



**X1000.5**

**X600.5**

**X350.5**

**X250.5**

**X150.5**

**XA200.5**

**XA160.5**

**XA100.5**

**XA60.5**

**XA30.5**

**X.5 Series**

**XA.5 Series**

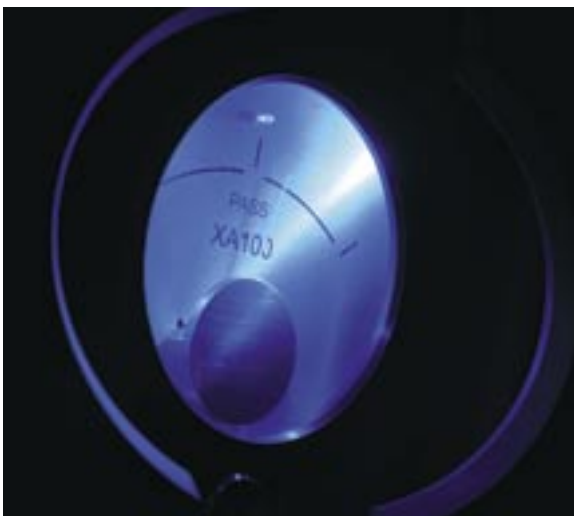
## Origin of the X amps.

In 1993, US Patent # 5376899 described an amplifying circuit that takes advantage of the character of matched balanced amplifiers cross-coupled to cancel distortion and noise. Called Super-Symmetry, it uses the complementary characteristics of balanced circuits to reject identical distortion and noise across the loudspeaker load without the need for feedback. It also extends this concept by using a small amount of feedback to make the non-identical distortion and noise more identical, finishing the job of cancellation.

As with the art of Aikido, the X circuit works with the intrinsic character of a balanced circuit and deftly turns that character toward perfection.

Super-Symmetry does not use the operational amplifier paradigm. The topology is that of a balanced gain circuit having two output terminals driving either side of the loudspeaker and two negative input terminals operating at virtual ground.

Super-Symmetry is ideally used to obtain high quality performance from very simple circuit topologies. This is important because there is a different character of sound attributed to simple linear circuits versus complicated circuits that obtain



their performance through the generous use of feedback.

It is difficult to produce high power amplifiers with simple circuits, and previous efforts have often been described as accurate but musically sterile. Super-Symmetry makes it easy to produce high quality kilowatt power amplifiers with the musical characteristic and stability of simple low power amplifiers.

"X" amplifiers offer the power, control and dynamic range of conventional big amplifiers, but they also retain the sensitivity and warmth found in the small amplifiers favored by many audiophiles.

The first example of this design is found in the Pass Labs X1000. Introduced in 1998, the amplifier delivered 1000 watts rms into 8 ohms. Competing amplifiers used as many as nine gain stages and tons of global feedback. The X1000 matched or beat their performance with two gain stages and a small amount of local feedback.

The following two years saw the introduction of several X amplifiers of lesser power, supplanting the Aleph products originally developed in 1991. The Aleph circuit, however, was to find a new use.

## XA amplifiers

Sometimes two designs complement each other so well that you are surprised they weren't invented together. So it was with the X Super-Symmetric amplifier and the Aleph single-ended Class A output circuit.

The Super-Symmetric (X) circuit demonstrated the possibilities for very high power, dynamic contrast, and effortless control by a simple circuit utilizing absolutely minimal feedback. The Aleph single-ended Class A amplifiers have outstanding sonic definition, warmth, and smoothness.

The two design concepts are not mutually exclusive, and in 2002 we approached the development of the XA series with an eye to creating a warmer/sweeter X amplifier, or conversely, a more powerfully dynamic Aleph. The result is a circuit which is described as balanced single-ended Class A, consisting of two balanced Aleph amplifiers sharing an X front end.

Pure Class A amplifiers, the XA's operated at approximately 33% efficiency - that is to say they idle at three times their rated output. This limited the maximum practical power available; for example the same hardware that delivered 1000 watts in the X1000 is the same as the 200 watts of the XA200.

By the nature of single-ended Class A, the

maximum available output current was strictly proportional to the idle bias current. As a result, original XA amplifiers provided less power into low impedance loads, not more.

Within these limitations, the early XA amplifiers offered significant improvements. They retained the warmth and lushness of the Aleph series without fluffy coloration, and had even better dynamic contrast than the X series. For a reasonably efficient loudspeaker with a load impedance above 4 ohms, the XA amplifiers have been the best choice for five years running.

### **X.5 and XA.5 Amplifiers**

Pass Labs continues to improve its power amplifiers through on going R&D. After





five years, these improvements acquired enough mass to warrant a change in designation, and in 2003 the X.5 series was announced. The improvements are:

Cascode JFET Symmetric front end – input differential MOSFETs have been replaced by the same JFETs we use for the input devices on our MM and MC phono stages. They have very much less noise, higher input impedance, and greater linearity. They operate self-biased in a symmetric quad topology, each device cascoded and level shifted to form the full voltage gain stage of the amplifier.

More power output devices – Greater quantities of matched complementary power Mosfets operated as followers, giving more current and power handling, and also improved linearity.

Single-ended Class A bias – The output stage not only uses a heavy bias current

for push-pull Class A operation to a large portion of the rated power, but also has a single-ended bias source for single-ended Class A at low wattage.

New bias circuit – A newly developed bias generator has eliminated three sources of variation in bias current in the output stage. It also allows approximately 20% greater power output for a given supply voltage.

Improved power supplies – The power supplies have been given greater storage capacitance, larger / quieter power transformers, fast recovery rectifiers (twice as many), and improved harmonic filtering in both the primary and secondary supply circuits.

Better layout – All portions of the amplifier circuitry have been refined with respect to wiring and circuit board layout so as to achieve lower noise and distortion and greater reliability and serviceability.

**These refinements improve the measured performance in the following key areas:**

Lower distortion – The X.5 circuits achieve lower distortion at all power levels and into all types of loads, particularly in the all-important audio midrange.

Greater control – The large heavily biased follower output stages have an intrinsically low output impedance, giving consistently high damping under all load and signal conditions.

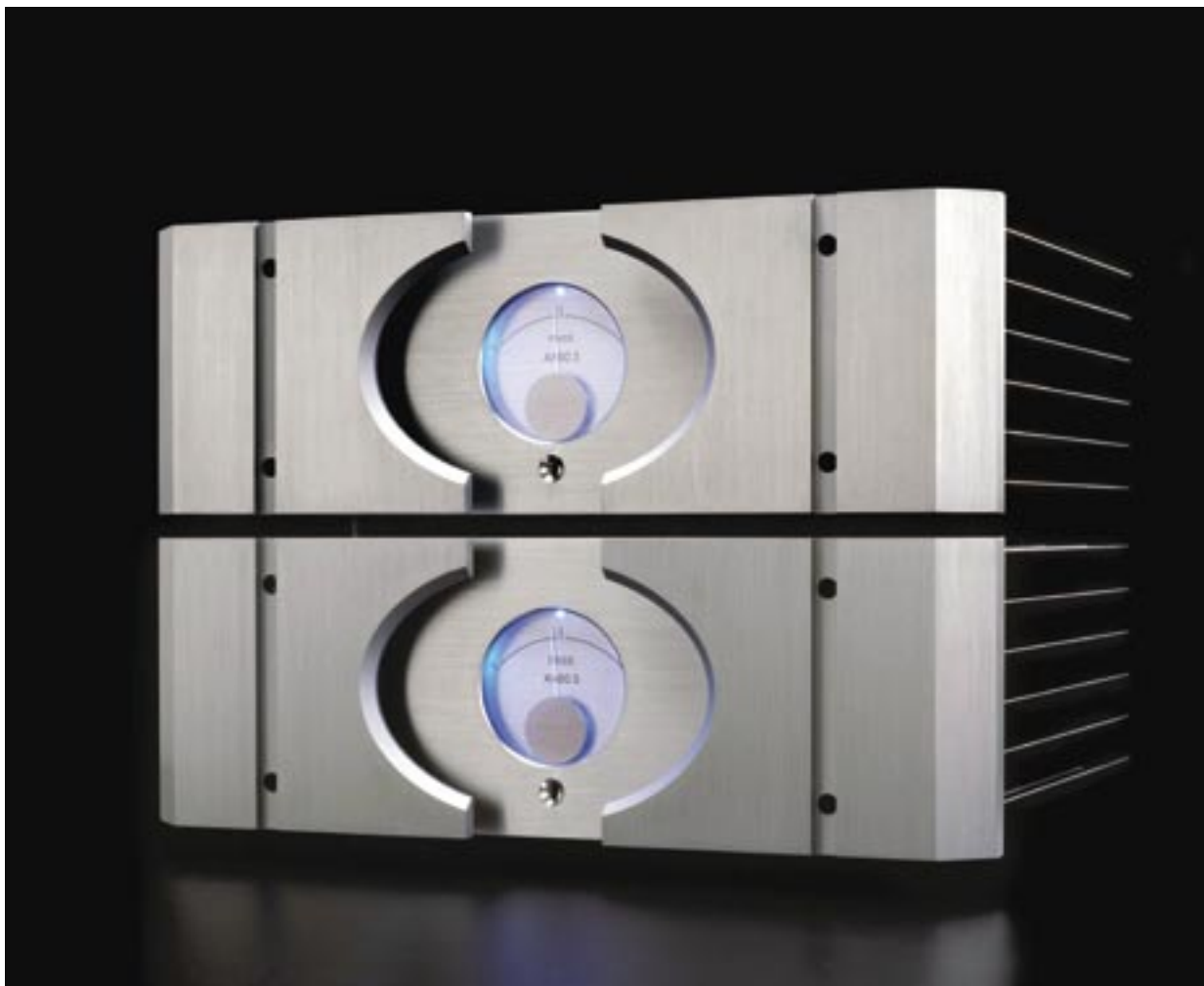
Greater stability – The X.5 circuits do not use any form of high frequency compensation; no little frequency rolloff or lag capacitors, no output coils, no Zobel networks, nothing. The amplifiers are stable because they are simple gain stages with minimal feedback.

Lower noise – the X.5 series has about 1/10 the noise from the audio to the radio frequency spectrum. The circuits are very immune to environmental noise, and mechanical transformer noise has been reduced even for bad AC lines.

Better bias control – The idle current of the amplifiers is dramatically more constant against variations in temperature, and line voltages, and signal transients. There is also reduced warm-up time to optimal performance.

Higher efficiency / More power – The circuits deliver approximately 20% more output power by operating at 20% greater efficiency.

Greater reliability – These amplifiers are harder to break, and are easier to repair if they do.



The newly introduced XA.5 series incorporates all of these improvements and also operate pure Class A. The distortion is even lower, the control is even better.

More importantly, the XA.5 amplifiers have tremendously larger output current capacity over their corresponding XA models – **more than five times the current** – which is more than 25 times the power into very low impedance loads. Very difficult loudspeakers are now very appropriate loads for XA.5's.

**Sonically the result is:**

Greater power and control – No matter what your loudspeaker, the X.5 and XA.5 power amplifiers have the power and sta-

bility essential to deliver the music without strain. They have the dynamic range to do justice to the 24 bit recordings of the 21<sup>st</sup> Century and the elegance to retrieve the micro dynamics offered by the most sensitive loudspeakers. This simplicity and power moves easily from total silence to explosive transients with ease and without information loss.

More music - These are not simply good high power amplifiers. They have been designed by lifelong audiophiles to deliver the warmth, sweetness, depth and space that are the hallmarks of fine audio products. Most importantly in this regard, the X.5 and XA.5 amplifiers are significant improvements on their classic predecessors.

	X150.5	X250.5	X350.5	X600.5	X1000.5
Gain (dB)	26 / 30	26 / 30	26 / 30	26 / 30	26 / 30
Sensitivity @ 26 dB gain (V)	1.73	2.24	2.65	3.46	4.47
Low Frequency Response	1.5 Hz	1.5 Hz	1.5 Hz	1.5 Hz	1.5 Hz
High Frequency Response	100 KHz	100 KHz	100 KHz	100 KHz	100 KHz
Power Output /ch (8 ohm)	150	250	350	600	1000
Distortion, (1 KHz, full power)	1%	1%	1%	1%	1%
Maximum Output (Volts)	50	64	76	99	127
Maximum Output (Amps)	18	20	28	36	48
Input Impedance (Kohms)	30 / 20	30 / 20	30 / 20	30 / 20	30 / 20
Damping Factor	150	150	150	200	200
Slew Rate (V/uS)	50	50	50	50	50
Output Noise (uV)	200	200	200	200	200
Input CMRR (dB)	-60	-60	-60	-60	-60
DC Offset (V)	0.05	0.05	0.05	0.05	0.05
Leaves Class A at pk Watts:	10	15	40	80	80
Power Consumption (W)	200	300	600	600	700
Temperature (deg C.)	53	53	53	53	53
Dimensions (W x H x D)	19 x 7 x 19	19 x 9 x 21.5	19 x 11 x 21.5	19 x 11 x 21.5	19 x 11 x 28
Ship Weight	75 Lbs	110 Lbs	150 Lbs	150 Lbs	200 Lbs



US005376899A

**United States Patent** [19][11] **Patent Number:** **5,376,899**

Pass

[45] **Date of Patent:** **Dec. 27, 1994****[54] AMPLIFIER WITH GAIN STAGES COUPLED FOR DIFFERENTIAL ERROR CORRECTION**[75] **Inventor:** Nelson S. Pass, Foresthill, Calif.[73] **Assignee:** Pass Laboratories, Inc., Foresthill, Calif.[21] **Appl. No.:** 192,173[22] **Filed:** Feb. 4, 1994[51] **Int. Cl.<sup>5</sup>** ..... H03F 3/45[52] **U.S. Cl.** ..... 330/253; 330/69[58] **Field of Search** ..... 330/69, 253, 255, 264, 330/277, 124 R**[56] References Cited****U.S. PATENT DOCUMENTS**

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*Primary Examiner*—Steven Mottola*Attorney, Agent, or Firm*—Schneck & McHugh**[57] ABSTRACT**

An amplifier circuit having two identical inverting fold-

ed-cascode amplifier stages coupled together through a coupling resistor at the positive terminals of the respective stages. Each stage includes an input gain transistor whose gate forms the negative input terminal of the amplifier stage coupled to receive an input signal through an input resistor, whose source forms the positive input terminal of the amplifier stage, and whose drain is connected to the source of a level-shifting cascode transistor. Both transistors are supplied current from a constant current source also connected to the source of the level-shifting transistor. The drain of the level-shifting transistor forms an output terminal of the amplifier stage. Each stage feeds its amplifier output negatively to the positive input of the other stage, while at the same time feeding its distortion and noise contribution positively, via input gain transistor conduction, to the other stage. Balanced amplified outputs are produced from either balanced or unbalanced inputs, and distortion and noise components are produced in common on both outputs for differential cancellation. Complementary-symmetry and power amplifier versions of the basic single-ended line-level amplifier are also provided.

**13 Claims, 7 Drawing Sheets**

XA200.5	XA160.5	XA100.5	XA60.5	XA30.5	
26	26	26	26	26	Gain (dB)
2.00	1.79	1.41	1.10	0.77	Sensitivity @ 26 dB gain (V)
1.5 Hz	1.5 Hz	1.5 Hz	1.5 Hz	1.5 Hz	Low Frequency Response
100 KHz	100 KHz	100 KHz	100 KHz	100 KHz	High Frequency Response
200	160	100	60	30	Power Output /ch (8 ohm)
1%	1%	1%	1%	1%	Distortion, (1 KHz, full power)
58	52	41	32	23	Maximum Output (Volts)
48	36	28	20	18	Maximum Output (Amps)
30 / 20	30 / 20	30 / 20	30 / 20	30 / 20	Input Impedance (Kohms)
200	200	200	150	150	Damping Factor
50	50	50	50	50	Slew Rate (V/uS)
200	200	200	200	200	Output Noise (uV)
-60	-60	-60	-60	-60	Input CMRR (dB)
0.05	0.05	0.05	0.05	0.05	DC Offset (V)
400	320	200	120	60	Leaves Class A at pk Watts:
700	600	300	200	200	Power Consumption (W)
53	53	53	53	53	Temperature (deg C.)
19 x 11 x 28	19 x 11 x 21.5	19 x 7 x 19	19 x 7 x 19	19 x 7 x 19	Dimensions (W x H x D)
180 Lbs	150 Lbs	110 Lbs	75 Lbs	75 Lbs	Ship Weight



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