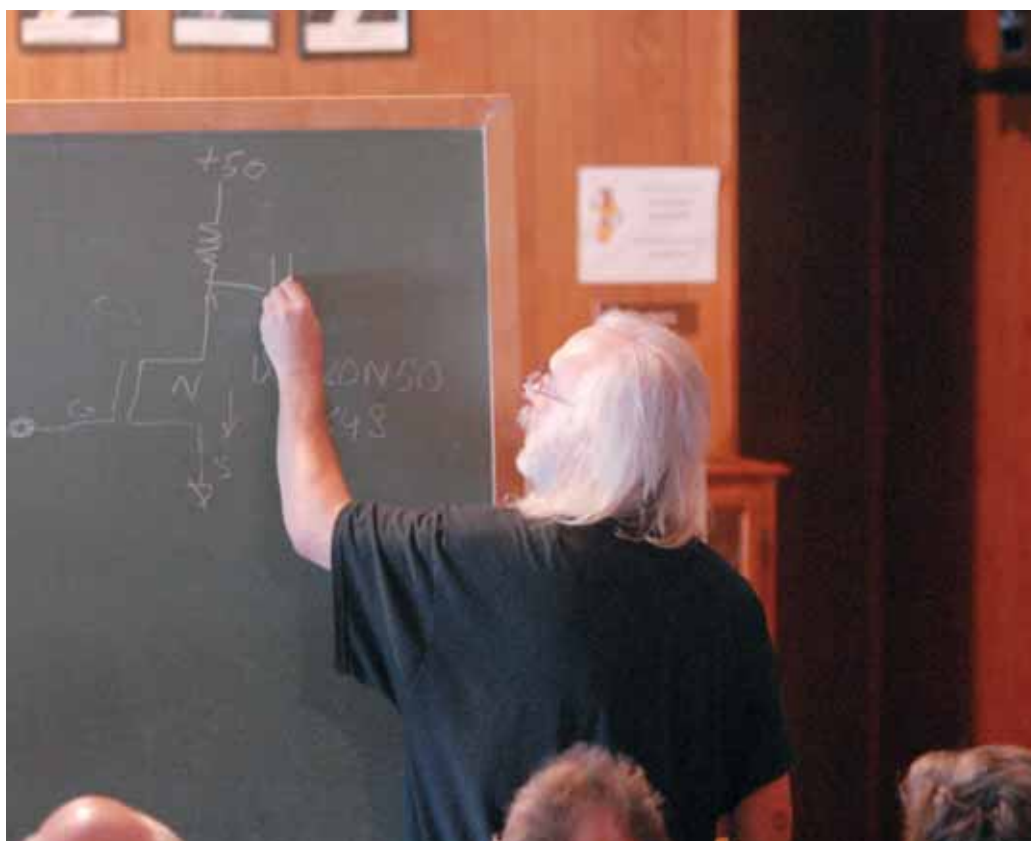


FIGURE 3: First Watt F1, how simple can it get?

phragm tester—and she doesn't have any problem with that. When I met her I had the Claw, a straight bass horn with a 50ft² mouth and 9' depth. Since then she has lived with the Kleinhorns (nearly as large, but stereo) and El Pipe-Os at 12' high, so a nice set of 4' × 8' open baffles doesn't cross the line.

Of course, the day finally came when Pass Labs decided to offer a loudspeaker, the Rushmore, which dipped our toes in the water, and several years later I surprised her with SR1s which have grille cloths, followed now by SR2s (SR = Son of Rushmore).

I spend a lot of time with those funny little full-range speakers—Lowther, Feastrex, Fostex, and so on in open baffles. They have their own appeal and mate nicely with my little First Watt amplifiers at 10 to 25W.



JD: You have been an early contributor to the audio DIY scene; I still remember an early article of yours in what was at the time *The Audio Amateur* magazine on cascodes, how they work, and their advantages. You have a knack of explaining engineering things very clearly in a few words, and you obviously enjoy doing it. You are also a very active contributor at www.diyaudio.com, being very generous with advice, tips, and complete amplifier designs that people can build. What do you get out of that interaction?

NP: I got my start when the boss at ESS sent an in-house paper I wrote to *Audio Amateur*. The first I heard about it was when he gave me the check for it. Over the last 36 years I've tried to do something fairly regularly for Ed Dell; in fact, I have a couple of new pieces in progress.

As to style, I like to speak to the teenager (me) who wanted to know this stuff—that's my audience. There are always people who appreciate a decent explanation that gets to the meat and

potatoes. I see it all as light entertainment with a little education thrown in.

The academic paper approach has its place, but it seems intended for people who mostly understand the stuff already. If you want to communicate with DIYers, you depend more on colorful analogies, a little hand waving, and very little differential calculus.

I get lots of personal satisfaction out of the whole enterprise. It gives me an outlet for some cool ideas and things that otherwise would stay bottled up, and I have an excuse to explore off-beat approaches purely for their entertainment value. Also, the process of communicating DIY stuff is a two way street—I would say I get about as much as I give.

(Author's note: Nelson's latest super-simple DIY design is the "DeLite" amp, which he presented at Burning Amplifier Festival 2009. Compared to DeLite, FirstWatt is overly complex. The DeLite design and construction is discussed at [http://www.diyaudio.com/forums/pass-labs/153832-pass-](http://www.diyaudio.com/forums/pass-labs/153832-pass-delite-amp-baf.html)

[delite-amp-baf.html](http://www.diyaudio.com/forums/pass-labs/153832-pass-delite-amp-baf.html)).

JD: Nelson, thank you very much for your time and your frankness during these discussions. As you said earlier, diyaudio has a special place in your heart. Do you have any advice for those DIYers out there who aspire to become successful designers?

NP: Ah yes, the concluding bit of sage advice: First of all, design for yourself, not for other people, and don't be afraid to try something. Then, when others want your designs, take great care of your reputation. You will not have much control over something that goes out into the world, but your name will still be on it. And, finally, be prepared for a lot of work. *ax*

The A40 power amp article was published in *The Audio Amateur*, 4/78, and the A75 power amplifier appears in *The Audio Amateur* 4/92 and 1/93. His other works are posted at www.passdiy.com.

Trials of Finding the Music

Lead-in can change look and feel

Is the CD now doomed with death from a thousand cuts inflicted by easy home copying, legal and illegal downloading, and the progressive disappearance of stores such as Tower, Fopp, Virgin/Zavvi, and Woolworths?

Tesco sells mainly current chart favorites, MDC now seems to be concentrating on budget Best Of boxed sets, and HMV (owner of a few old Foppes) is morphing into a sell-everything-vaguely-connected-with-music megastore.

Buying chart CDs by big name artists—such as Madonna or Miles Davis—is easy at HMV. But, as with MDC, the specialist stock becomes thinner by the day. Unfamiliar names are mainly on CDs that have been gathering dust in the racks and are unlikely to be re-stocked. When they're gone, they're gone. And customer care is decidedly iffy, too.

When I tried to buy tickets for the London concert to celebrate the 50th anniversary of Miles Davis' *Kind of Blue*, it took ten minutes to find someone in HMV Oxford Street who could unlock a ticket sales terminal. They could then offer me only an incomplete choice of price options, no seating plan, and no method of printing tickets, despite a £4 booking fee per ticket. I kept my money.

So it's small wonder that online CD mail-order sites such as Amazon and Play.com have done so well. But buying CDs this way is now becoming

difficult, too. Amazon is adopting the cost-cutting policy of stocking physical CDs for fast-moving music, but switching specialist sales to MP3 downloads. As CD pressings of specialist titles sell out, the last remaining discs are offered at premium prices or cheap download. Amazon already boasts "over 5 million DRM-free songs" at prices that undercut physical CDs and identical songs from iTunes.

Try searching Amazon's website for specialist CDs that suit your personal

eral dealers at prices ranging between £65 and £120! www.amazon.co.uk/Kansas-City-Bounce-1936-1940/dp/B0025YW86I/ref=dm_cd_album_Ink?ie=UTF8&qid=1244107510&sr=1-1 and

www.amazon.co.uk/Teddy-Hill-1935-1937/dp/B00261M5OU/ref=sr_f3_5?ie=UTF8&s=dmusic&qid=1244107702&sr=103-5

Of course, I'd rather have a pressed CD, with printed artwork and sleeve notes, than a home-burned CD and scrappy DIY sleeve and label; but not at a £60 premium and the risk that the CD may become lost in the post.

Trade insiders reckon that Amazon is taking a loss of between 20p and 40p per track when it sells selected tracks at 29p to try and win market share from iTunes—because record companies such as EMI are asking 49p per track for a WMA download and 62p for MP3, and there are overheads such as credit-card charges. But this loss-leading is encouraging more people to buy a download. [p = pence, the British penny. 100 = 1 pound.—Eds.]

The BPI, trade body for the UK record companies, says digital downloading now accounts for 10% of music spending. The official line is a big welcome. Says Geoff Taylor, BPI Chief Executive: "The rapid growth of the digital market is clear evidence that British



musical taste. As an example, I tried to buy a couple of early jazz CDs, *Kansas City Bounce* by Andy Kirk, and *Teddy Hill and his Orchestra 1935-1937*. Neither is likely to be available in any High Street store, or even by mail order.

In each case, Amazon offers a 256 kbps MP3 download (giving quite adequate quality for early recordings), which is cheap, easy, and quick to find. The complete *Teddy Hill* CD as an MP3 download costs £4; the same music on pressed CD is on offer from sev-

record companies have the business models in place to deliver music to fans online.”

What the BPI doesn’t say is that because MP3 has no DRM [Digital Rights Management, which limits use of digital content—Eds], a purchased file can legitimately be copied to a Sony Walkman or iPod for portable play, or emailed, or burned to Red Book CD for playing on any CD player, with no limit on the number of copies that can be made for family and friends.

(DRM)-FREE MUSIC

Nokia’s new Comes with Music is an all-you-can-eat free music service that comes bundled with selected mobile phones. In Nokia’s own words, NCWM is a “free and legal music download service—which brings you the unprecedented freedom to find, own and listen to the music you love, with unlimited free and legal downloads from the Nokia Music Store—with over 6 million tracks for every taste, ranging from the current Top 40 to a brilliant back catalogue from major and independent labels alike.”

In theory the music (recorded at 192 kbps in Microsoft’s Windows Media Audio format, which gives higher quality than MP3) is protected by DRM (also from Microsoft), which locks it inside one PC, and one Nokia portable player. In practice there are already illegal hacks which defeat the DRM. And there’s off-the-shelf software, quite legally sold for recording webcasts and Internet radio, that lets a PC capture any protected music while it is playing—e.g., from Nokia CWM or iTunes—and burn it in CD format to a blank CD.

This software, which I will tactfully not name, lets anyone with a Nokia CWM password download those elusive Andy Kirk and Teddy Hill CDs for free and burn them to CD. And because NCWM offers the legal opportu-

nity to download an unlimited number of complete CDs or individual tracks, which remain accessible even after the year’s free subscription expires, the owner could spend a year building a personal back catalog music store that lasts the rest of his/her life.

How has this crazy situation come to pass?

By failing to agree on an industry standard for music—and movie—downloads, the entertainment industry handed Apple and iTunes the opportunity to create a de facto standard with

was struck) how they had finally persuaded the BPI to agree to DRM-free MP3 download sales.

“It’s been a long, long battle,” says Coultart. “Finally so many people got involved that the noise just got too loud for the BPI to ignore.”

“It had to happen. The BPI finally had to buy in,” says Bayley.

But had the BPI and IFPI world trade body been aware of the risks that all-you-can-eat services such as Nokia Comes With Music pose for the record industry?

“We have lived long enough with dire forecasts for the demise of the CD, but there’s no sign of it happening.”

AAC music and H.264 video. Although AAC and H.264 are open standards that anyone can use if a license is paid, Apple locked up iTunes with a proprietary Digital Rights Management system called FairPlay. By refusing to license FairPlay, Apple turned the de facto standard into a monopoly.

The only way for record companies to break free was to agree to something they had previously, vehemently opposed—DRM-free MP3.

In November 2008, the Entertainment Retailers Association launched the “MP3 Compatible campaign” with a logo “to indicate to consumers that MP3 downloads will play on every PC and every Mac and on virtually every commercially available digital music player.” This is how Amazon can now compete with Apple.

I recently asked Kim Bayley, ERA’s Director General, and Russel Coultart (who runs online sites for artists ranging from the Beatles to Bob the Builder and was ERA Chairman when the deal

FUTURE OF CD

John Kennedy, Chairman and CEO of IFPI, carefully ducked the risk question, saying: “There’s a great deal of experimentation going on, and different models are competing but I don’t think anyone expects the end result to be a one-size-fits-all situation. Amid this digital revolution, I don’t see anyone in the music business writing off the CD.”

“We have lived long enough with dire forecasts for the demise of the CD, but there’s no sign of it happening. In 2001 analysts told us there would be no CD manufacturing plants within five years, but they were wrong. The truth is that the CD remains incredibly popular and it still accounts for the lion’s share of recorded music sales. Interestingly, Entertainment Research in the UK last year found a very small minority of consumers who download music legitimately have stopped buying CDs.”

Said Geoff Taylor, BPI Chief Executive: “CD sales continue to account for

84% of the UK market, so even with the fast rise of digital, the format remains a crucial part of the UK's music buying. For many consumers, including digital consumers, the CD still offers a package of great features—outstanding sound quality, durability, a physical back-up copy, artwork and lyrics, premium packaging and a physical object to own and display.”

When reminded that this completely ignored the risk awareness question, the BPI's spokeswoman could only add: “We think it's great so much choice is available for consumers via services that funnel music back to those who make it.”

Fine words, but as anyone who shops for non-chart CDs can see with his/her own eyes, fewer record companies can now afford to press small runs of specialist titles.

BURN ON DEMAND

Fortunately, there is another option—burn on demand. Instead of pressing discs in batches, and warehousing them until sold, the record company burns blank CDs, one at a time, when needed.

When I mail-ordered a CD of the Bill Elliott Swing Orchestra, it arrived from the US as a home-burned CD. I wasn't best pleased.

A year or so ago, when I ordered a Universal Music CD by 70s UK soul artist Jess Roden from Amazon, it arrived by mail from a supplier called The Disc Kiosk (www.thediskkiosk.com/cdo.htm). It had been burned on demand and the sleeve art was poorly printed, with minimal and incorrect information. At £10 I felt ripped off.

Amazon no longer offers the burn option, and a CD copy now costs up to £140.

[//www.amazon.co.uk/gp/offer-listing/B00000JA0F/ref=dp_olp_0?ie=UTF8&condition=all](http://www.amazon.co.uk/gp/offer-listing/B00000JA0F/ref=dp_olp_0?ie=UTF8&condition=all)

For a lesson in how to do the burn-on-demand job properly, look no further than the Wyastone Leys manor and estate deep in beautiful country near Monmouth. This was the home of Nimbus Records, pioneer in Ambisonics, purveyor of top-notch LPs, maker of the first high-quality PCM digital tape recordings, first manufacturer of CDs in the UK and developer of high-density mastering with blue lasers. After some financial upheavals (including being owned by the unlovable rogue Robert Maxwell), Nimbus was bought back in 2002 by its founding directors, changed its name to Wyastone, and started a burn-on-demand service.

The trigger was discovering on buy-back that more than two-thirds of the catalog was unavailable or deleted because it no longer sold in sufficient quantities to meet the minimum repress requirements.

Says Wyastone's Business Director, Antony Smith: “It was clear we had to find a way to bring back all deleted titles and create a system that would cost-effectively keep them in print. By returning 500 titles to the catalog and with sales per title averaging just 75 pieces per year it increased our revenues by more than £175,000 per year. More importantly by switching all of our production to this method it reduced our stock by 80% over three years.”

Wyastone worked with Sony DADC in Austria on producing burned discs with predicted 35-year life that cosmetically look exactly like a replicated CD, or DVD. The disc data is stored on computer hard disc servers and verified as a bit-perfect copy of the original. When a disc is ordered, the master audio file is selected along with the matching artwork file. Duplication and digital printing is by automated robotic systems.

There is no minimum quantity for CD or DVD duplication; customers order exactly the quantity they need right now.

[Digital printing matches the quality of traditional lithographic printing, but with the flexibility to print exactly what is needed when it is needed. The artwork is stored on the servers, with the music or video, and can be anything from simple two-page inserts to 64-page stitched booklets, single- or double-sided, in color or black and white. Digital printing is price competitive for quantities less than 2000 copies.]

All new Nimbus titles since May 2002 have been created using this short run manufacturing technique. During that period some have sold many thousand copies and some only a few hundred. In June 2008 Wyastone opened a sister facility in New Jersey, to cut out the cost of transatlantic shipping.

Says Anthony Smith: “We have used the system to re-release all titles on the Nimbus label, restored the Saydisc, Lyrita and MusicMasters (Classical and Jazz) labels and enabled Hall and Red Priest to start their own labels. In total we manufacture for about 160 labels.”

The entire Lyrita catalog—of over 130 titles—will be brought back over the next 18 months. Many of Lyrita's original analog masters have never been available on CD.

Having seen a batch of jazz discs produced by Wyastone, I can vouch for the fact that I would never have known they were burned to my demand. And I would far rather pay more for them than make downloads and home burns.

On-demand replication looks increasingly like the only way to save the non-chart CD—and probably DVD, too—from extinction. How odd that neither the BPI nor IFPI thought to mention it.

ax

Super Fidelity

By John Sunier | www.audaud.com



JS Bach | Cembalo Concertos | Francesco Cera, Diego Fasolis, harpsichords, I Barocchisti | Arts Multichannel SACD 47729-8

I am a believer in the need to perform works originally written for the harpsichord on that instrument, rather than on the modern piano. In fact, I can't think of any early keyboard concertos for which performance on the instrument for which they were written is more important than Bach's concertos. His D minor (BWV1052) is perhaps the most famous, and is the longest of the four on this disc. It uses material from two of his cantatas, opening with almost the same theme as the *Cantata BWV146*, except that the dramatic solo part is played on the organ. It has been performed and recorded frequently on harpsichord, but mostly with larger orchestral forces that tended to drown out the rather meek voice of the harpsichords. In this smaller chamber-size aggregation the two instruments are well-balanced against the other players.

Art Lande | While She Sleeps (Piano Lullabies) | Blue Coast Records Stereo-only hybrid SACD BCRSA 2012a

This is a very unusual album, musically, technically, and financially (it retails at US \$40!). Grammy-nominated Art Lande's piano style is a cross between Paul Bley and George Winston, but more tonal than the first and less predictable than the second. The microphones were so close to the piano that it sounds as though your head is under the lid.

This pickup is appropriate, however, because the music is very quiet, simple and subtle, and due to the amazing resolution, thousands of tiny details are clearly delineated instead of being lost. Although ideal for music therapy, the 14 tracks are more musical than 99% of New Age piano noodling. I am sure it's going to get plenty of play at hi-fi shows.



The Larry Coryell Organ Trio | Impressions | Chesky Records Multichannel SACD 337

Larry Coryell is one of the top jazz guitarists working today, with more than 100 albums as both leader and sideman. This is his first as a guitar/B-3/drums trio. For this session he uses Paul Wertico, his regular drummer of the past five years, and one of the newer breed of B-3 players, Israeli-born Sam Yahel. The nine tunes include two Coryell originals and one by Wertico. The others are by Gershwin, Harold Arlen, Bill Evans, and Coltrane. The venue was St. Peter's Episcopal Church in New York City, often used by Chesky for its natural acoustic. Coryell's guitar is dead center, with the drums on the right and the B-3 on the left. There are no overdubs or gimmicks, just the natural sounds of the three players. Coryell's guitar has a clean and wide-range timbre, and he refrains from over-electronic tricks.

Grieg | Peer Gynt Suite | Bizet: Carmen Suite | LSO/Oivin Fjeldstad; NPO Charles Munch | HDTT HDDVD150

Two different quarter-track Dolby open reel tapes were accessed for this DVD-R (it's also available on CD-R). The Peer Gynt was transferred from a London pre-recorded tape originally recorded in 1961. The Carmen Suite is from a London tape of 1966. Both are suites which will be very familiar to most. The first is a ten-track set which includes such big Grieg hits as *Anitra's Dance*, *Morning Mood*, and *In the Hall of the Mountain King*. The Carmen suite includes the famous *Toreador Song* and the *Entracte Aragonaise*. The transparency of the recordings and the crystal-clear spatiality of the various instruments of the orchestra elevated my interest in hearing this overly familiar music again. Because not many audiophiles have open reel decks anymore, this is the best way to enjoy the superior two-channel fidelity still available from open reel tapes on a properly set up reel-to-reel deck.



Vintage Cinema | Classic Film Score Themes | CPO/Erich Kunzel | Telarc Multichannel SACD-6070

The program opens with one of the first blockbuster film scores: Max Steiner's dramatic music for "King Kong." The second track brings us the composer who made his Germanic Late-Romantic lush orchestral style the accepted standard for Hollywood film scores for decades: Eric Wolfgang Korngold. The excerpt is from his 1938 music for "Robin Hood," starring Errol Flynn. Then there's Alex North's music for "A Streetcar Named Desire," which was the first big Hollywood production to make use of jazz, followed by the music from Leonard Bernstein's score to "On the Waterfront." Miklos Rozsa brings an exotic twist from his Hungarian background to his score for "El Cid."

He and Franz Waxman are the only two composers represented by two selections on the disc. The Cincinnati Pops plays with great gusto throughout, not just reading off the notes—as on some orchestral re-creations of soundtrack music.

Tutti! | Orchestral Sampler | Vivaldi, Stravinsky, Mozart, Paray, et al | Reference Recordings Stereo Only SACD RR-906SACD

This is Reference Recordings' first Super Audio disc, and more are planned—great news when other labels are dropping SACD releases due to limited sales. I don't see how they could have come up with a more exciting and interesting classical sampler of two-channel material.

There are the expected warhorses, such as the last two sections of *Pictures at an Exhibition*, but there are also unexpected off-the-beaten-path gems such as Malcolm Arnold's *The Padstow Lifeboat*. A quick A/B comparison with the CD layer of this hybrid disc shows again the sometimes subtle but often shockingly major enhancement that the high-res format provides—even in two channels. One element is the more extended, tighter, and increased physical sensation of the lowest bass drum or tympani. Another is the analog-like quality of "air" around all the performers.



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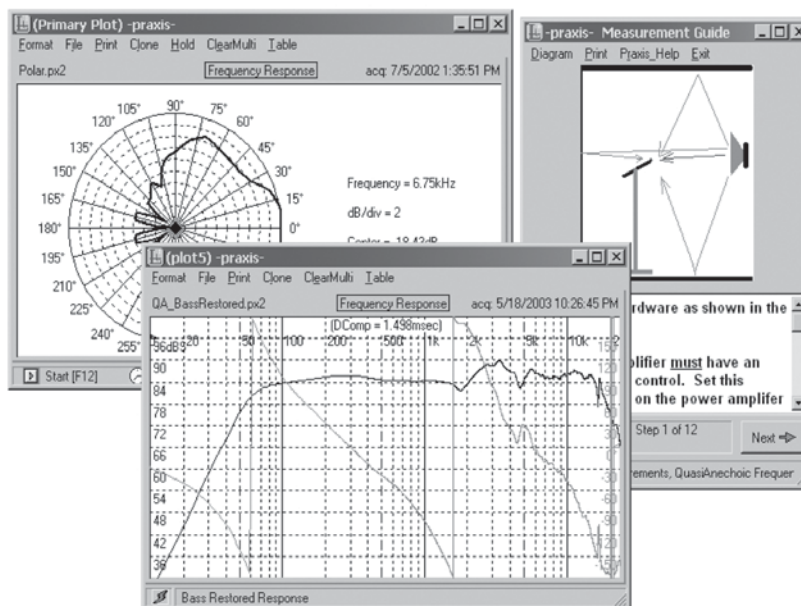
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New from **Earthworks, Inc.**, the SR40 high-definition microphone offers extremely fast impulse response, short diaphragm settling time, and high rejection of sounds from the rear of the mike. Its acoustic input rating is 145dB, requires 48V phantom power, and has an optional screw-on windscreen. To learn more, visit www.earthworksaudio.com.

"Assessment of Audio Systems for better speaker design" was a seminar presented by Dr. Wolfgang Klippel on March 2nd, in Seoul, Korea. Addressing the evaluation of sound reproduction systems based on objective measurements, this course covered fundamentals, modeling, large signal performance, and approximation. Measurements and analyses included persistent excitation, complex structures, sound field, and room interaction, while interpretation and diagnostics mentioned tolerances, specification, perception, and evaluation. Interested loudspeaker engineers can contact www.klippel.de.

New from **Audience**, the ClairAudient LSA 16+16 loudspeaker is a bi-pole design incorporating the company's proprietary full-range, crossoverless A3-S drivers. The LSA 16+16 measures 15" W x 12" W x 6' H, and was featured at the AXPONA Audio Expo North America in Jacksonville, Fla., March 5-7. Other Audience products featured at the show include the Wavemaster buffered autoformer preamplifier, Adept Response aR6-T and aR12-T power conditioners, Au24 powerChords, and more. To learn more, please visit www.audience-av.com.

The SMS-1 Sound Measurement System 1, from **TDL Technology**, consists of a TDL Model 411 microphone preamplifier and a TDL Model 818 measurement microphone. While you can add a Behringer ECM-8000 and/or Dayton EMM-6 measurement microphone, the Model 411 supplies a +5V DC to the Model 818 mike and a +48V DC reference. For more information, go to www.tdl-tech.com or e-mail RTipton@tdl-tech.com.



Zaxcom's signal distribution software platform, Zaxnet, is now available for free download to all users of the company's current audio recording hardware. Zaxnet provides a 2.4GHz RF network for distributing remote control signals, timecode, IFB audio, and metadata, and incorporates many company products, such as the Zaxcom IFB100 transmitter. To learn more, go to www.zaxcom.com/support_software_updates.htm.

Cyber Clean Home & Office is a cleaning compound that can quickly and easily remove any damaging substances on a DVD or CD. While it cannot take out scratches or smudges, Cyber Clean can eliminate any dirt buildup that has accumulated on the surface that may lead to further damage, and it will not harm your discs. The process involves rolling Cyber Clean in your hands, making the pH balance in the substance match the pH balance in your hand, then placing the compound on top of the surface of the disc, and lightly pressing down. The dust and dirt will become micro encapsulated inside Cyber Clean when you roll the compound between your hands. For further info, go to www.cyberclean.tv.



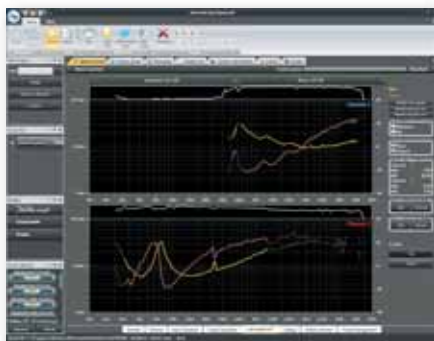
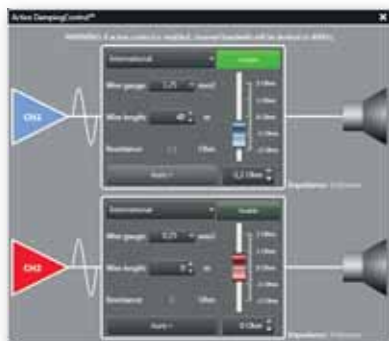
New from **Panasonic**, the 7.1 surround-sound tower speakers are a wireless pole-speaker system for home-theater setup. For more information, visit www.panasonic.com.

NTI Audio AG's XL2 Audio and Acoustic Analyzer has been updated with a Scope Function, and extended with new firmware V1.12. Available as a free upgrade, firmware 1.12 now records voice notes and wav files for complete documentation of the measured sound. The scope function displays the waveform of the electrical input signals, and auto-ranges to the proper scale, then triggers on the fundamental frequency automatically. The firmware is available at www.nti-audio.com/XL2.

New from **Leon Speakers**, the Aaros is a 10" ultra-thin subwoofer in a compact enclosure with a depth of 4.5". The subwoofer (model A10-UT) uses 400W with minimal distortion, weighs 45 lbs, and can produce the bass response matched to the space for which it is intended. For more, visit www.leonspeakers.com.

Warpia's wireless USB A/V adapter set allows you to wirelessly stream video content straight from your computer to your big screen or projector. Once you've finished installing, just plug the adapter into your computer's USB port to instantly watch Netflix, YouTube, Hulu, and photo slideshows. The adapter achieves 32-bit true color depth for high quality images, 720p HD resolution, and 16-bit stereo sound, and its range includes same room coverage of up to 30'. Visit www.warpia.com for more information.

Powersoft (www.powersoft.it) has released the Armonia Pro Audio Suite sound system management software. Designed to work on any PC, Armonia delivers an intuitive and comprehensive solution for managing and controlling sound systems that rely on Powersoft amps to drive the speaker systems.



OWI has released an amplified surface mount speaker package, which contains a 30W, self-amplified, two speaker system with an active, self-amplified, two-way surface-mount speaker and a matching, passive 4Ω speaker. By combining the amp with the speaker, maximum damping control is achieved due to low source impedance, resulting in optimum high-fidelity reproduction and response without a bulky external amp. For more information, visit www.owi-inc.com.



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