

How to upgrade your 1st Gen Klipsch Jubilees to 2nd Gen (Heritage) Jubilee Acoustic Performance

This is aimed at those owners and potential future owners of first-generation Klipsch Jubilees that want to upgrade them to meet and/or exceed the acoustic performance of second-generation Jubilees.



Figure 1 Second-Gen and First-Gen Jubilees, Side-by-Side in Hope Arkansas Listening Room Next to Anechoic Chamber

The following areas of acoustic performance will be discussed below for upgrades:

- 1. A short description of the first-generation Jubilee**
- 2. The 2" compression driver and optional output phase plug extension**
- 3. Extending bass performance down to 16-18 Hz (-3 dB)**
- 4. DSP crossover upgrade (hardware and software tweaks) to achieve flattened phase and excess group delay**

[This thread does not deal with improving the visual appearance--which of course can be achieved via several approaches, as evidenced by the second-generation Jubilees (shown above to the left).]

For reasons unknown, the first-gen Jubilee has been retroactively dubbed the "Underground Jubilee" after production had ceased. We will continue to call them "first-gen Jubilees" in this document. This was the original home version two-way Klipsch Jubilee, then available via special order through an

existing pro-cinema dealer (American Cinema Equipment) until discontinued by Klipsch due to the introduction of the much higher priced “Heritage Jubilee”.

Physical and price data on the two Jubilee versions:

Jubilee version	Price (New)	Weight (per pair)	Dimensions
First (“Underground”)	\$6.8K (less DSP)	500 lbs. (277 kg)	41.5” W x 24.5” D 105 cm W x 62 cm D
Second (“Heritage”)	\$35K+ (with fixed DSP)	816 lbs. (370 kg)	50.25” W x 30.25” D 127 cm W x 77 cm D

A short description of the first-generation Jubilee

The first gen Jubilees were actually a kit--integrated via DSP crossover by the customer--who was also responsible for inputting the preset data for the PEQs, delays, channel gains, and crossover filters. A small handful of Jubilee owners had built passive balancing/dividing networks, but passive hi-fi implementations as designed by Klipsch cost in excess of \$3500 in component and materials alone, are *very* large, do-it-yourself, and, most importantly, lack time alignment of the bass bin to the HF horn/compression driver. They also must be completely redesigned if the owner decides to change compression drivers.

Notional DSP crossover preset files for the stock compression drivers and bass bins were provided via spreadsheet around the time of delivery, which was via drop-shipment from Hope, AR.

Over the years, at least one other compression driver (TAD TD-4002) was offered on special order through a third-party supplier. These drivers were EQed with the K-402 horn in the anechoic chamber in Hope and the resulting 4002-specific DSP presets made available to Jubilee owners.



Figure 2 A single passive first gen Jubilee crossover

First Gen Jubilee 2” Compression Driver History

The original 2” compression driver provided with the initial purchase was the Klipsch K-69-A, which is a modified-phase-plug P.Audio BM-D750 driver. This was a “good enough to get started” compression driver with a 2” titanium-dome diaphragm. This driver experiences fairly audible dome diaphragm breakup (non-pistonic motion) above 14 kHz, which can be heard using a recording with conspicuous ride cymbal accompaniment such as that used in bebop jazz. Klipsch DSP crossover support for this compression driver included text-based DSP settings support for either an ElectroVoice Dx38 DSP crossover or Crown DSP amplifiers (XTi 1000).

About two years later, TAD TD-4002 drivers were offered via a group buy option (about \$1600 USD for each driver, \$3200 for a stereo pair in 2009). These drivers represented a large leap in acoustic performance over K-69-A drivers. However, due to the price, perhaps only about nine of the first gen Jubilee owners opted to buy the beryllium-dome drivers. (This driver is still unsurpassed in terms of its subjective sound quality, and in any discussion of upgrading the compression driver in the following text, it should be understood that, to date, there are no “upgrades” in compression drivers from the TAD TD-4002, now discontinued.)

Later, the K-69-A driver was replaced in the special-order two-way Jubilee (the home hi-fi version) with the Klipsch K-691 driver, a phase-plug modified B&C D-75 2" driver. The performance of this driver above 14 kHz was better than the K-69-A, but dome diaphragm breakup is still audible from its 2" exit titanium dome design. This was the compression driver that was used until the discontinuation of the first gen Jubilee in mid-2022 when the new second gen Jubilees began shipping.

New 2" Compression Driver/Phase Plug Extension for the Second Gen Jubilee

The second gen Jubilee uses an unmodified Celestion Axi2050 2" compression driver on a K-402 horn ([more about this combination here](#), including DSP settings and measurements), crossed at 350 Hz.



Figure 3: Celestion Axi2050 Driver mounted on K-402 Horn

There is an added “phase plug extension” between the driver’s exit and the horn throat entrance. This device helps to widen the polar output of the Axi2050 driver on the K-402 from 6.8 kHz-14 kHz. The 6.8 kHz frequency corresponds to a half-wavelength fitting across the 2" horn throat entrance—at which point compression driver output will tend to become detached from the horn walls and begin to beam. A free 3D printer file approximating this plug geometry is available for local 3D printing:



Figure 4: 3-D Printed Phase Plug Extension

A 3D print file is embedded, below:



Figure 5: 3D print file of Phase Plug Extension

Other 2" compression drivers can also be used to upgrade the first-gen Jubilee. The Radian 950BePB (beryllium dome diaphragm) goes for about the same price as the Celestion Axi2050 and will have a bit more sparkle on the high end than the Celestion, but have an octave higher high-pass frequency on its low end (~550 Hz).



Figure 6: Radian 950BePB Beryllium Dome Driver

Another driver worthy of consideration is the BMS 4592ND (dual diaphragm) driver. Bi-amped/dialed in, this driver will turn your Jubilees into three-way loudspeakers. The BMS driver also has the distinction of being able to sustain very high SPL for PA duty because of its dual diaphragms (separate diaphragms for

treble and midrange) and their ring radiator design, which precludes audible non-pistonic diaphragm motion (chattering):



Figure 7: BMS 4592ND Dual Diaphragm Ring Radiator Driver

The BMS 4592ND does require bi-amping in order to provide the necessary one wavelength of time delay at crossover on the high frequency diaphragm relative to the lower frequency midrange diaphragm to time align its two diaphragms.

Both of the above alternative drivers will sound very similar to the TAD TD-4002 (beryllium dome) compression driver when they are dialed-in to achieve time alignment and flat amplitude/phase response. The BMS driver provides a lower cost alternative, but at the added cost of another amplification channel.

Extending Bass Bin Performance Down to 16-18 Hz (-3 dB)

[Description of the second-gen Jubilee bass bin design, acoustic performance, and price](#)

A schematic illustration of the now patented second-gen Jubilee bass bin configuration is provided below showing the internally loaded horn-loaded bass reflex ports (the three smaller round holes in the lighter cream-color baffle):



Figure 8 The Heritage Jubilee bin illustration

Some Jubilee owners might be satisfied with the low frequency cut-off of their first-gen bass bins when placed within one foot (30 cm) of a room corner. Typical low frequency cutoff performance of 28-31 Hz using DSP crossover is achievable with the first-gen exponential horn expansion.

But other first-gen Jubilee owners may be inclined to upgrade to the 16-18 Hz performance of the second-gen Jubilees, and there is good reason to do so from the standpoint of its visceral listening experience.

The second-gen bass bin uses a different horn expansion profile in order for it to be EQed to flat response down to 18 Hz using the Klipsch-supplied fixed DSP crossover. This crossover provides significant low bass boost EQ—roughly 20 dB at 22 Hz, 1-octave bandwidth PEQ filter (as shown in figure 10, below). The reason for this lower bass extension point is the apparent avoidance of using an exponential horn profile with its attendant hard “cutoff” frequency. The figure below, taken from Harry Olson’s *Acoustic Engineering* text, shows the various acoustic impedance profiles for horns of the same length and throat size for comparison of their acoustic impedance properties:

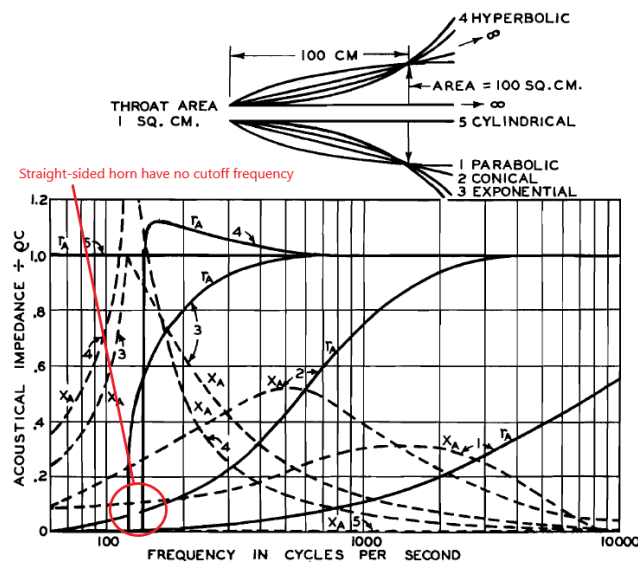


FIG. 5.5. Throat acoustical resistance r_A , and acoustical reactance x_A , frequency characteristics of infinite parabolic, conical, exponential, hyperbolic, and cylindrical horns having a throat area of 1 square centimeter. The cross-sectional area of the parabolic, conical, exponential, and hyperbolic horns is 100 square centimeters at a distance of 100 centimeters from the throat.

Figure 9 A comparison of relative throat acoustic loadings vs. frequency of different horn profiles

The real part of the impedance, i.e., acoustic resistance is plotted as solid black traces for each horn profile shape, above, represents the acoustic loading that the horn supplies to the output of the attached acoustic drivers, which is the effect that gives us horn loading. Conical or straight-sided horns have reduced loading relative to both exponential and hyperbolic horns, as shown above, starting at much higher frequencies. However straight-sided horns have no distinct cutoff frequency, as shown inside the red circle on the plot, which shows conical still providing horn loading at the point where both hyperbolic and exponential horn profile acoustic resistance has dropped to zero. Using a straight-sided

horn profile bass bin requires suitable equalization to offset this loss of horn loading as frequency decreases.

The design of the second-gen bass bin uses the back chamber of the bass bin, with twin 12" woofers shown above the bass reflex ports, to provide horn-loaded bass-reflex augmentation that feeds the folded horn at its throat (at the beginning of the horn, not after the horn). While the bass reflex ports inside the horn increase the efficiency of the horn below the woofer equivalent resonance frequency, the ports themselves can only bring <3 dB increase in throat response, i.e., not quite doubling the acoustic power over that of a closed-box configuration used by conventional horns, but only for about a half octave below the frequency at the horn's $\frac{1}{4}$ wavelength axial length. There are also trade-offs with regard to phase growth and AM distortion, which will also be discussed, as well as size and weight.

If the internal bass reflex ports and back chamber are designed to have a low-enough tuning frequency (as it does), the actual bass bin cutoff is not quite an octave below that of the first-gen Jubilee bass bin--18 Hz vs. 31 Hz. However, it should be noted that the second-gen Jubilee bass bin requires a full 20 dB of EQ boost centered at 22 Hz to achieve its in-room performance, and while placed away from the listening room's walls, as is shown below in the electrical output of the Klipsch DSP output for bass bin (fixed EQ response):

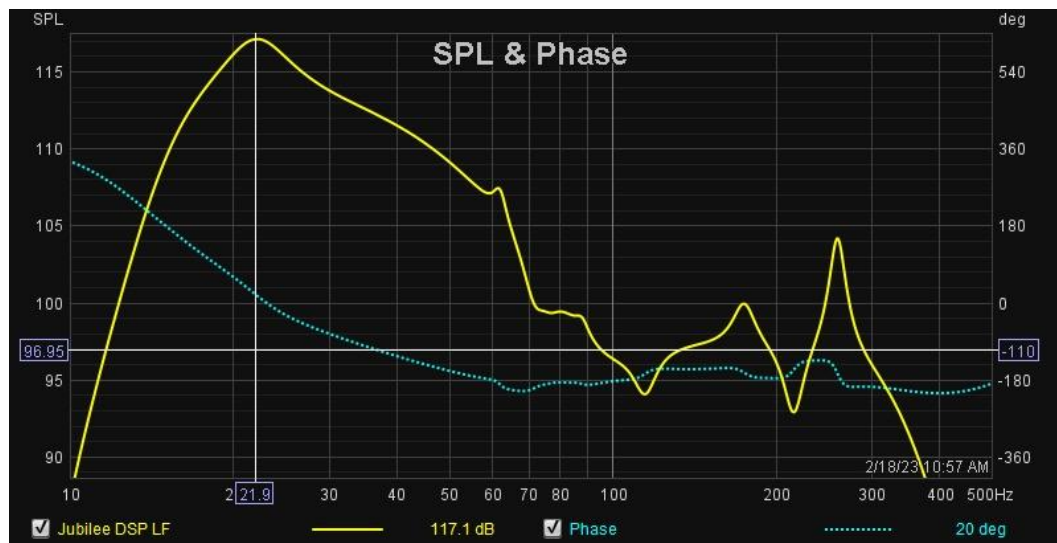


Figure 10 Second-gen Jubilee equalized output from its Klipsch-provided DSP crossover

Both the first-gen and second-gen bass bins use a “W” cross-section dual-mouth (“bifurcated”) horn that can easily pick up room boundary gain if placed near a room wall or corner, that extends their -3 dB response more than one octave below their free-air response--just like the Klipschorn bass bin.

The depth of the first-gen bass bin was designed to fit into a room corner of approximately the same footprint as the original Klipschorn, while the second-gen bass bin was allowed to grow in depth by about 7 inches (~18 cm), and its width by almost 9 inches (~23 cm), thus making the new bass bin design significantly larger and heavier. It also requires equalization to boost its performance below ~80 Hz.

Additionally, the approximate price of the new 350 pound/160 kg weight is responsible for about \$25K-\$30K of its breathtaking \$35K asking price (when compared to the first-gen bass bin), which should give the potential buyer pause to consider its value/price implications. It is also made of MDF, a change from

the plywood designs of the first-gen bass bins, reportedly due to post-CNC instability of plywood holding its shape over time in this design. This implies that the new owner can no longer move these bass bins by themselves without the aid of piano movers or significant in-home moving equipment. Its size can preclude movement or placement into owner's listening rooms if narrow stairs or corridors block the access to the room because of the bass bin size/shape/weight, as has been mentioned in many forum threads.

[An Alternative Approach to Extending the Bass Performance Down to 16 Hz](#)

As can be seen in the above description of the second-gen Jubilee bass bin, there are significant considerations as to the design choices made in order to extend its bass rolloff frequency from 31 Hz to 18 Hz using only two "ways": high frequency K-402 horn/Axi2050 driver with phase plug extension, and internal bass-reflex bass bin.

One topic not yet discussed is the contribution to distortion of deep bass reproduction below 28-31 Hz (first-gen bass bin cut-off frequency) to higher frequencies up to ~350 Hz. If the excursions of the second-gen bass bin's dual 12" drivers at very low frequencies become large (i.e., loaded like direct radiating woofers due to the low horn loading of the horn profile at those low frequencies) while playing deep bass program material, amplitude modulation (AM) distortion becomes significant and causes the sound quality of the higher frequencies well above 28-31 Hz to sound opaque and muddled—not at all like the horn-loaded bass of the first-gen, Khorn, La Scala, and Belle bass bins. AM distortion, which is the predominate type of bass distortion in addition to thermal compression distortion, produces non-harmonic frequencies not found in the input signal driving the loudspeaker. Because these modulated frequencies are not related in integer multiples of either the lower or higher frequencies being reproduced, these distortion-produced frequencies are much more audible and objectionable than typical harmonic distortion.

The figure below illustrates harmonic and modulation distortion versus frequency, which shows up on *higher* frequencies reproduced than on the deepest bass frequencies:

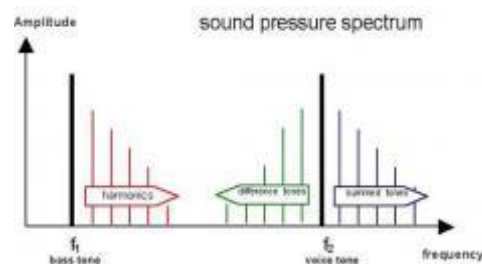


Figure 3: Visualization of harmonic and modulation distortion

[One alternative approach...](#)

Another approach that has at least equal merit is a separate DIY horn-loaded subwoofer box of the appropriate dimensions, sized to extend the bass response to 16-18 Hz, but which doesn't suffer from

deep bass AM distortion at higher frequencies because it is cross over to the first-gen bass bins at 40-50 Hz. There are many horn-loaded subwoofer designs that are available to choose from.

One approach that appears to be tailor-made for upgrading first-gen Jubilee deep bass response and is of about the correct shape and dimensions is the [“TH-SPUD” subwoofer design](#), based on the [Danley Sound Labs “SPUD” tapped horn](#) design (also available for purchase directly from DSL). A photo of a first-gen Jubilee with a covered DIY TH-SPUD box just behind it, as well as a picture inside the subwoofer box after one side baffle has been removed in figures 11 and 12, below.



Figure 11 A first-gen Jubilee in front of quilt-covered DIY TH-SPUD



Figure 12 DIY TH-SPUD on floor with side removed showing drivers, baffles, and horn mouth

A plot of the raw response of a single TH-SPUD positioned in a room corner is also shown in fig. 13, showing smooth and flat natural SPL/phase response that is easy to EQ and time align, and -3 dB cutoff point (14.3 Hz).

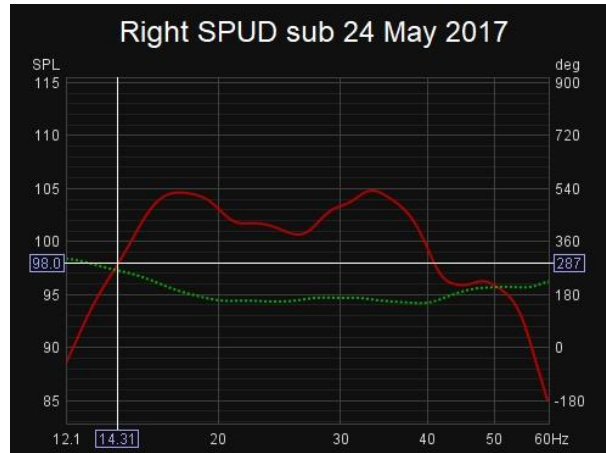


Figure 13 SPL and phase response of DIY TH-SPUD in-room

Two of these TH-SPUDs are recommended in-room--placed just behind the first-gen Jubilee bass bins to each Jubilee and TH-SPUD forming a unit, and a backstop to the Jubilee bas bin to co-locate the bass generation for greater mutual reinforcement in order to provide sufficient deep bass response to 14 Hz for any kind of deep bass program material.

The measured harmonic distortion of the KPT-KHJ-LF bass bin with DIY TH-SPUDs at very high SPL output is shown below in figure 14. The TH-SPUDs produce extremely clean output down to 14 Hz, which far exceeds the distortion performance of direct radiating subwoofers. The harmonic distortion levels are so low, in fact, that localization of the subwoofers in-room is not possible, or even if one subwoofer is on vs. two.

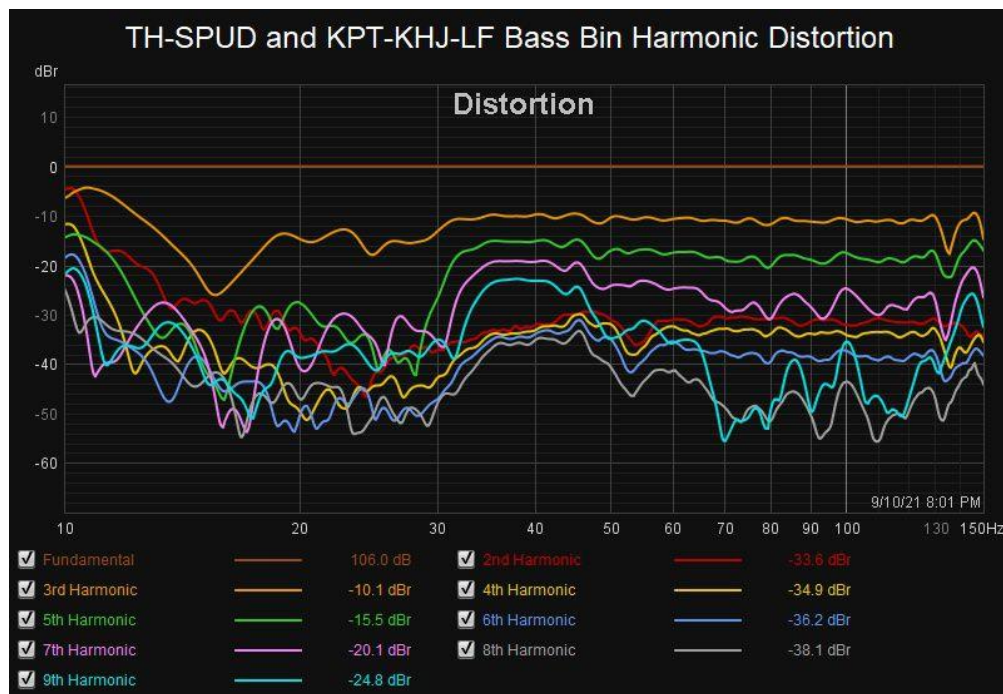


Figure 14 Measured DIY TH-SPUD subwoofers and KPT-KHL-LF bass bin harmonic distortion in-room (105 dB@3m)

The cost of the DIY TH-SPUD and Tang Band W8-740P drivers is less than \$400 per subwoofer box, including drivers and associated fasteners (subwoofer amplifiers of sufficient output power are also relatively inexpensive and often already sit on the shelf of owners). Plans, build photos, and acoustic measurements are available [here](#). The price and simplicity of the build, as well as the dimensions/relative shape to position just behind the Jubilees, and weight (less than 150 lbs.) make this an extremely attractive alternative as compared to the \$25K-\$30K Jubilee bass bins. Distortion is actually lower with the SPUDs than second-gen bass bins, especially phase distortion, which is extremely difficult to correct at frequencies below 40 Hz due to the time delays introduced by FIR filters in this frequency band.

DSP Crossover and Settings

The second gen Jubilee comes with a non-adjustable DSP crossover, with only gain controls for balancing the output amplifiers:



Figure 15: Klipsch-provided fixed DSP crossover for second-gen Jubilee

There is no provision to equalizing the in-room bass amplitude response below the room's Schroeder frequency (~ 150-200 Hz for most listening rooms) using the Klipsch crossover, something that is quite easy to do with a general-purpose DSP crossover, such as a Xilica or higher-quality miniDSP crossover.

Phase Growth Due to Embedded DSP Crossover Filters

The crossover filters used in the Klipsch DSP box appear to be fourth order IIR filters, (apparently Linkwitz-Riley type) low-pass/high-pass filters *without* FIR filter phase correction. The plots below compare a first-gen Jubilee converted using a dialed-in Celestion Axi2050 driver and a Xilica XP DSP crossover (orange traces) to the second gen Jubilee using its Klipsch-provided DSP crossover (yellow traces).

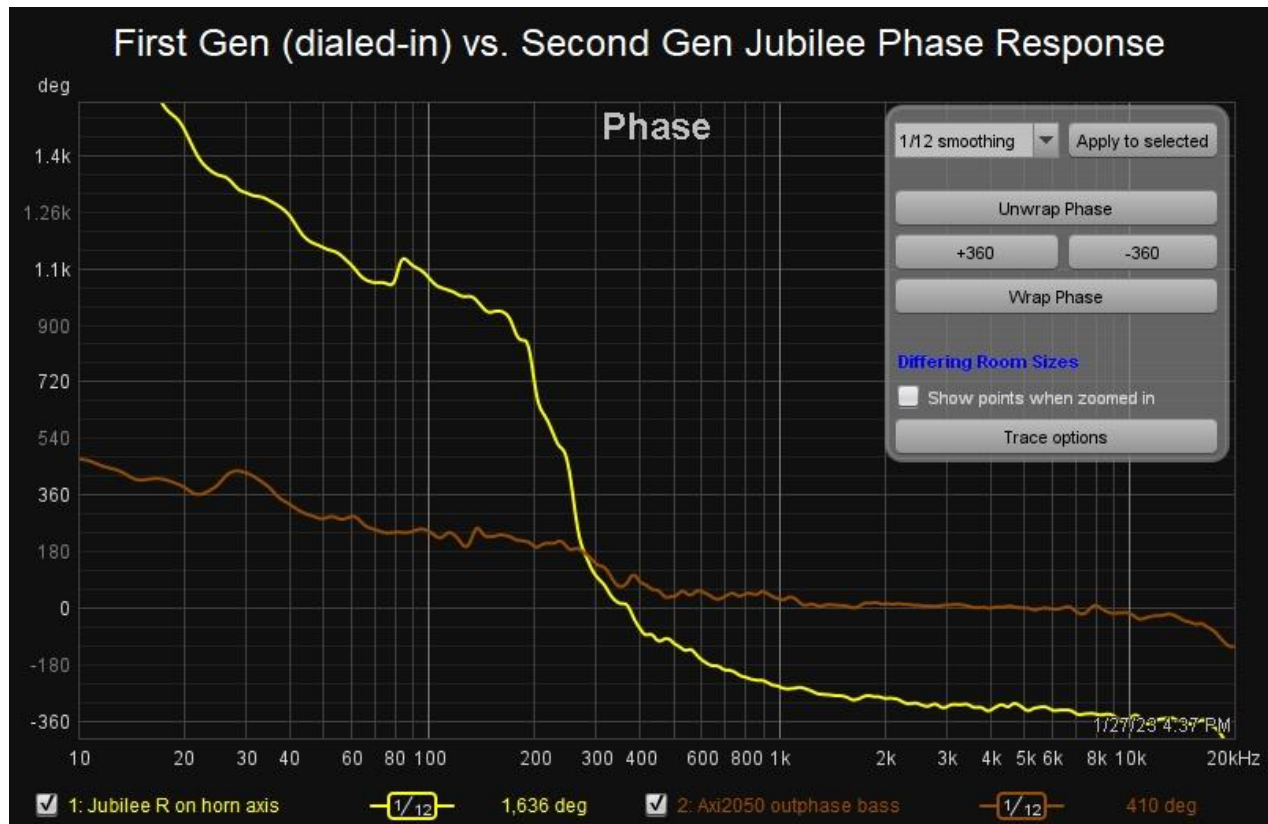


Figure 16 First-gen (orange) vs. second-gen (yellow) Jubilee phase response

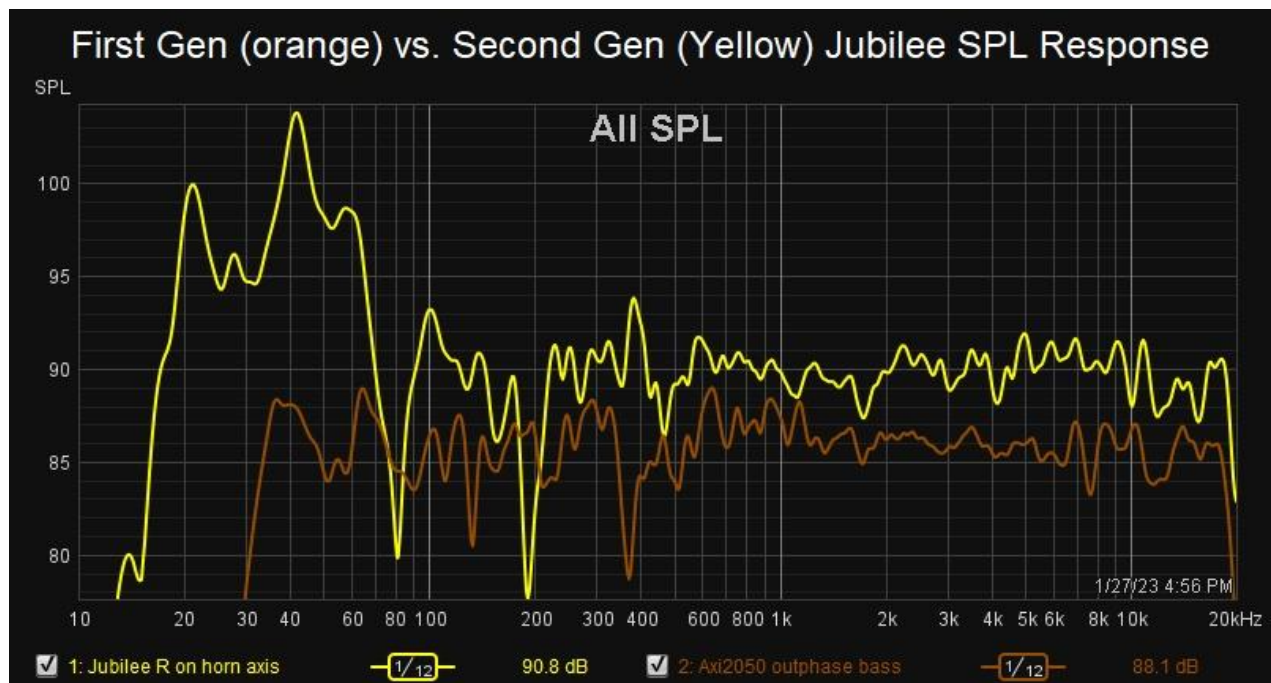


Figure 17 First-gen (orange) vs. Second-gen (yellow) SPL Response On K-402 Axis

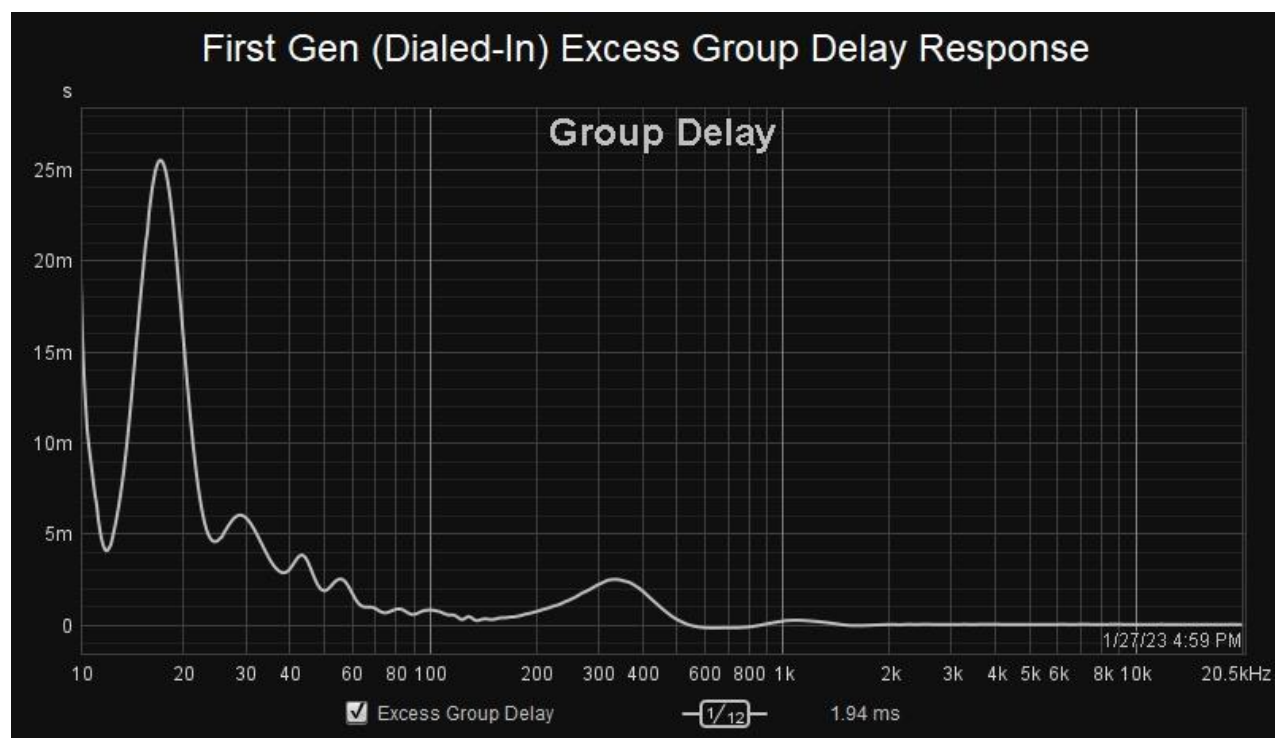


Figure 18 First-gen Jubilee excess group delay response (i.e., SPL output only above 31 Hz)

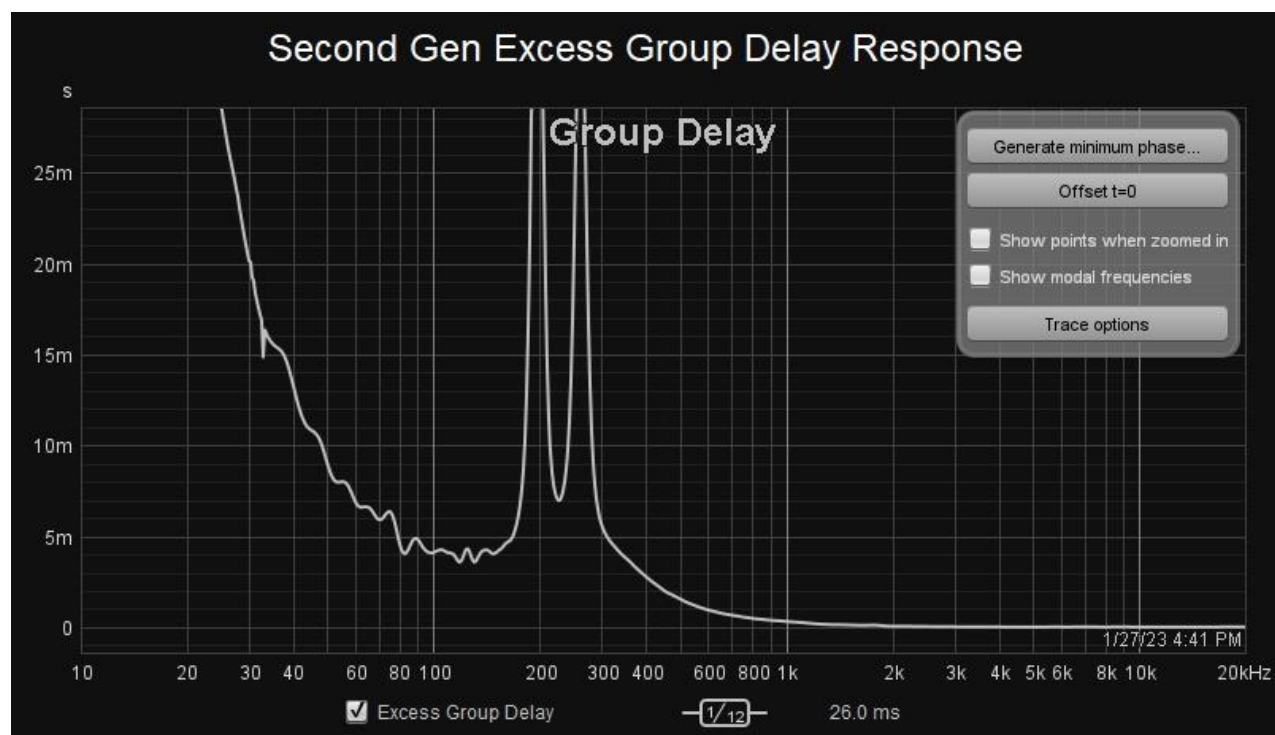


Figure 19 Second-gen Jubilee excess group delay response using Klipsch DSP crossover (SPL output to 16 Hz)

With a loudspeaker the caliber of the Jubilee, the sudden growth of phase and excess group delay (i.e., the instantaneous slope of the phase curve) is very audible. In order to remedy this in the crossover

design, the entire DSP crossover must be replaced with a third-party unit due to the inability to adjust any settings in the Klipsch DSP crossover (except relative output overall channel gains). Note that the quality of the replacement DSP unit must be high enough to preclude noisy operation and lower resolution digital processing (96 kHz sampling rate vs. 48 kHz) since the loudspeaker itself has something like 105 dB/1m sensitivity and extremely clear output response.

Without the use of FIR filters to correct phase and group delay, this produces a large phase/group delay discontinuity throughout the crossover interference band, as shown in figures 16 and 19 above, resulting in the large phase growth across the loudspeaker's passband. Removing this phase growth and its attendant large excess group delay at the crossover point will result in a much different subconsciously engaging sound presentation. Below is an excerpt from a forum thread on the subjective/subconscious effects of achieving phase correction of Jubilees to explain what that difference is. This effect was one of the most exciting discoveries that this author has made in his Hi-Fi experiences:

Increased Perception of Bass

One of the interesting changes that occurred when reworking the first-gen Jubilees crossover filters to achieve flat phase response [ref. figure 15] is that my wife started to comment on how much more bass response there was. While this may seem farfetched, Toole talks about this subjective effect in his book:

Craven and Gerzon (1992) stated that the phase distortion caused by the high pass response is audible, even if the cutoff frequency is reduced to 5 Hz. They say it causes the bass to lack "tightness" and become "woolly." Phase equalization of the bass...subjectively extends the effective bass response by the order of half an octave.

This effect occurred in my listening room even though the measured on-axis SPL response was flat or slightly rising to 17 Hz both beforehand and afterward. The crossover frequency between the subwoofers and the first-gen Jubilee bass bins is 40 Hz.

Elimination of Harshness:

Others have mentioned that they are no longer hearing harsh sounds from the loudspeakers. Any time that we play a recording that hasn't been multitrack recorded in recording booths, i.e., symphonic, solo concertos and sonatas, choral pieces, etc., the sound is like sitting in the audience of a large music hall. **It's actually difficult now to stop listening to these recordings once they're turned on.**

Recently, I've seen people asking how to reduce the "fatigue factor" and the harshness of sound in various home theater threads. I believe that I now know exactly how to achieve that--but the price of admission is bi/tri-amping and DSP crossovers to flatten not only the frequency response, but also the phase response of all of the loudspeakers in the array. In stereo mode, the effect is actually heightened over this effect in multichannel mode.

Quasi-linear-phase response has further improved upon the overall subjective sound quality. Phase response flatness does have a large part to play in the hi-fi reproduction of music.

Apparently, a large part of the "little monitors on stands" or full-range drivers experience/preference is wrapped up with this effect. When flattening the phase with a full 5.1 array, the effect is pronounced when playing the best acoustic recordings.

It is recommended to use Xilica XP, XD, or Solaro series processors for DSP units for this upgrade. Trying to use DSP crossovers of lesser quality will be audible in the output of the Jubilee in the form of noise floor and reduced overall fidelity.

FIR filtering can also be used in the crossover or upstream in a PC if the user desires steep slope crossovers. This will also achieve flat phase/excess group delay response through the crossover band, but requires significantly more real-time computing horsepower, and also significantly higher insertion time delays (which can be a problem in home theater setups synchronizing video).

However the response seen above for the first gen Jubilee uses PEQs only combined with naturally falling driver/horn acoustic response to accomplish the low phase growth.

Summary Costs and Required Effort of DIY First-Gen Jubilee Upgrades

To say that the difference in sound quality from the Jubilees as they sounded from the factory using K-69-A drivers, XTi-1000 amplifiers, and no subwoofers is like the difference between the living and the dead...would be an understatement. I suppose no amount of hyperbole could match the audible differences in what we hear now. That makes it difficult to report on the net result of the upgrades.

To be sure, the upgrades mentioned above were arrived at incrementally by the author over the span of 15 years in the author's listening room. However, you don't have to wait 15 years or even a year to upgrade first-generation Jubilees to match or exceed second-gen Jubilee performance in-room. The upgrades mentioned above can be priced:

Price Item

\$2K 2 x Celestion Axi2050 2" compression drivers (BMS 4592ND drivers cost roughly 2/3rd that price)

\$100 2 x 3D printed phase plug extensions for the Axi2050 drivers (none needed if using BMS 4592NDs)

\$1K Xilica XP-4080 DSP crossover or equivalent (i.e., but **not** Behringer, DriveRack, miniDSP 2x4, etc.)

\$800 2 x DIY TH-SPUD subwoofers (assumes user supplies stereo amplifier already on hand)

\$3.9K...or as little as about \$2.3K using alternative components

These upgrades applied to first-gen Jubilees with stock K-69-A or K-691 compression drivers will equal or exceed the sound quality of the second-gen Jubilee in-room. Cosmetic upgrades are at the discretion of the owner, but in no case should the cost of veneer, horn-mouth plywood frames and acoustic cloth to cover the bass bin mouths exceed \$1K, even for exotic applique wood veneers.

Clearly, the effort required to build DIY TH-SPUD subwoofers is the most time-consuming task listed above, but 40 hours (max.) is probably a conservative estimate, along with any added time to make the exterior finish look pretty--not included in the 40-hour estimate. A quilted cover, like the picture shown above, is a way to avoid large investments of time and “elbow grease” on making the TH-subs look nice and inviting in-room. The rest of the upgrades takes only the time to unbolt/bolt-up compression drivers and reconnect associated cable connectors for the DSP crossover.

Comparing even the \$3.9K higher price shown above with the price of buying new second-gen Jubilees (\$35K+) is a motivating factor to achieve the same (or better) sound quality from your first-gen Jubilees.

Dialing-In the Setup Using REW and DSP crossover after hardware upgrades

Contact the author via private message for assistance in the task of dialing-in your setup using whichever compression drivers and subwoofers you choose. The author has helped many on-line owners dial-in their setups using email as the communication medium for the REW measurement files and the DSP crossover preset files (*.xdat or *.xml, etc.). It usually takes an afternoon of measurements and email exchanges to properly dial-in a setup using 7-8 round-robin updates. (This is a no-cost service for first-gen Jubilee owners.)

Chris Askew 19 February, 2023