

A Concise Guide to the Published Amplifier Circuits of Nelson Pass

© Brian Willoughby, Sound Consulting

Nelson Pass has over a half of a dozen patents covering audio inventions. He has also published a few dozen articles featuring power amplifier circuits, a couple in conjunction with other authors. Most of these publications concern power amplifier designs, but some are about preamplifier circuits, phono preamp circuits, crossovers, or even physical speaker construction. Since all of the articles are available freely, there's really no reason not to read them all. They are each full of many useful tidbits of his experience, and sometimes introduce totally new concepts while at other times refining existing techniques to new levels. But if you're itching to build your own power amplifier, and want to know where to start, then it seems like some sort of guide would be helpful to point to the relevant articles. Even if you have read all of the articles, it helps to have an index of sorts to the various pieces of technology covered in each. This text hopes to provide such a guide.

The first list will be individual topics of interest, followed by all of the articles that touch on the given topic. Note that a given design may not actually use the technology listed, but the cited article will at least discuss it in contrast to the specific implementation. Sometimes it's a little difficult to say whether a given design is single-ended or push-pull, balanced or unbalanced, with or without feedback - at least when the article mentions modifications to achieve either. Abbreviations for the articles will be used which hopefully correspond to the DIY Audio community standard abbreviations where possible. Afterward, a chronological list of articles is provided for a historical perspective.

For the sake of consistency, phono and speaker articles are excluded, as are articles that appear on the Pass Laboratories site from other authors. Although not technically considered 'amplifiers,' the preamplifier circuits are included simply because it might make sense to build some of the preamp circuits as the input gain stage of an amplifier. Some of the First Watt schematics may be missing from the list, particularly the ones that do not offer balanced inputs.

April, 2011

Technology Index:

Balanced Input:

A75, BOZ, SOZ, BOSOZ, SUSY, DOA, ZV1, ZV3, ZV4, XA, F1, ZV6, ZV7, PLH, BA1, BA2

Today's high-end DAC outputs are balanced, and generally demand a balanced-input amplifier for optimum performance.

Current Sources:

CAA, A40, A75, ZEN, ROZ, BOSOZ, DOA, POW, ZV2, XA, F1, ZV7, F2, PLH, ZV9, B1B, BA1, BA2

Class A amplifiers can be biased in one of three ways: resistors, constant current sources, or bias voltage source. Current sources are more efficient than high power bias resistors, but less efficient than a bias voltage source. Zen Variation 2 focuses on the many current source circuits.

Floating Bias Supply (Aleph):

ZV2, XA, ZV4, ZV9

U.S. Patent #5,710,522 covers the Aleph current source. Zen Variations 2, 4 & 9 discuss the circuit.

Super Symmetry Output Stage:

SUSY, XA, F1?, ZV6, ZV7 (FIG 8)

U.S. Patent #5,376,899 covers a balanced output stage power amplifier with feedback to cancel distortion. Zen Variations 6 and 7 give example circuits. I put the F1 on the list because it looks like it might be possible to convert it to Super Symmetry.

Single-ended Output Stage:

CAS, ZEN, ROZ, BOZ, SEA, SOZ, BOSOZ, DOA, POW, ZV1, XA, F1, ZV6, ZV7, F2, ZV8, PLH, ZV9, LEAVE, B1B, DIST, BA1, SWEET, DLT

Single-ended output stages perform similar to the atmosphere where we listen to music. They are less efficient than push-pull stages, but require fewer parts (unless used as a balanced pair of single-ended stages, or in super symmetry). Biasing is possible with high power resistors or constant current sources. Distortion is primarily second harmonic.

Balanced Single-ended Output Stages:

ZV1, ZV2, ZV4, XA, F1, ZV6, ZV7

Balanced single-ended output stages share characteristics of single-ended and push-pull output stages. They require up to twice the active components as a single-ended stage, and are the base for super symmetry. Distortion is primarily third harmonic.

Complementary / push-pull Output Stage:

A40, CAS, C12, A75, ZV5, F5, PLH, LEAVE, DIST, BA2, SWEET

The most efficient Class A amplifier design uses a pair of complementary transistors with a bias voltage source. Crossover distortion is a potential issue, as is the option to run the circuit in Class AB mode. Distortion is primarily third harmonic.

Current Output Stage:

F1, F2

Nearly all amplifiers are voltage output circuits employing feedback to control the wildly varying current as the complex speaker impedance reacts to this voltage. A current output amplifier gives a speaker driver exactly what it needs to reproduce the waveform, so that the voltage can be ignored. See related articles on Current Source Amplifiers, Crossovers, and Full-Range Drivers.

Cascode Circuits:

CAS, A75, SUSY, DOA, MOS, ZV8, ZV9, BA2, SWEET

Cascode circuits take some of the heat off of active transistors, but are less efficient. Start with the first article in this list, which is dedicated to the topic. Other articles may only mention cascode as an optional modification.

Bipolar (BJT) Power Transistors:

CAA, A40, CAS, C12, A75, PLH

For those who are interested in BJT designs, a few of the early articles cover this technology. The MOSFET Citation 12 article is obviously focused on retrofitting MOSFET power transistors into an old design, but the context of the original BJT design might be interesting to see. Part 1 of the A75 articles also discusses a BJT design. The PLH article is the most recent to discuss an FET redesign of a BJT circuit.

FET (MOSFET, JFET) Power Transistors:

C12, A75, ZEN, ROZ, BOZ, SOZ, BOSOZ, DOA, ZV#, XA, MOS, F1, F2, F5, PLH, LEAVE, DIST, BA#, SWEET, DLT

Nearly all of the Pass designs except the very oldest are based on FET power transistors.

JFET Input Stages or Output Stages:

C12, DOA, F1J, F2J, F5, ZV8, ZV9, B1B, DIST, BA1, BA2, SWEET, DLT

JFET inputs are perhaps more of a concern with preamplifiers, but they are worth considering anywhere that high input impedance is needed.

Negative Feedback (NFB):

CAA, A40, CAS, C12, A75, ZEN, ROZ, SUSY, DOA, POW, ZV1, ZV2, ZV4, XA, MOS, ZV5, F1, F5, ZV6, ZV7, ZV8, PLH, ZV9, DIST, BA1, BA2, SWEET

There is nothing wrong with negative feedback in a well-designed amplifier. The worst issue with NFB is when it is used as a crutch to prop up poor or cheap designs. Note that many Nelson Pass designs incorporate some amount of feedback, and the patented super symmetry requires feedback in order to work. By the way, Positive Feedback causes circuits to explode, so you probably won't see it in a power amplifier.

Power Supply:

POW, XA, ZV9

Nearly every article has at least a basic power supply circuit. Some articles have incremental improvements or advanced techniques. The first on the list is an article from 2001 commenting on power supplies from a consumer perspective.

Single Rail (unipolar) Power Supply:

ZEN, ROZ, BOZ, ZV1, ZV4, F1, DLT

Single-ended and Super Symmetry only need one supply voltage.

Split Rail (bipolar) Power Supply:

CAA, A40, C12, A75, SOZ, BOSOZ, ZV3, ZV5, F5, BA1, BA2

Complementary output stages basically require split power rails, but single-ended amplifiers can also use them (see BA1). ZV3 is dedicated to active supply regulation.

Preamplifiers:

BOZ, BOSOZ, B1B

Fair game for inclusion as the front end of any (non JFET?) amplifier which needs help with input impedance.

“Crazy” Circuits:

ZV1, DLT

Amplifiers that use standard, incandescent light bulbs!

misc.:

Articles covering soldering, troubleshooting, repair, transistor matching and selection. There is also an article on modernizing the 1978 A-40 with Y2K parts.

Chronology with Abbreviations for Articles and Manuals:

1976/11/30	3,995,228	Active Bias Circuit for Operating Push-Pull Amplifiers in Class A Mode	
1977	CAA	Build a Class-A Amplifier	
1978/8/15	4,107,619	Constant Voltage - Constant Current High Fidelity Amplifier	
1978	A40	The Pass A-40 Power Amplifier	
1978	CAS	Cascode Amp Design	
1981	C12	Build a MOSFET Citation 12	
1988/6/21	4,752,745	Opto-Isolated Bias Circuit for Operating Push-Pull Amplifiers in Class A and Class AB Modes	
1992	A75	A75 Part 1 and Part 2	Aleph series
1993		How To: Matchings Devices:	
1994/8/30	5,343,166	Efficient High Fidelity Audio Power Amplifier	
1994	ZEN	The Pass Zen Amplifier: 10 Watts of Single-Stage Single-Ended Class A	
1994	ROZ	Return of Zen	
1994	BOZ	Bride of Zen	
1994/12/27	5,376,899	Amplifier with Gain Stages Coupled for Differential Error Correction	
1995	SEA	Single-Ended Class A	
1997	SOZ	The Son of Zen Amplifier	balanced
1997	BOSOZ	Balanced Zen Line Stage	Gerbers
1998	SUSY	Super Symmetric Amplification	
1998/1/20	5,710,522	Amplifier Having an Active Current Source	
1998	DOA	D.I.Y. Op Amps	
2000		A40 Part Substitutions	see A40
2001	POW	Power Supplies: Commentary for Consumers	
2001/12/1	ZV1	The Zen Variations - Part 1: Zen-lightenment	
2002	ZV2	The Zen Variations - Part 2: The Penultimate Zen's Current Source	
2002	ZV3	The Zen Variations - Part 3: Active Supply Regulation	
2002	ZV4	The Zen Variations - Part 4: The Penultimate Zen	Gerbers
2002	XA	Like Peanut Butter and Chocolate	
2003	MOS	MOSFET Testing	
2003	ZV5	The Zen Variations - Part 5: The Complementary Zen	
2004	F1	First Watt F1 Service Manual	
2004	ZV6	Zen Variations 6: Son of Zen gets Xploited	
2004	ZV7	Zen Variations 7: More fun with Son of Zen and SuperSymmetry	
2005	F2	First Watt F2 & Aleph J Manual	no schematic
2005	ZV8	The Power JFET Amplifier - Zen Variations #8	
2005	PLH	The PLH Amplifier: The classic JLH - Pass style	
2005		First Watt F3 Manual	see ZV9
2006	ZV9	Zen Variations #9	
2008	LEAVE	Leaving Class A	
2008/6	B1B	The First Watt B1 Buffer Preamp	Gerbers
2008/5/24	F5	First Watt F5 Service Manual	
2008/11/1	DIST	Audio, Distortion and Feedback	
2009/1/22	BA1	Burning Amplifier #1	
2009	BA2	Burning Amplifier 2	
2009		First Watt J2 Manual	simplified
2009/10/10	SWEET	The Sweet Spot	
2010	DLT	De-Lite Amplifier	