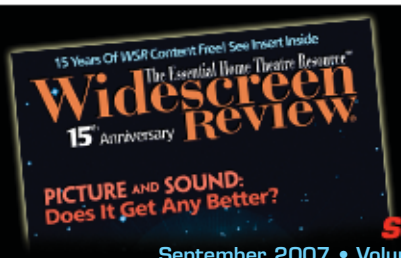

The Essential Home Theatre Resource™
Widescreen Review NEWSLETTER

ISSUE 124 on newsstands soon! SUBSCRIBE TODAY!

September 2007 • Volume 2, Issue 16 • The Official FREE Newsletter Of Widescreen Review Magazine

WELCOME!

Well, the 2007 CEDIA EXPO has come and gone, and the entire *Widescreen Review* staff is scrambling, trying to sort through the mounds of press releases and scores of follow-up emails. So, while news from the EXPO didn't make its way into this Newsletter, look to Issue 125, November 2007 for the first installment of our annual CEDIA EXPO Report, with an in-depth look at the video products that were announced at the show.

For this month's Archived article, we have gone back to "Power Envelope—Amplification For MultiSpeaker Arrays" by Daniel Sweeney, which was first published in Issue 17, November/December 1995. This is a great article describing the methods of power amplification, which goes into great detail explaining all of the parameters that must be addressed when designing loudspeaker amplifiers. We have split this article into two parts, and Part 2 will appear in next month's Newsletter. Enjoy.

Gary Reber
Editor-In-Chief, *Widescreen Review*

NOW AVAILABLE ON NEWSSTANDS

Issue 124, October 2007 of *Widescreen Review*:

- Celebrating 15 Years Of *Widescreen Review*
- "Samsung LN-T4665F 1080p LCD HDTV" By Mike Marks
- "Adcom GFR-700HD Receiver" By John Kotches
- "Toshiba HD-XA2 HD DVD Player" By Bill Cruce
- "Panasonic DMP-BD10A BD Player" By Danny Richelieu
- "DALI Euphonia MS 5 Loudspeaker" By Gary Reber
- "Display Technologies — Part V: Microdisplay Projectors" By Lancelot Braithwaite
- "HDMI Conference At Sea™" By Gary Reber
- Over 40 Blu-ray Disc, HD DVD, and DVD picture and sound quality reviews
- And more...

ATTRACTIONS

I Want To Know

The Studio Scoop

Rumors, Reports, & Ramblings

Stacey Pendry

You may be wondering why the byline for The Studio Scoop has changed yet again. Well, along with my illustrious new title comes the pleasure of writing this column. Enjoy!

Walt Disney Studios Home Entertainment

The highly anticipated sequel *High School Musical 2* has hit a record in viewing audience numbers. According to Nielsen estimates, the TV sequel was watched by an estimated 17.2 million kids, 'tweens, and teens—which is more viewers than any other basic cable telecast has received in the past 2-1/2 years. You can catch up with the gang from East High on December 11, 2007 when Walt Disney Studios Home Entertainment will release *High School Musical 2* in both standard DVD and Blu-ray Disc formats.

In more Disney-related news: Walt Disney Studios Home Entertainment announced a 2008 "Title Wave" of Blu-ray Disc releases, including their first ever "Platinum" series release. "The Platinum titles are the crown jewels of the Disney Studios, and we do not take lightly releasing them on any format," Bob Chapek, President of Walt Disney Studios Home Entertainment noted. Stay tuned for the first title to be released in the Disney Platinum Blu-ray Disc series.

Paramount And DreamWorks

Paramount announced that they will solely support the HD DVD format for their future DVD releases. The exclusive HD DVD commitment will include all movies distributed by Paramount Home Entertainment. This includes titles released by DreamWorks Pictures, DreamWorks Animation SKG, Paramount Vantage, Nickelodeon Movies, and MTV Films. DreamWorks will release the much anticipated title *Shrek The Third* on November 13, 2007. *Transformers* will be released by Paramount Home Entertainment in both standard DVD and HD DVD formats on October 16, 2007. Interestingly this exclusivity does not apply to films directed by Steven Spielberg; his films may be released in either format.

MGM

MGM announced that they have chosen Ashley Tisdale, star of Disney's *High School Musical* franchise, to play the lead in their DVD Premier unit project: *Picture This*. The made-for-DVD project will begin production in Montreal during the last week of August, with no street date announced at this time. MGM's Premier DVD division is slated to release new installments of other properties such as *Legally Blonde, Cutting Edge, Stargate, and Species* with hopes of releasing some 12 titles annually.

Sony Pictures Home Entertainment

Chalk one up for Sony Pictures Home Entertainment! *Close Encounters Of The Third Kind: 30th Anniversary Ultimate Edition* is slated for release in standard DVD and Blu-ray Disc on November 13, 2007. This is exciting news for both Sony and Blu-ray Disc, as it is the first Spielberg title to be launched in either high-definition format. Bragging rights indeed, as Mr. Spielberg's body of work is to be exempt from the exclusivity clauses binding films to one format over the other.

Warner Bros. Studios

Warner Bros. has named Zack Snyder (Director of *300*) to produce and direct a remake of *The Illustrated Man,* which is based upon the 1951 Ray Bradbury collection of short stories with the same name. The Sci-Fi story is about a man with mysterious living tattoos that are able to predict the future. Rod Steiger starred in the original big-screen adaptation in 1969. The film will be produced through Snyder's Cruel And Unusual Films and Di Novi Pictures.

20th Century Fox And MGM

How do you answer Paramount's and Dreamworks' decision to go HD DVD exclusively and shut out Blu-ray Disc? It seems Fox and MGM feel that by announcing 29 new releases and "must have" Blu-ray Disc titles, available by the end of 2007, is just what is needed. *Fantastic Four: Rise Of The Silver Surfer* and *Live Free Or Die Hard* are a couple of the heavy-hitting titles slated for release this Fall. Many of the titles that are to be released in this latest attempt to quash the HD DVD camp will include BD-Java interactive elements, enhanced and integrated menus, and BD-Live functionality.

News In Brief

Actor Owen Wilson has pulled out of Dreamworks' ensemble comedy *Tropic Thunder* after he was hospitalized for an undisclosed medical problem (a reputed suicide attempt). The project also stars Jack Black and is to be produced by Ben Stiller's Red Hour Films. Stiller and Wilson have collaborated on eight films together, including *Zoolander* and *Starsky And Hutch*. It is still unclear if Wilson's role in *Tropic* will be recast or if it will be eliminated altogether. We wish Mr. Wilson a speedy recovery and are looking forward to his next flick.

Michael Bay, director of this summer's blockbuster hit *Transformers*, was so annoyed when he first read of Paramount's decision to solely support HD DVD that he quickly vented his views on his personal Web forum. Bay's initial reaction: "No *Transformers 2* for me. I want people to see my movies in the best formats possible. For them [Paramount] to deny people who have Blu-ray [Disc] sucks!" was tempered when Bay met with Paramount execs the following day. After meeting with the studio brass, Bay removed his original posting from his Web site and replaced it with the following statement: "As a director, I'm all about people seeing films in the best quality possible, and I saw and heard first-hand people upset about a corporate decision. So today I saw *300* on HD and it rocks! So I think I might be back on to do *Transformers 2*!" Hmmm...what a difference a day makes! WSR

NEWSLETTER EDITION

Coming Soon...
To A Retailer Near You

Danny Richelieu

NAD Electronics has unveiled four new A/V receivers, the **T 785** ($3,000; 7 channels x 120 watts), **T 775** ($2,500; 7 x 100), **T 765** ($2,000; 7 x 80), and **T 755** ($1,300; 5 x 80). With these receivers, NAD decided to "concentrate on functions and technologies that really make the difference in sound and in picture." Each feature NAD's PowerDrive™ power-supply arrangement, which holds a measure of current in reserve to be called upon by transient demands in your audio, BurrBrown audio DACs, a Texas Instruments Aureus™ 7.1-channel audio DSP, and Audyssey™ Auto Calibration. The T 785 and T 775 also add Audyssey's MultEQ XT™ as well as MultEQ Pro™ that can allow a custom installer or system designer to derive even more accurate and more extensive room corrections by further utilizing the processing power of a home PC. All four models are XM Ready and have HDMI v1.3 inputs with video transcoding (but no scaling), and the T 785 and T 775 will decode audio off the HDMI inputs.

NAD T 775

NAD Electronics *905 831 6555* *www.nadelectronics.com*

Pinnacle Speakers has introduced their first on-ceiling/wall loudspeaker, the **OC HT 1**, which features a circular cabinet of varying depths, designed to enhance the bass response by minimizing standing waves. Housing a 1-inch silk dome tweeter with neodymium magnet and a 5.25-inch polypropylene woofer, the OC HT 1 delivers a frequency response of 110 Hz to 20 kHz with an 87 dB per watt per meter sensitivity. The nearly 9-inch circular loudspeaker (with about a 4.5-inch depth) includes two grilles—one perforated metal and one cloth—and sells for $350. A three-pack is available for $1,000.

Pinnacle Speakers OC HT 1

Pinnacle Speakers *800 346 2863* *www.pinnaclespeakers.com*

ATC Loudspeaker Technology has introduced their **SCM16A** active monitor loudspeaker, which features newly developed Constrained Layer Damping (CLD) technology in their 6-inch mid-bass driver, which sandwiches two lightweight cones and a constrained damping layer for high damping without a significant increase in cone mass. Combined with their 1-inch soft dome tweeter and onboard 200-watt Class A amplifier (up to two-thirds of output), the SCM16A can deliver SPLs greater than 108 dB with a frequency response from 70 Hz to 17 kHz at ±2 dB (62 Hz to 20 kHz, ±6 dB).

ATC Loudspeaker Technology SCM16A

ATC Loudspeaker Technology *203 888 3759* *www.atc.gb.net/*

Fusion Research has added a new **1080p Cinema Player** to its line. This completely new design offers both 1080p upscaling of DVD movies as well as playback of 1080p high-definition content over its HDMI output. Combined with Fusion's Cinema Server, the Cinema Player creates a complete movie and music media server system that is connected over your home network. The "ultra-quiet" design has a 1U chassis with rack ears, and includes digital and analog audio and video outputs.

Fusion Research 1080p Cinema Player With GUI Screenshot

Fusion Research *925 465 1333* *www.fusionrd.com*

Anchor Bay Technologies has introduced the **DVDO® iScan™ VP50PRO**, the first outboard video processor to include HDMI v1.3 receiver and transmitter chips and support for Deep Color™ and pass-through for the new advanced audio codecs from Dolby® and DTS® (Dolby Digital Plus, Dolby TrueHD, DTS-HD High Resolution Audio, and DTS-HD Master Audio). The iScan VP50PRO includes three new Anchor Bay VRS™ (Video Reference Series) technologies that were not included with the iScan VP50: Mosquito Noise Reduction, Fine Detail Enhancement, and Edge Enhancement. Holdovers from the VP50 are 10-bit Precision Deinterlacing™, 10-bit Precision Video Scaling™ to 1080p, PReP™ (Progressive Re-Processing), Progressive Cadence Detection, and RightRate™. The processor also includes two 12-volt triggers for controlling devices like screens or anamorphic lenses (the VP50PRO also includes a mode to stretch a 2.35:1 signal to fill a 1.78:1 frame for using an anamorphic lens), and is ISFccc certified. A module is also available that will provide two SD/HD-SDI inputs. The iScan VP50PRO is shipping this month (September 2007).

Anchor Bay DVDO iScan VP50PRO

Anchor Bay *866 423 3836* *www.anchorbaytech.com*

Impact Acoustics 6x2 Component Video Matrix Selector Switch

Impact Acoustics has introduced its new **6x2 Component Video Matrix Selector Switch**, enabling up to six high-definition sources to be delivered to up to two displays (the same or different sources can be delivered simultaneously to the two outputs). The switcher contains six component video inputs with 300 MHz bandwidth—capable of delivering up to 1080p—as well as six 2.0-channel analog inputs and six digital TOSLINK S/PDIF inputs. In addition to the two component video outputs, there are also two 2.0-channel analog outputs and two TOSLink outputs. The device comes with an infrared remote control featuring discrete commands, and the front-panel buttons also allow a user to easily switch between source devices.

Impact Acoustics *877 283 9737* *www.impactacoustics.com*

DisplaySearch HDTV Conference 2007
Sign Up Today and Save!

Participating companies include
Amazon.com, Buena Vista Home Entertainment, CompUSA, Dolby, ESPN, LGE, Microsoft, Panasonic, Pioneer, Sony, Texas Instruments, THX, Toshiba, Universal, Vizio, Warner Home Video and many more.

The HD countdown has begun... 16 months after the highly anticipated ***5th Annual DisplaySearch HDTV Conference***, to be held October 10-11, 2007 at the Universal City Hilton, the conversion from analog to digital will be completed! The entire supply chain - including consumers, retailers, filmmakers, studio and network executives as well as hardware manufacturers and others - will touch or be touched by this milestone technological transition into the digital age.

The impact cannot be underestimated as the entertainment industry's creative community converges with content distributors and hardware manufacturers - all with the same goal: maximizing the potential of HD content.

HD hardware and content has rapidly been embraced. In Q2'07, HDTVs accounted for 79% of North American TV shipments and 95% of TV revenues. There are now 40 million HDTVs 26" and larger in American homes, with 16% of US households subscribing to HD service. HD service is set to explode as the number of available channels jumps to 100 by the end of 2007 and 150 by mid-2008 as satellite, cable and telcos expand their capacity and compete aggressively to add new subscribers. In addition, HD gaming has exploded with over 7.5M HD gaming platforms cumulatively sold in the US through July. Furthermore, all the movie studios have now embraced high definition DVDs and both HD-DVD and Blu-ray player and movie sales have begun to surge.

Sign up??by September 26 and Save $100!

REGISTER NOW!

Day 1 Topics

- "The Format War Is Over! No Wait, This Just In..."
- HD Broadcasting Outlook
- HD Content Distribution Outlook
- HD Gaming Outlook

Day 2 Topics

- New Display Advances
- Next Gen DVD Hardware Outlook
- Enhancing the HDTV Experience
- Home Connectivity
- TV Market Outlook
- Retailer Panel

Register for both HDTV and the DVD Forum North America DVD Conference and Save!
DisplaySearch has co-located the ***HDTV Conference*** with the ***DVD Forum North America DVD Conference***, which takes place on Tuesday, October 9, 2007. **Register for both events and save $100**. For more information on both events, please visit www.displaysearch.com/hdtv2007. Media interested in attending should contact Heather Boudreau at heather_boudreau@displaysearch.com

Join us for the industry's most credible guest speakers providing the most current and accurate information and insights into what's happening today and what you can expect in the HD future.

Sincerely,
Heather Boudreau
Marketing & Events Specialist
DisplaySearch
(ph)516-625-6133
(email) heather_boudreau@displaysearch.com

Power Envelope
Amplification For MultiSpeaker Arrays

By Daniel Sweeney

When we set out to do a comprehensive article explaing amplifier design as a preface to an expansive review of multichannel ampliferes now on the market, I asked our Contributing Editor Dan Sweeney to take on the challenge. Dan has done a tremendous job explaining what is a rather complex subject. His work provides an excellent reference on the subject of amplification for multi-speaker arrays applied to home theatre entertainment, whether movies or music.—Gary Reber, Editor

"Oh No, Not Power Amps"

"Not power amps," I said. Definitely not."

"You've got to do 'em, Dan. We've done processors, and we've done speakers. Now we have to do amps," declared Gary.

"But—but you don't have that much product differentiation with power amps, and you certainly don't have the same degree of design innovation—at least not anymore. It's a relatively mature technology. There's just not that much to write about—it's all been written!," I said.

"Where's it been written?" asked Gary.

"Well, it isn't all in one place." I replied.

"Well, now it will be," he said.

And that's how I got talked into considering the universe of video oriented multichannel power amps in particular, and such general issues in amplifier design that might have a bearing on that universe.

I guess I should begin by stating that the objections I expressed prior to accepting this assignment were quite sincere. In terms of circuit topology the evolution of power amplifiers has, to all appearances, slowed to a state approaching stagnation. Designers, at least for the most part, make no claims for fundamental innovation nowadays, and that includes folks like John Curl considered radical innovators in the past. Why, even the marketing bozos can't come up with anything suggesting pivotal breakthroughs anymore—no more New Class A, Superfeedforward, Zero Distortion Rule—none of the baffling nomenclatures we used to laugh at during the heyday of esoterica a dozen years ago while half hoping that something lay behind them.

To illustrate just how little has been happening in the field of late, I'd like to refer to an article I co-wrote with one Stephen Mantz (currently a consulting engineer with Citation) in 1985, and which was published in the June '88 edition of Audio.

After reviewing the historical evolution of solid state amplification, Mr. Mantz and myself concluded that amplifier design was essentially mature and unlikely to change significantly in the future, barring the development of radically different active devices. We also predicted, very presciently, that a market for vacuum tubes would continue to exist in 1995.

In conducting research for this article, I recontacted Mr. Mantz and asked him how he thought our predictions had held up over the years.

"Almost perfectly," he answered. "There's practically nothing new in circuit design since then. The only major change is in the transistors themselves. They've gotten much better. We were obviously right about tubes also."

Most of the other design engineers I've contacted agree in the main, though a few were willing to admit to exceptions—the Carver Lightstar and Sunfire amplifiers were repeatedly mentioned in this regard. But no one is suggesting that the amplifier design community is in the throes of a creative frenzy. Thus in considering contemporary design, to a significant extent we're covering old ground.

What Matters

Many of the stalwarts of the audio press corps have long maintained that all amps of a given power rating are pretty much equivalent and that therefore obtaining the most watts per dollar should be your guiding principle when shopping for power amplification. I am strongly opposed to that viewpoint. Amplifiers having the same nominal power ratings but hewing to different design principles do not exhibit identical behaviors, particularly when driving real world speaker loads, and thus the assumption of equivalence must be based upon the rather incredible proposition that listeners are unable to distinguish between what are often gross quantifiable differences in amplifier behavior.

I believe that rather than maintaining equivalence against all evidence to the contrary, we should focus on divergence. I further believe that if we carefully examine those measurable behaviors—or, more properly, misbehaviors—that tend to diverge from one amplifier to the next at the loudspeaker interface, we will not only establish that clear model to model distinctions exist within the category, but that we attempt to determine how these differences correlate with common perceptions of sound quality. At which point we can begin to develop a strong basis on which to compare different models of power amplifiers and to determine their suitability for use with the high performance speaker system of our choice.

Note that I said behaviors (plural). Ideally an amplifier should have only one behavior. It should replicate an input waveform perfectly in a load independent manner and at a set value of gain at every frequency of interest. The fact that none do this is what makes amplifier design a subject of enduring interest even if fresh approaches are in short supply at present.

Amplifier Misbehaviors

Amplifier misbehaviors have but one result, the alteration of the input waveform as it appears at the output of the amplifier. Such alterations reflect basic nonlinearities in the circuitry of an amplifier, a topic which will take up the second part of our discussion.

Alterations in the waveform take three forms: linear distortions, nonlinear distortions, and noise. In theory these three categories encompass every sort of misbehavior that can occur in an amplifying circuit.

Linear Distortion

A linear distortion is a frequency dependent variation in amplifier gain—that is, the circuit provides more gain at some frequencies than at others. Normally the gain of an amplifying circuit will fall off above and below certain frequency points while remaining relatively constant over a broad band of frequencies in between those points. Thus nonlinear distortion will tend to be most pronounced at the extremes of the amplifier's bandwidth.

And what are those corner frequencies likely to be? That will depend upon a number of factors including the type of active and passive devices used in the amplifier and the value of overall feedback employed in the circuit.

In the past, commonly available bipolar transistors—the output devices of choice for most designers for the last quarter century—had limited open loop bandwidth (intrinsic bandwidth prior to the closure of the feedback loop) to begin with, and the open loop response of the amp was further degraded by the use of compensating capacitors in the signal path which would roll off the response at frequencies well down into the audible range.

The rationale behind such compensating networks is well worth examining because it touches on several key aspects of circuit design. In simplest terms compensation is necessary because there exists an inverse correlation between the value of degenerative feedback and the permissible bandwidth in a circuit—any circuit. The reason that this is so is a little involved, so please bear with me for a moment.

Negative feedback, which I will discuss in great detail in a later section, is employed to reduce distortion and lower output impedance, thus serving a very useful function, contrary to high end prejudices. But since feedback reduces gain by the same measure that it reduces distortion, the circuit employing feedback must have open loop gain equal to the feedback in addition to the gain required for the individual circuit application. Thus, for instance, if we want a power amp to have a final gain of 25dB and at the same time we have to reduce distortion from 10 percent to 0.1 percent, which in itself requires 20dB of feedback, we will need an open loop gain of 65dB. Conversely, to get the distortion down to 0.01 percent, we must have 85dB of open loop gain. You get this kind of gain by either linking gain stages one after another in a "cascade," or by use of devices known as active loads, which increase the gain of individual stages. Unfortunately all this gain is had at a price, and the price is open loop bandwidth.

High values of gain reduce the permissible bandwidth of a circuit due to the relationship between loop gain and phase rotation within a feedback circuit, and since phase rotation itself is related to bandwidth, we have three interdependent variables. Here, briefly, is how they relate.

The output of any active device begins to undergo phase shift at the same frequency where the gain begins to drop. Now because negative feedback is simply a portion of the output shifted in phase 180 degrees, the feedback will be shifted more than 180 degrees at the frequencies above where the device's natural rolloff begins—in other words, it will begin to be shifted toward the positive. Positive feedback is destabilizing because it increases gain to the point of clipping and initiates oscillations, so the feedback must be attenuated completely before a complete 180 degree shift back to positive is effected, and that entails bringing the gain of the circuit down to unity at the point where complete phase rotation occurs. Essentially that requires compensating the circuit, that is rolling off the output with a capacitor, and the more gain the circuit has, the further down in frequency the rolloff must begin in order to kill the feedback before a complete phase reversal has occurred. Which creates a double whammy in respect to the bipolar because it tends to have relatively low bandwidth as is. In fact the cheap, high gain op amps used in the front ends of most receivers normally compensate the circuit starting at 100Hz and often as low as 10Hz, though the feedback itself will re-equalize the circuit by bringing down the low frequency gain even as the high frequency response is rolling off.

Such severe compensation is necessary to keep the high gain, high feedback amplifier stable in the higher reaches of the audible band, but it results in circuits with little high frequency headroom and rapidly falling power response above 20kHz. Many reviewers have argued that the performance of such designs is perfectly adequate, but they've tended to be rejected by critical listeners.

Interestingly, both power vacuum tubes and power MOSFETs greatly surpass the bipolars of the past in regard to power bandwidth, and have been favored by many in the high end on that account, but today a new generation of bipolars is available with full power bandwidth extending into the hundreds of kilohertz—equivalent to that of the best power MOSFETs of a few years back. Thus in solid state design there is no reason other than cost today for a designer to build an amplifier subject to a lot of out of band linear distortion—-unless that designer is shooting for ultra-low distortion numbers and sacrificing bandwidth through heavy compensation in order to achieve those numbers.

I would point out here that in the small world of vacuum tube design, a world of admittedly only limited relevance to home theatre, nonlinear distortion tends to be a big problem though for different reasons than was the case with the older bipolar amps. Power tubes themselves, with rare exceptions, have wide power bandwidth, in some cases extending well into the megahertz, but the transformers used to couple them with loudspeakers are severely bandwidth limited. Moreover, the transformer's secondary will normally have about a half ohm resistance as compared to a tenth of an ohm or less for a solid state design,

and this re-sistance combined with reactive elements in the speaker's im-pedance will create dip filters across the audio band. Even worse in this regard are OTL (output transformerless) tube amplifiers such as the Atmasphere and the Prodigy which normally have output impedances that are effectively several ohms and therefore will exhibit correspondingly greater linear distortions driving all but perfectly resistive speaker systems. In either case, the re-sulting colorations may well appear euphonic to many listeners, but they are distortions nonetheless, and, moreover, they are distortions that lie squarely within the audio band.

It might be noted that a couple of tube amps, the Wolcott Audio Presence and the Margules U-280-SC from Uruguay have special positive current feedback arrangements for reducing effective output resistance to zero, and thus do not suffer from such distortions, but such circuits are difficult to stabilize and are little used on that account. Thus to say that vacuum tube amplifiers are particularly prone to nonlinear distortion is a safe generalization.

Another aspect of linear distortion is phase shift over a given frequency range, this failing, as we have seen, being normally associated with variations in gain in adjacent

frequency bands. Well designed solid state amplifiers today exhibit negligible phase shift within the audio band and should be able to reproduce nearly perfect 10kHz square waves. The majority of vacuum tube amps measure poorly in this regard—-primarily as a result of deficiencies in the output transformer.

A phase anomaly which has particular relevance to sound quality is a phenomenon known as ringing whereby a circuit resonates and continues to emit a residue of frequencies from the exciting signal for some time after the signal has passed through the input of the circuit. On an oscilloscope ringing takes the form of a series of ripples impressed upon and following the test signal (square waves are frequently used to test a circuit's susceptibility to ringing since the phenomenon shows up so clearly on this type of waveform). Ringing is indicative of a complex, high Q, multi-pole filter somewhere in the circuit and does not speak well of the design.

The same tendencies toward instability

that generate ringing can give rise to a more extreme time domain anomaly known as oscillation where the amplifying circuit clips and recovers continuously in a positive feedback condition. In this mode the amplifier will emit a continuous tone at the frequency at which the oscillation itself occurs. The spurious tone emitted at oscillation constitutes an addition to the signal but is neither noise nor nondistortion (see below) in the strictest sense since it is neither random in nature nor closely correlated to input signal. Oscillation may afflict either solid state or tube circuits.

Nonlinear Distortion

Nonlinear distortion, the second major type of amplifier misbehavior, occurs when the waveform is augmented with additional tones not present in the input signal, but mathematically correlated to it, these augmentations occur due to dynamic variations in gain and represent amplitude modulations of the signal. All active devices, vacuum tubes, bipolars, and MOSFETS, produce plenty of intrinsic nonlinear distortion, normally at several percent of the signal amplitude, and to a considerable extent circuit engineering represents a range of techniques for reducing such distortion.

Nonlinear amplifier distortions take several forms, the most common being harmonic distortion and intermodulation distortion. Amplitude modulation of a single frequency creates harmonic distortion where distortion products are multiples of the fundamental of the signal, while modulation of two or more frequencies simultaneously creates sum and difference tones in addition to the harmonics.

Harmonic and intermodulation distortion are present in all power amplifiers, commonly at levels below a tenth of a percent in solid state equipment. Intermodulation distortion is generally deemed more offensive, and high values—a half a percent or more—should be viewed with suspicion.

Harmonic distortion components, as the name suggests occur at one octave intervals above the fundamental frequency. The relative intensity of these components has a major bearing on the perceived sound quality of an amplifier, and a decrease in amplitude as the number of the harmonic rises is usually considered desirable.

By themselves the different harmonics are variously perceived as consonant, veiling, and discordant—with the first attribute associated with second and fourth harmonics, a veiled or hooded sound quality with the third harmonic, while harshness and stridency are perceived in the presence of all of the others. Triode vacuum tubes, alone among active devices, exhibit a subjectively pleasing distortion spectrum, a fact which has prompted many tube designers to err on the side of euphonic colorations and engineer their circuits to retain most of the inherent distortion of the devices. In contrast, solid state designers generally try to reduce distortion components considerably.

Another form of distortion termed subharmonic distortion is also known to exist and is mentioned in the technical literature, though tests for its presence are almost never made on audio frequency circuits. Subharmonic distortion consists of additional tones below the signal frequency and on that account it should be especially audible. I've not been able to find a discussion in the literature of the mechanism(s) responsible for subharmonic distortion, but this type of distortion has been described in relation to solid state r.f. circuits where it is manifested in the form of spurious sidebands. I suspect that subharmonic distortion has audible consequences in solid state audio circuits.

Noise

Noise, yet another typical form of circuit misbehavior, consists of additional tones that are random and uncorrelated to the signal. Noise is generally treated as a unitary entity in audio electronics, but one perhaps can argue for the existence of subspecies called quantization noise which is commonly discussed in reference to digital switching circuits but is said to exist at very low signal levels in analog amplifiers as well.

Noise in general is broadband, but it is usually spectrally skewed, and the spectral distribution of noise components often serves as a marker for the identification of an audio device. Tubes in general produce noise of a distinctly different spectral balance than the noise of solid state devices.

Finally the degree to which the noise is modulated by the signal, that is, increases in proportion to the signal level on a dynamic basis, is also significant in determining the sound of a given circuit. Normally in a well designed circuit, noise will decrease proportionally with the signal level up to the point of overload, but in certain circuits the opposite condition known as noise modulation will manifest itself, imposing a distinct coloration on the sound.

Noise, as the folks at Lucasfilm have pointed out, tends to be a significant problem in multichannel amplification because the noise of all five channels will sum acoustically and create an audible background during no signal conditions. Thus noise standards for multichannel amps should probably be more stringent than for stereo models.

Circuits Passing Waveforms

When we speak of amplifier misbehavior in terms of distortions and noise we refer simply to waveform anomalies at output. Such anomalies are symptoms; they tell us little of what is transpiring within the circuit except that is failing to replicate the input signal accurately.

In order to understand how such inaccuracies arise we have to look at the circuits themselves both in terms of the way that the parts of the circuit relate to one another and in terms of the circuit's relationship to the outside world represented by the input, the powerline, and the speaker load.

Enumerating and describing all of the various types of circuits used as building blocks for audio power amplifiers would require a fair sized book. Fortunately my aim is more modest. I seek nothing more than to identify those aspects of design related to high performance as well as to block out in the most general terms how a power amplifier circuitry hangs together. Describing these

fundamental aspects of design is sufficient, I believe, to permit meaningful discussion of amplifier performance under load as well as to provide a basis for comparing the various models under consideration and the circuit topologies that they utilize.

The Primacy Of The Output

Most textbooks describing amplifier operation take a global view of circuit architecture, but I think that in order to comprehend the performance requirements of a high fidelity power amplifier and how they may be met through appropriate technology, it's better to concentrate on the output stage. That's because the accuracy of the amplifier may be determined absolutely by the voltages impressed across the amplifier's output terminals measured from moment to moment as the amplifier produces an alternating current waveform, and, coincidentally because the output stage is generally where the amplifier is going to manifest the most severe problems.

At the output of a power amplifier the positive and negative terminals of the amp form the poles of a circuit which is closed by the loudspeaker, and this total amplifier-loudspeaker circuit is referenced back to the amplifier's own signal and power grounds. The power supply, which is a reservoir of electrical energy for the signal circuitry, enables the amplifier to establish the correct electrical potentials across the impedance of the loudspeaker at the output terminals, and ideally these potentials will exactly track the rise and fall of the voltage potentials at input, though the magnitude of voltage swing will, of course, be much greater at output.

The output devices themselves function in a sense as voltage regulators, though unlike the regulators in a power supply they do not hold output voltage to constant value but instead follow, more or less exactly, the swings of the input voltage. The ability of the output stage to set the correct voltage instantaneously in order to replicate with a high degree of accuracy the rise and fall of the input waveforms is largely a function of three aspects of the output circuit. These are the intrinsic linearity of the devices themselves below saturation, their current capabilities which establish the point of saturation, and the storage capacity of the power supply itself.

Linearity: So much voltage at input gets you so much voltage at the output terminals into a constant load. We want to see a straight line relationship and that's why we use the term linearity.

Current Capability: We all know Ohm's law, and we know that current must increase across a fixed or falling resistance to meet increasing power demands. If the load is at all capacitive, current must increase still further to charge the capacitance while maintaining the requisite voltage at the terminal. Active devices, whether they be bipolars, MOSFETs or tube are individually rated as to the amount of current they can pass, and the current limitations of the devices themselves determine the amount of current the amplifier can dump into the speaker load.

Power Supply Capacity: A power supply consists primarily of a bank of capacitors. Essentially capacitors are akin to batteries except they are designed to discharge and recharge very, very rapidly. The charges stored in these capacitors provide the current that the output devices pass. The capacity of the power supply capacitors has just as great a bearing on the current capabilities of the output stage as do the ratings of the active devices themselves.

[Editor's Note: Next newsletter, Daniel examines each of these factors a little more closely to see how they relate to modern circuit design.]