MoreTrix 2 way Speaker kit Design

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MoreTrix 2 way speaker kit design

MoreTrix is an uncompromising 2 way design offered in 3 enclosure sizes and types using some of Morel's most capable drivers. Knowing that not everyone is endowed with advanced mechanical skills, I kept the enclosures simple to construct, while not compromising their sonic qualities in any way. The crossovers are relatively simple to construct and ample visual aids are provided for circuit board layout. While I realize it is quite difficult to express the sonic attributes of any design solely with the written word, I will say that I am quite enamored with the resulting designs. In return for the builder's time and efforts in cabinet construction, most well-turned-out kits or DIY designs will offer capabilities rivaling or in some cases exceeding commercial designs cost several times more.

Knowing from my past designs that builders desire to individualize their speakers to best suit their unique applications I've taken the same basic design and built/voiced 3 different enclosure choices. None of the design enclosure options affect the quality of the speaker. The differences being size, optimal placement distance from the front wall, and the low end extension of the speaker.

Designer
Curt Campbell

The Sealed Bookshelf AP version:

The smallest is an aperiodically damped design. Aperiodic damping is not new, and the concept has been utilized in many high end commercial designs over the years. It does have a vent in the rear panel of the enclosure, but unlike a conventional vented design utilizing a Helmholtz resonator, the vent is impeded by damping material so the air can only slowly pass, but the air will not resonate at a specific frequency. Its advantages are twofold: The resistive port allows a smaller enclosure to emulate a larger enclosure for an optimal configuration in a smaller speaker 'footprint'. It also improves the woofer response around the system resonance, providing better definition at bass frequencies, while still providing the 12 db / octave response roll off of a sealed enclosure. For applications that require close placement to walls or other boundary, where the rear of the enclosure is a foot or less from the wall, this is the one to build.

Leading Particulars of the Aperiodic design:

- Size: 9"w x 14.5"h x 11" deep. Suggested construction: ¾" MDF
- Designed for placement near or on the wall.
- Applications: Home Theater, Office speakers, Computer Monitors, or anywhere a small speaker is appropriate.
- Frequency response: 52 Hz to 20 kHz +/- 3 dB under anechoic conditions. With the normal support from room boundaries, useful bass response extends to 40 Hz.
- Capable of maximum linear SPL's exceeding 104 dB / 1 meter when the HT receiver high pass filter is set to 80 Hz.
- Sensitivity approximately 82 dB / 2.8 volts / 1 meter.
- 8 ohm nominal impedance
- Simple construction and small size makes for minimal intrusion into the room.

Figure A- Frequency Response Aperiodic Speaker

The Vented Bookshelf Version:

A little larger than the AP version, the vented version uses a traditional 2” flared port to provide additional bass extension. The crossover is voiced for the speaker front baffle to be approximately 3 feet from the front walls. This provides a significant improvement in soundstage realism and depth. The actual distance from the front wall will depend on the room, and your tastes in bass reproduction. If you must place it close to the front wall, I suggest you consider the AP version instead. Recommended orientation is toed in towards the listening position, however it is acceptable to adjust them more towards orthogonal with the room to adjust the amount of ‘air’ to an appropriate level in based on the treble absorption of your listening environment.

Leading Particulars of the vented design:

- Size: 9”w x 21”h x 11” deep. Suggested construction: ¾” MDF with bracing.
- Designed for placement away from wall boundaries for best soundstage depth
- Applications: Stereo applications in mid sized rooms. Home theater only if appropriate room placement can be accomplished.
- Frequency response: 35 Hz to 20 kHz +/- 3 dB
- Rear firing port
- Capable of maximum linear SPL’s exceeding 100 dB / 1 meter -Simple construction and small size makes for minimal intrusion into the room.
- Basic sensitivity 82 dB / 2.8 v / 1 meter.
- 8 ohm nominal impedance
- Recommended stand height 18 inches.
- Simple construction similar to the sealed design, with the addition of 2 cross braces.

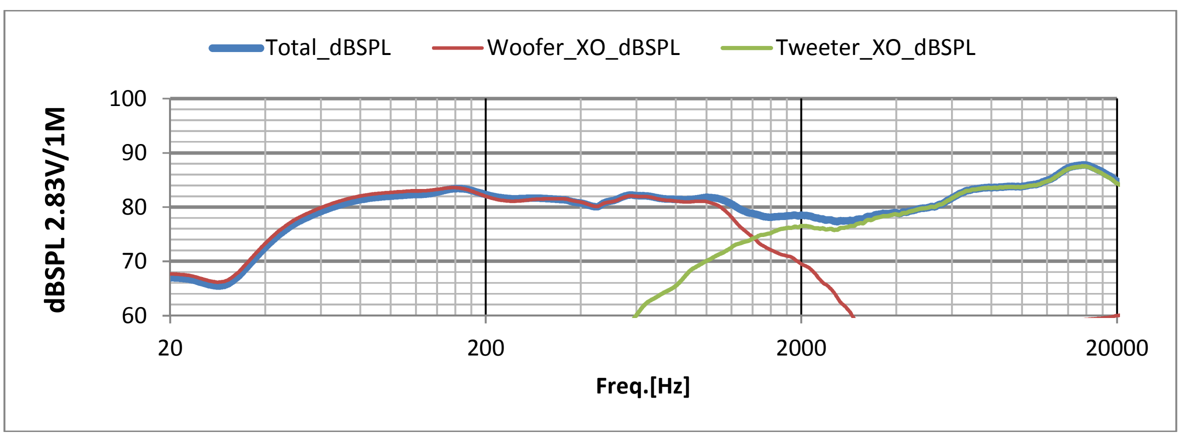

Figure B -Frequency Response Bookshelf Vented

The MLTL (Mass Loaded Transmission Line) version.

The largest of the 3 designs, it is actually quite svelte, having the same baffle width as the other designs, but shaving an inch off the depth. At 42", it is a free standing design, giving it a slim unobtrusive appearance in spite of being a tower speaker. Because of its stature, and low frequency capabilities, I've added additional bracing and recommend construction utilizing of 1" MDF. While this may add cost, the drivers respond positively to the higher mass platform.

Transmission line speakers are similar to vented designs but having the additional attribute of the additional low end support due to the quarter wave response of the line. In a mass loaded transmission line, we actually have 3 factors governing the bass response of the speaker. Like a vented design, we have the parameters of the driver itself, and the tuning of the Helmholtz resonator (port). In addition, we also have the support of the standing wave propagation of the line, which in this case is the enclosure height. Careful attention to the line length and the position of the Midwoofer and port position on the line provide additional low end extension, and another method to optimize the transfer function of the low end roll off.

Leading Particulars of the MLTL design:

- Size: 9"w x 42"h x 10" deep. Suggested construction: 1" MDF with bracing.
- Designed for placement away from wall boundaries for best soundstage depth
- Applications: Stereo applications in mid sized rooms. Home theater only if appropriate room placement can be accomplished.
- Frequency response: 30 Hz to 20 kHz +/- 3 dB
- Rear firing port
- Capable of maximum linear SPL's exceeding 100 dB / 1 meter
- The small footprint makes for minimal intrusion into the room, yet the height and solidity of the cabinet make a powerful visual statement.
- Basic sensitivity 82dB / 2.8 v / 1 meter.
- 8 ohm nominal impedance
- Simple construction similar to the vented design. A total of 5 braces are recommended.

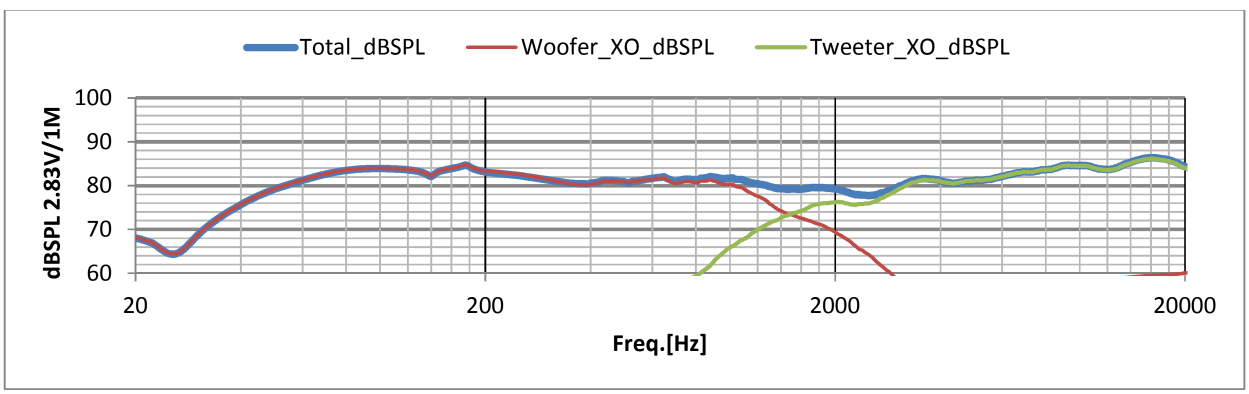

Figure C-Frequency Response MLTL

The Cross Over

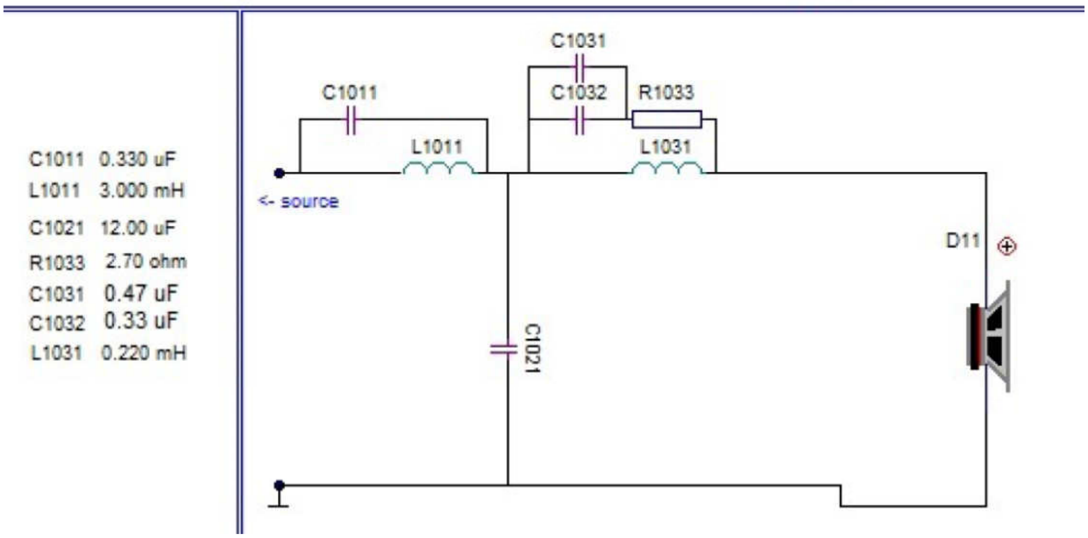

Figure D-Woofer Cross Over Network

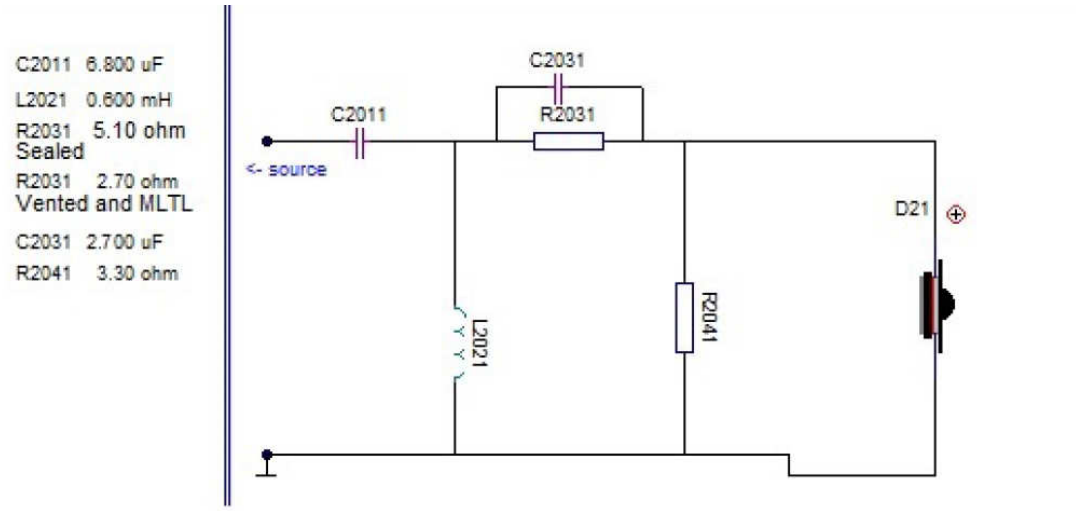

Figure E-Tweeter Cross Over Network

The topology is a mixed Q high pass and low pass filter. All drivers are connected in phase. All three designs share the same crossover with one resistor change.

The woofer crossover is effectively a 2nd order electrical filter. Additionally it utilizes a Cauer elliptic filter integrated into the LP filter, and a parallel notch filter after it. This results in a smooth 3rd order BW acoustic transfer function. Response peaks in the stop band are down more than -45 dB from nominal.

The tweeter is also a 2nd order electrical filter followed by a 2 resistor attenuator. An additional capacitor is paralleled across the series resistor to improve the power response of the system. This series resistor value changes depending on the enclosure design choice, but it is the only component change required. The tweeter acoustic transfer function emulates a low Q (flat group delay) 3rd order at 1800 Hz. The crossover exhibits excellent phase tracking between the drivers.

Impedance normalization network (optional):

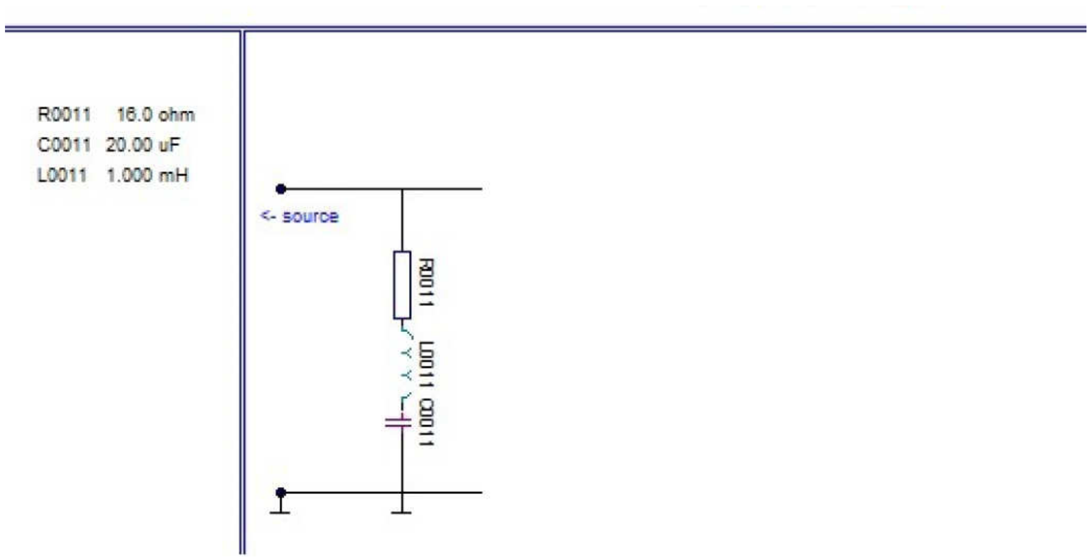

Figure F-Impedance Normalization Network

Most tube power amplifiers will have a high enough output impedance to cause response variations when driving a typical speaker, with its characteristically non linear impedance. These variations can significantly change the voicing or timber of the sound from the intended response, but are generally ignored by the speaker manufacturer. To address this issue for those who prefer this type of amplification, an impedance normalization network was designed. When added to the crossover, this provides a significant improvement in the speaker impedance linearity and likely much lower linear distortion (and transient distortion) levels when driven by an amplifier incorporating tubes. This circuit can be added to the speaker during construction, or built as a separate external component that merely is attached across the speaker binding posts when desired.

Enclosure designs:

Recognizing that not everyone who desires to build their own speakers are not master craftsmen, (including myself) the enclosures have been intentionally kept as simple as possible to construct. Access to a router for the driver holes and rebates would be required. A table saw would be advantageous, but the use of a circular saw with a saw guide could be made to work as well. All cuts are square, and there are no mirror image panels to be concerned with. I've added cut lists to the enclosure drawings. MDF or similar would be my recommendation as the material of choice. All three designs are fully stuffed, except for immediately behind the midwoofers and in front of the ports. I've specified polyfill pillow stuffing as its properties are sufficient for this purpose.
The amounts of stuffing are specified for each design on the drawings as well. Stuffing materials with similar properties are acceptable. As with any stuffed design, the actual amount and type of stuffing required will best be determined by the constructor, their individual tastes, and circumstances. The port length for each design is specified on the drawings, as is the construction of the aperiodic vent.

Listening impressions:

These are among the finest drivers I have experienced. Their ability to resolve fine detail is apparently only limited only by the partnering electronics.
Warning: Those who listen solely to poorly recorded and engineered source materials may run the risk of no longer being able to tolerate listening to this material without the 'filter' of a low resolution speaker.
For those who are fortunate enough to have and enjoy quality recordings and the equipment to reproduce them, I believe will find a suitably capable partner in these speakers.
Bass: Excellent in all three designs. Deep, yet well controlled. Midrange: Detailed, yet delicate. Clean transients, yet lots of punch when required. (This leads me to believe I've determined why 3 inch voice coils on a 6" driver are a such a good thing.) Treble: Excellent transient response and timber. Cymbals not only sound like cymbals but the inner tonality is evident. Discerning the sound of the individual brush wires on the snare head seems readily apparent.

Bill of Material Per speaker

Drivers Bill of Material

Tweeter – 1 X Morel ET338 ,Elite Tweeter, 110mm IDR™ 8Ω
Woofer- 1 X Morel TiCW638Nd, 6" Bassmid 8 Ω, Coopersleeve Neolin™ Motor, Titanium bobbin

Crossover Bill of Materials

Woofer network (Net 1)
L1011 3.0 mH laminated core inductor 15ga.
C1011 0.33 uF Clarity PX or similar
C1021 12.0 uF Clarity PX or similar
C1031 0.47 uF Clarity PX or similar
C1032 0.33 uF Clarity PX or similar
R1033 2.7 ohm 10 watt Mundorf MOX or similar
L1031 0.22 mH air core 16 ga.

Tweeter network (Net 2)
C2011 6.8 uF Clarity SA or ESA or similar
L2021 0.6 mH air core 18 to 20 ga.
C2031 2.7 uF Clarity SA or ESA or similar
R2031 AP sealed 5.1 ohm Mundorf MOX or similar
R2031 VT and MLTL 2.7 ohm 10 watt Mundorf MOX or similar
R2041 3.3 ohm 10 watt Mundorf MOX or similar

Impedance normalization network (Common net)
C0011 20 uF Clarity PX or similar
L0011 1.0 mH air core 18 to 20 ga.
R0011 16 ohm 20 watt (use two 8.2 ohm 10 watt resistors in series, or two 33 ohm 10 watt resistors in parallel for R0011) Mundorf MOX or similar

Ports Bill of Material

Sealed Bookshelf AP version- 1.5" dia. x 2" deep port filled with foam plug for Aperiodic damping

Vented Book shelf- A flared vent 2" x 8.5" is recommended , Straight vent 2" x 7.5" is permissible

MLTL- A flared vent 2" x 6.5" is recommended , Straight vent 2" x 5.5" is permissible

Stuffing

Sealed Bookshelf AP version- 4 oz. of polyfill stuffing

Vented Book shelf- 6 oz. of polyfill stuffing ,

MLTL - 12 oz of polyfill stuffing

Frequently Asked Questions:

Most speakers I see have rounded or beveled baffle edges. Why don’t these speakers have them, and will it help if I add rounded/baffled edges?

Good question. If one would investigate my previous designs, they would see that I always round over or bevel my front baffles to partially address the diffraction effects caused by the tweeter’s acoustic radiation illuminating the baffle edges. Prior to receiving the actual tweeter samples from Morel, I spent a fair bit of time modeling the ‘best’ place to put the tweeters on the baffles to minimize the diffraction effects. When I actually measured the tweeters on baffles, I found they exhibited no diffraction artifacts whatsoever. It appears the clever engineers at Morel added a small waveguide to the front plate of the ET338, subtly altering their radiation pattern. Consequently, any treatment of baffle edges in these designs will be for cosmetic purposes only. They simply are not necessary to the performance of the design.

Isn’t it a good idea to offset the tweeters on the baffle?

Generally, laterally offsetting the tweeter on the baffle will improve the response irregularities due to the baffle edge diffraction effects. However, doing so smooth’s the on axis response at the expense of a worse response off axis. In addition, the lateral power response is no longer symmetrical. With the ET338 tweeter and its response characteristics, there is no need to offset the driver, and the lateral power response will be symmetrical.

I want to build these but I want to change the enclosure dimensions to accommodate my situation. Will that affect the design?

I get this question a lot, along with “Can I use different drivers and the same crossover and enclosure as this design?” (The answer to this second question is no, by the way.)
Normally I only allow very small changes to front baffle width as it will almost certainly affect the voicing. However in this instance, with the Morel tweeter I can relax this a bit, as the only audible changes will be the woofer response due to changes in ‘baffle step’. Increases in baffle width will tend to exaggerate the male voices, but this can be somewhat compensated by using large bevels or roundovers to bring the effective baffle width back towards the indicated values. Changes in baffle height are less intrusive, but the response of the VT and especially the MLTL require the prescribed internal height to be maintained.

Can I put the port (vent) in a different position, like the front baffle?

Yes, but with caveats, and I do not recommend it on 2 way designs. The port doesn’t just output energy around its tuning frequency, but is also an outlet for any frequency in the midwoofer’s pass band that happens to find its way to the port. All this ‘extra’ energy exits the port and sums with the desired energy from the midwoofer in a rather erratic fashion depending on the frequency and time of flight delays. Of course this same extra energy outputs a rear port as well, but it is somewhat attenuated and delayed as it is ‘aimed’ at the front wall, lessening its impact on the sound emanating from the midwoofer.
The position of the vent with respect to the enclosure has been carefully modeled to provide minimal response aberrations. Its vertical position on the enclosure should not be altered on either design. It is permissible to bottom fire the port if the inner port mouth is at the same vertical position as the centerline of the rear port as indicated on the drawings.

Is it OK to move the position of the woofers on the front baffle?

Sorry, No. Its position on the baffle is the best position for it based on extensive modeling in the enclosure design phase. The models suggest that moving either the Midwoofer or the port, as little as a half inch can have detrimental effects to the response.

I want to build the VT or MLTL version of this design but put them up against the front wall. Can I just substitute the resistor change for the AP (sealed) design into these and expect the same response?

Well, it would be better than not changing the resistor, but unfortunately that's not saying much. If you want the look of a larger enclosure, just build the AP enclosure inside the larger enclosure and the rest will be dead space. Think of it as a built in stand for the AP design. This still won't be optimum, but it will likely be acceptable, and some small adjustments to the resistor value may improve things. If you will be using these with a subwoofer anyway, the AP version is the best choice.

Is it possible to use different crossover components than the ones you have specified?

As long as the component values are kept the same, and the woofer inductor has a similar DCR, it should be fine. I will suggest that in my experience these drivers respond well to quality capacitors. Lesser quality capacitors may not provide the level of performance this design is capable of.

I have a solid state power amplifier. Should I use the impedance normalization network?

Because of the low output impedance of most solid state amplifiers, the normalization network will serve little purpose other than to make the speakers a slightly easier load for your amplifier. Certainly it will do no harm to incorporate it, should you choose.

I see the MLTL enclosure is 1" thick but the AP and VT are only ¾". Would it be good to make the AP or VT with 1" instead?

I chose ¾" for the AP and VT to keep their size relatively small, because their relatively small panel dimensions, and due to the availability of ¾" MDF as opposed to 1". Making them from 1" certainly won't hurt anything, and may help them sonically due to the extra rigidity. I'll leave it up to you to change the external dimensions to suit the additional thickness. The inside dimensions must not be changed, nor should the positions of the drivers and port relative to the inside dimensions. Bevel or roundover of the front baffle to maintain the front baffle size is recommended, but not required.

I can't find 1" MDF in my area. What do I do?

1" MDF isn't available in my area either. However, ¼" MDF or HDF is. Also available in my area is ¼" plywood with several different wood veneers to choose from. I suggest cutting all panels slightly oversized, then glue the ¼" panels to the ¾" MDF. When dry, trim your new 1" material to the exact size. While not recommended, it is acceptable to build the MLTL from ¾" material, as the design is well braced.

Appendixes

Sealed Book Shelf Enclosure Drawing

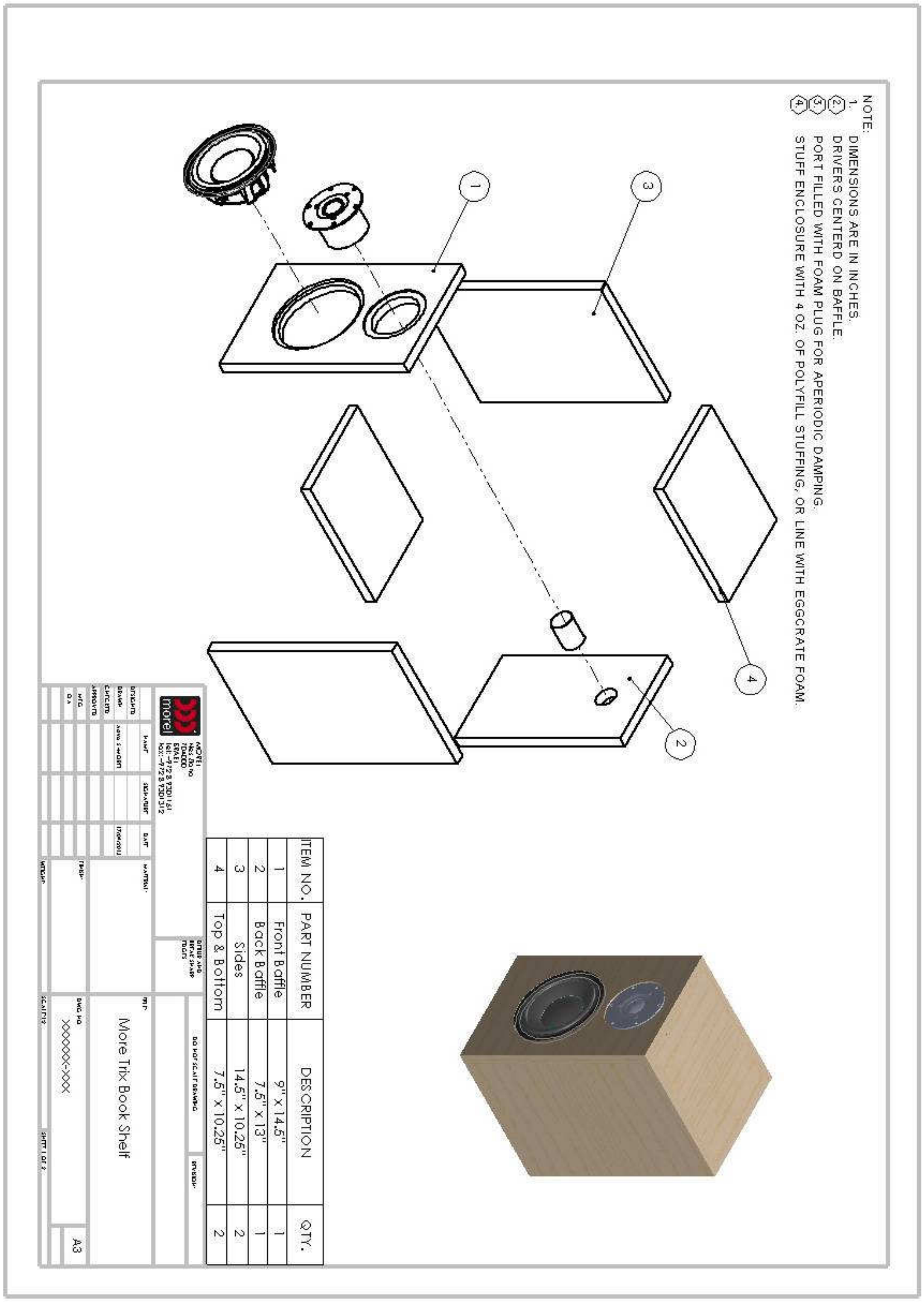

Figure G-Exploded View 3D Sealed Bookshelf AP

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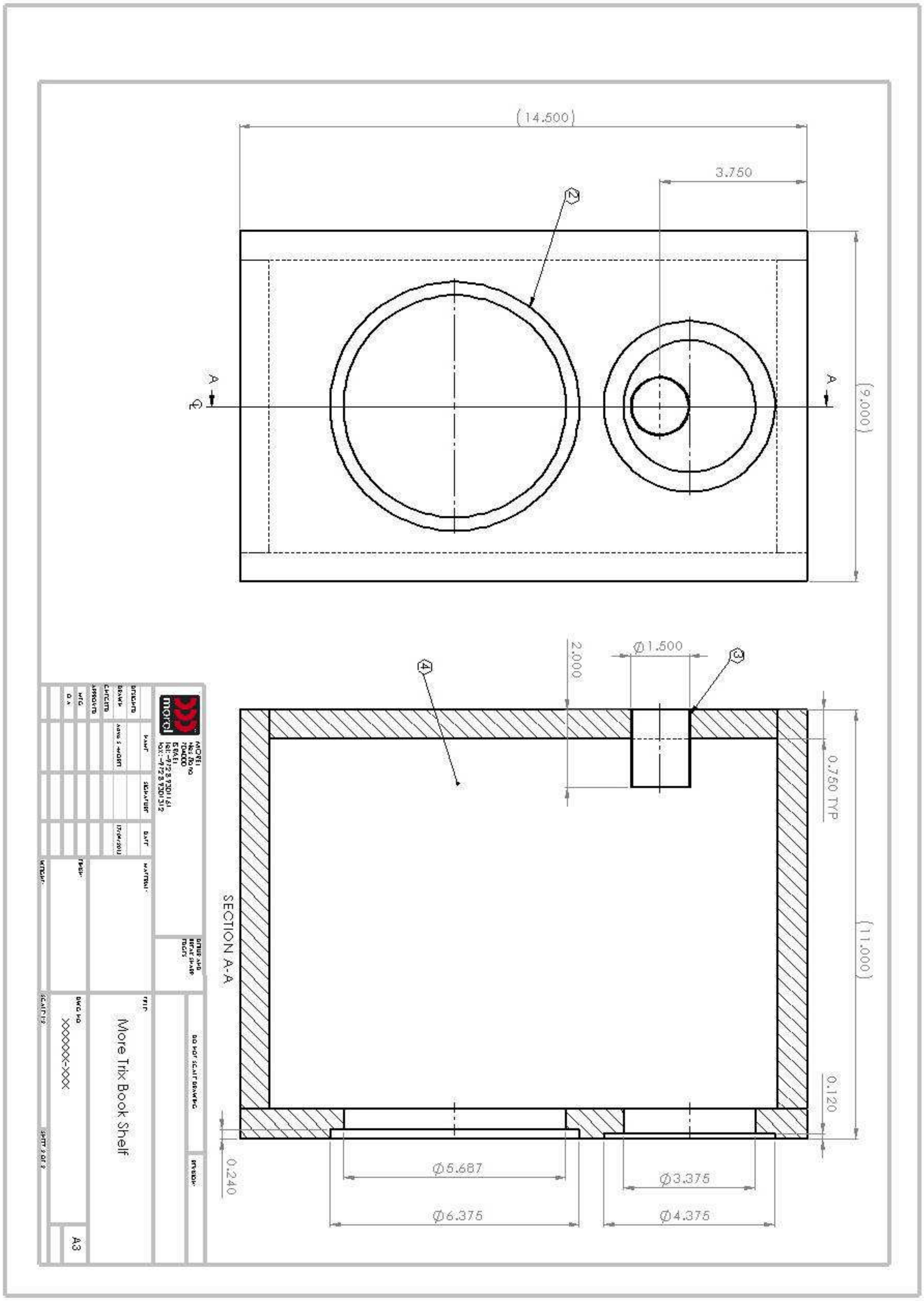

Figure H- Sealed Bookshelf AP Drawing

To Open the PDF Document Click Here

Vented Book Shelf Enclosure Drawing

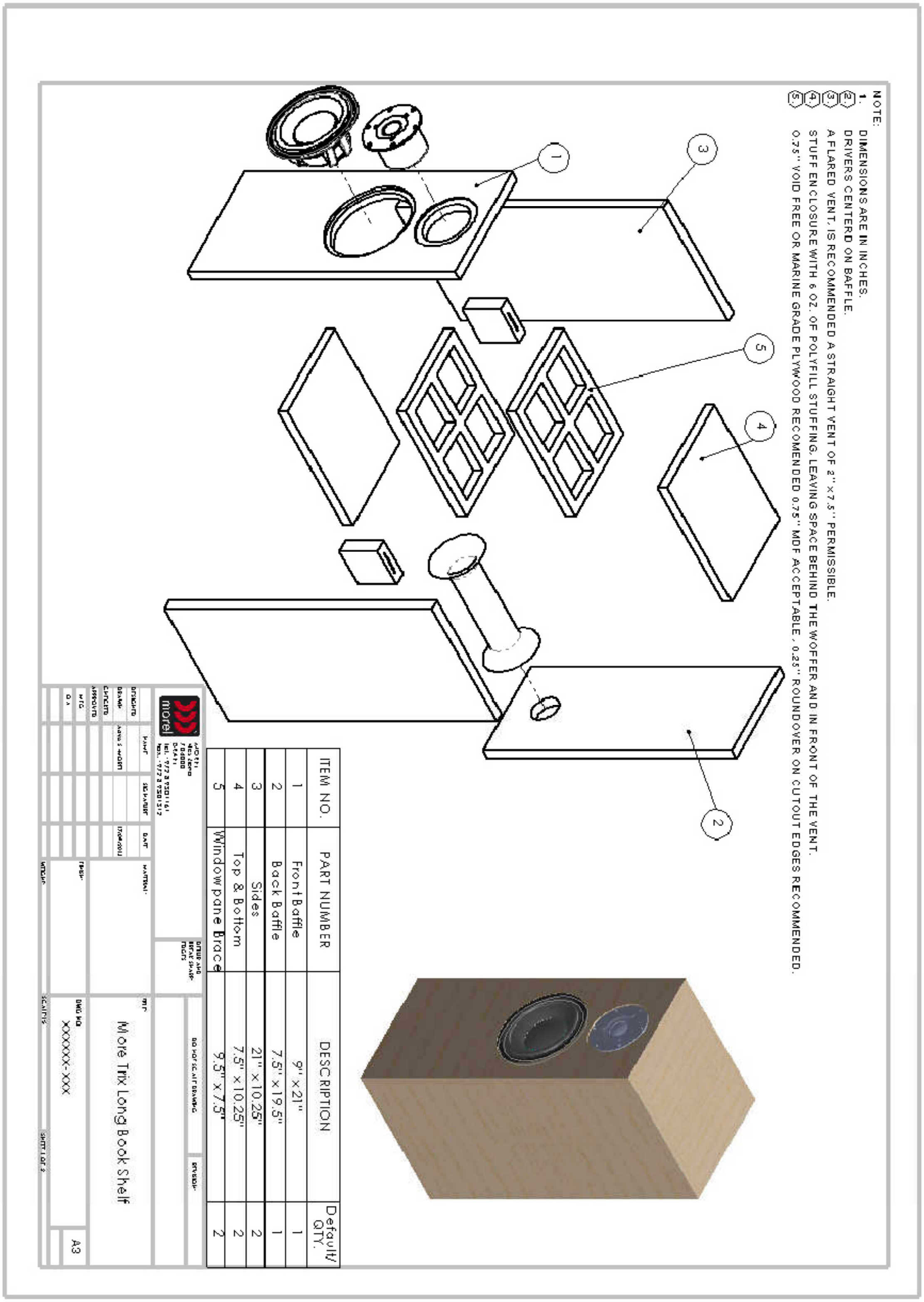

Figure I-Vented Bookshelf Exploded 3D View

To Open the PDF Document Click Here

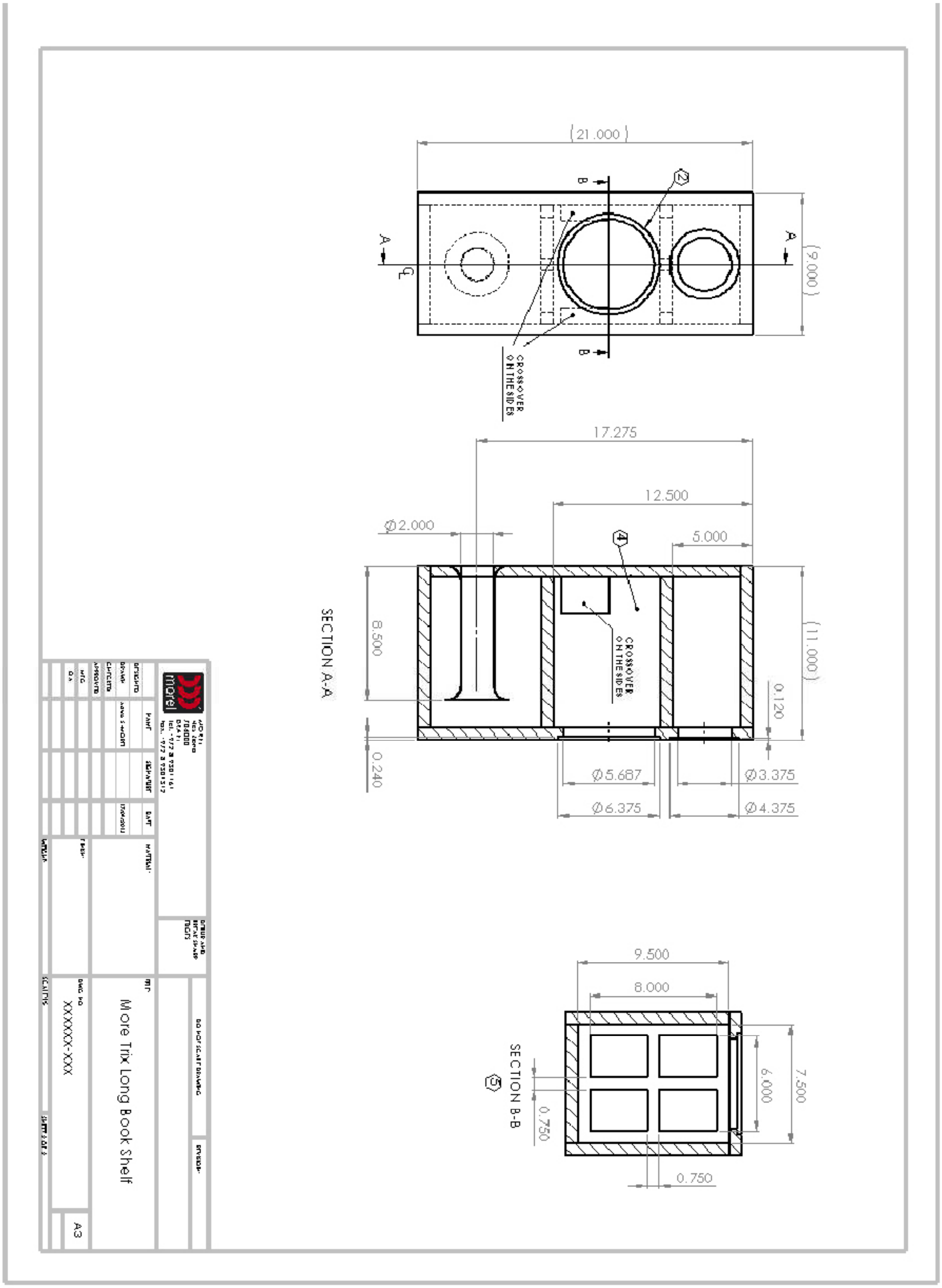

Figure J- Vented Bookshelf Drawing

To Open the PDF Document Click Here

MLTL Enclosure Drawing

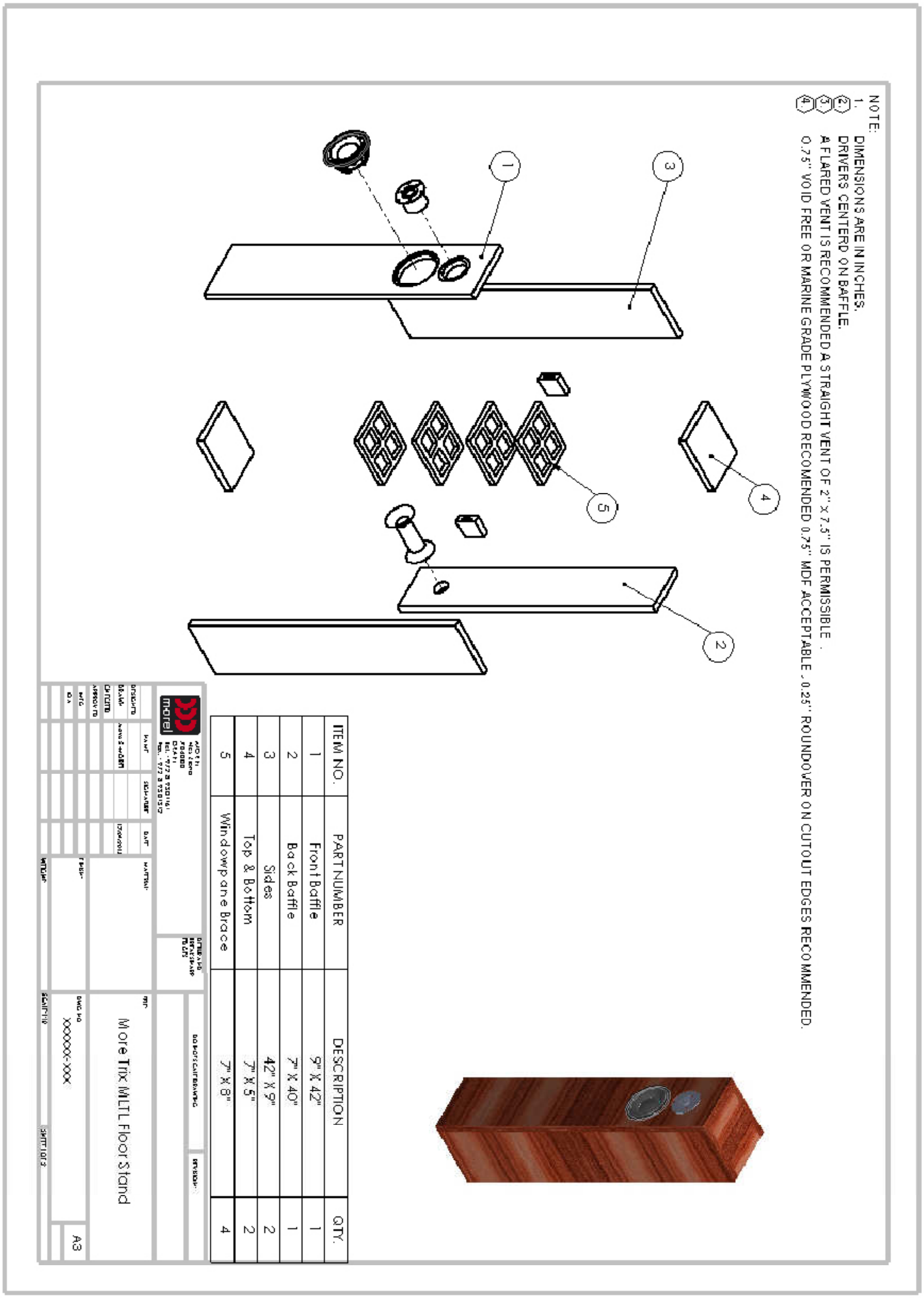

Figure K-MLTL 3D Exploded View

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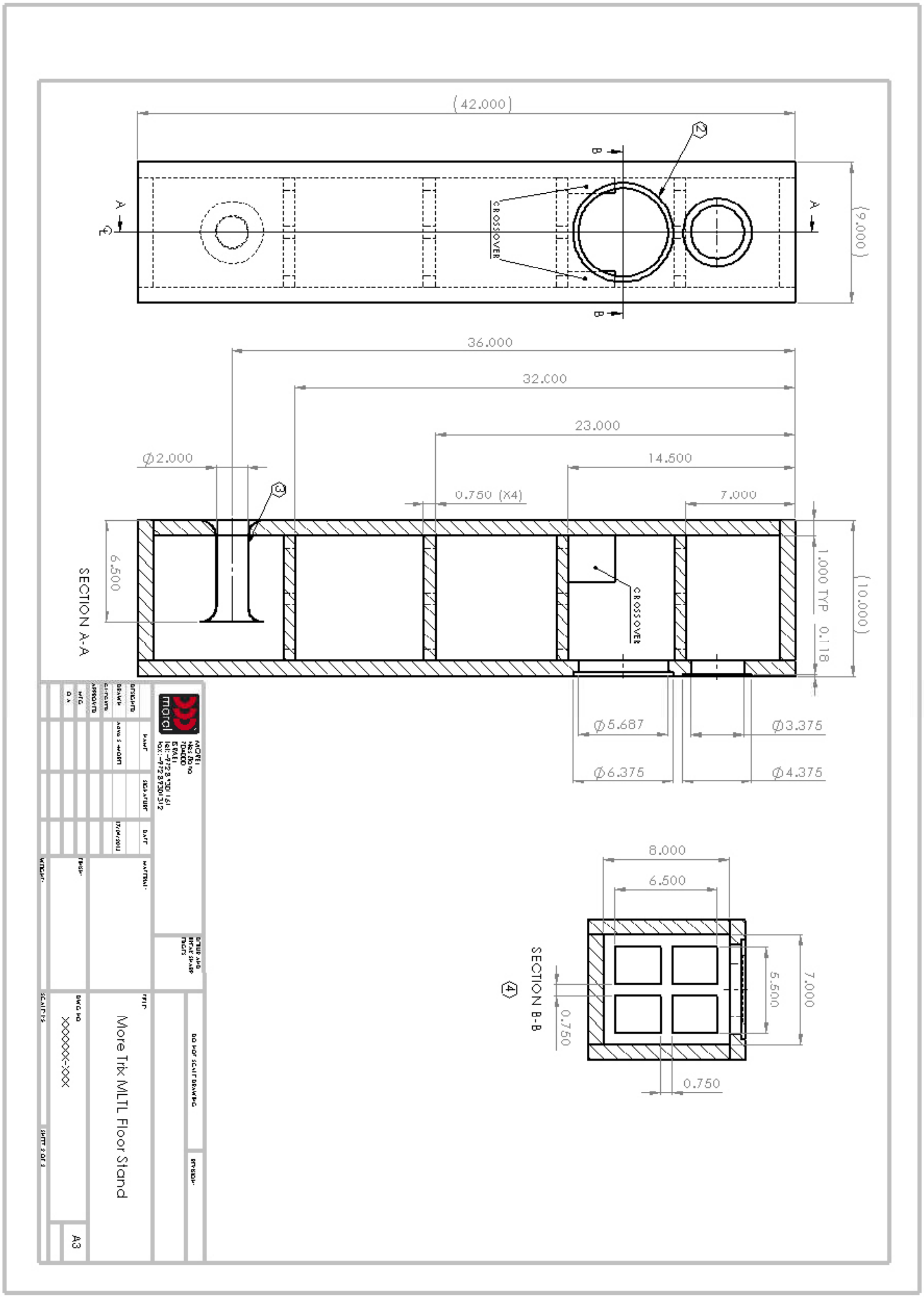


Figure L-Mltl Drawing

To Open the PDF Document Click Here

Woofer Crossover Component Layout

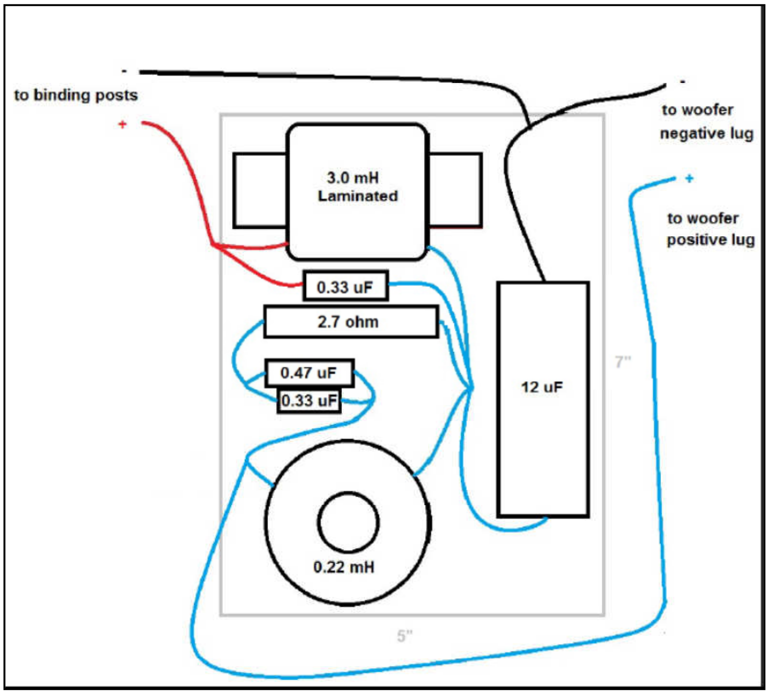


Figure M -Woofer XO Network Components Layout

Tweeter Crossover Component Layout

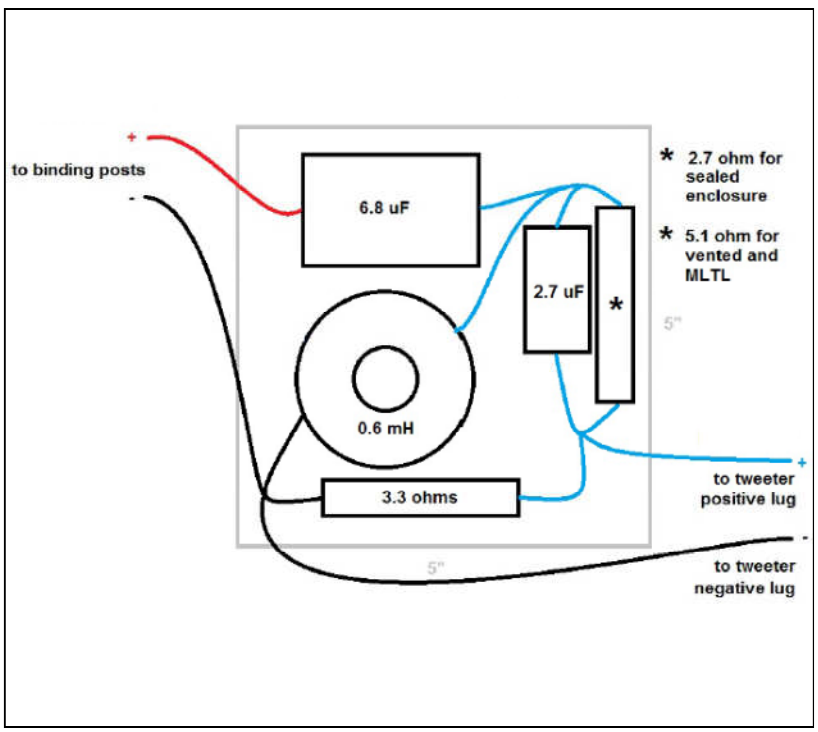


Figure N-Tweeter XO Network Components Network

Common Impedance Component Layout

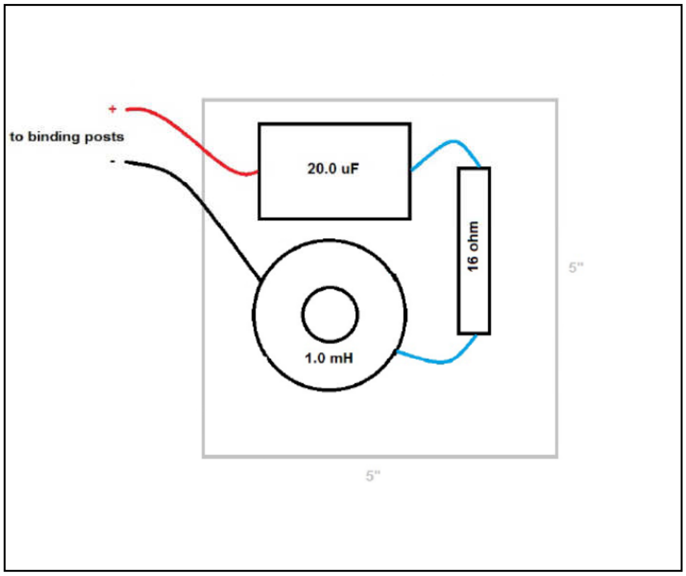


Figure O- Common Impedance Components Layout

Woofer Datasheet TiCW638Nd

morel

TiCW 638Nd

Titanium Advanced Woofer

Ø 6", Ø 3" voicecoil, 8Ω

SPECIFICATIONS

General Data		
Overall Dimensions	DxH	160mm (6.3") x 69mm (2.71")
Nominal Power Handling (DIN)	P	150W
Transient Power 10ms		1000W
Sensitivity 2.83V / 1M		87dB
Frequency Response		See graph
Cone Material		Injected Damped Polymer Composite
Net Weight	Kg	1.2 Kg

Electrical Data		
Nominal Impedance	Z	8Ω
DC Resistance	Re	5.40Ω
Voice Coil Inductance @ 1KHz	LBM	0.32 mH

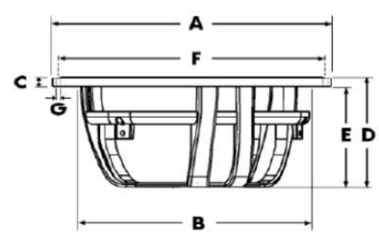
Voice Coil and Magnet Parameters		
Voice Coil Diameter	DIA	75 mm (3")
Voice Coil Height		15.5 mm (0.62")
HE Magnetic Gap Height	HE	5 mm (0.20")
Max. Linear Excursion	X	± 5.25mm
Voice Coil bobbin		Titanium
Voice Coil Wire		Hexatech™ Aluminum
Number Of Layers		2
Magnet System Type		Hybrid™ Neodymium/Ferrite
B Flux Density	B	0.78 T
BL Product	BXL	7.5 T.m

T-S Parameters		Small Signal	1 V
Suspension Compliance	Cms	0.70 mm/N	1.46 mm/N
Mechanical Q Factor	Qms	4.68	2.47
Electrical Q Factor	Qes	0.47	0.32
Total Q Factor	Qts	0.42	0.29
Mechanical Resistance	Rms	1.073 Ωm	1.339 Ωm
Moving Mass	Mms	16.80 gr	16.80 gr
Eq. Cas Air Load (liters)	VAS	14 Lt.	29 Lt.
Resonant Frequency	Fs	45 Hz	33 Hz
Effective Piston Area	SD	119 cm ²	119 cm ²

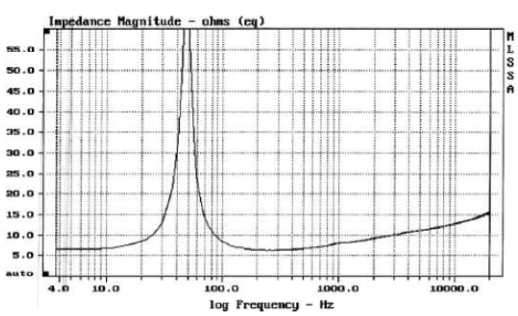
FEATURES

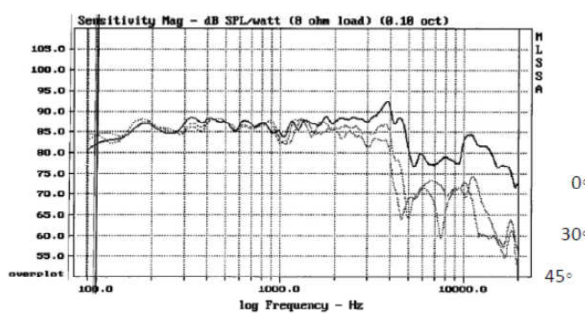
* Uniflow™ Aluminum diecast chassis
* Hybrid™ Neodymium/Ferrite magnet system
* Coppersleeve Neo™ Motor
* 3" Large Hexatech™ Aluminum voice coil
* Titanium coil bobbin
* High power handling
* High Xmax, Low Qts, Low Fs, High QMS

Unit Dimentions



A - Overall diameter	160mm
B - Cut out diameter	140mm
C - Flange thickness	6mm
D - Overall height	69mm
E - Basket + magnet depth	63mm
F - Mounting holes location diameter	152mm
G - 6 Mounting holes, at 60º interval, inner hole diameter	Ø 4.2mm





Measured on IEC baffle using Bruel & Kjaer 3144 model microphone.

Morel operate policy of continuous product design improvement, consequently specifications are subject to alteration without prior notice.

Figure P-Woofer Datasheet TiCW638Nd

Tweeter Datasheet ET338

ET 338
Elite Tweeter,
Ø 110mm, 8Ω

SPECIFICATIONS

General Data

Overall Dimensions	DxH	110mm(4.33")x66mm(2.59")
Nominal Power Handling (DIN)	P	200W
Transient Power 10ms		1000W
Sensitivity 1W/1M		92.5dB SPL
Frequency Response		1,800-20,000 Hz
Cone/Dome Material		Acuflex™ hand coated soft dome
Net Weight	Kg	1.08

Electrical Data

Nominal Impedance	Z	8Ω
DC Resistance	Re	5.2Ω
Voice Coil Inductance @ 1KHz	LBM	0.09mH

Voice Coil and Magnet Parameters

Voice Coil Diameter	DIA	28mm
Voice Coil Height		2.7mm
HE Magnetic Gap Height	HE	2.5mm
Max. Linear Excursion	X	
Voice Coil Former		Aluminum
Voice Coil Wire		Hexatech™ Aluminum
Number Of Layers		2
Magnet System Type		Triple Ferrite
B Flux Density	B	1.95 T
BL Product	BXL	6.3 N.A

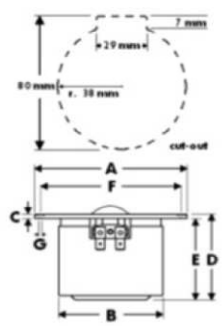
T-S Parameters

Suspension Compliance	Cms		
Mechanical Q Factor	Qms		
Electrical Q Factor	Qes		
Total Q Factor	Qts		
Mechanical Resistance	Rms		
Moving Mass	Mms	0.44 g	
Eq. Cas Air Load (liters)	VAS		
Resonant Frequency	Fs	700 Hz 10%	
Effective Piston Area	SD	6.0 cm ²	

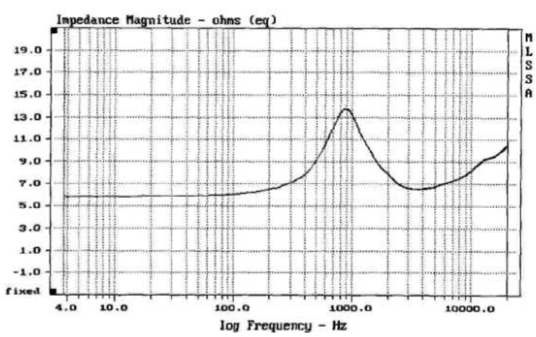
Features

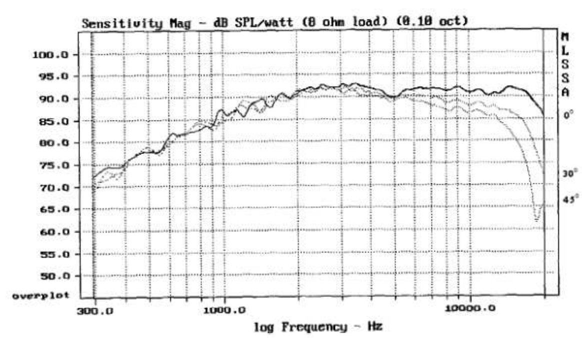
* 110mm IDR™ Improved Dispersion Recess
* Aluminum Face Plate
* Large Hexatech™ aluminum voice coil
* Replaceable Acuflex™ dome / coil assembly
* Triple magnet system
* High power handling
* Sturdy gold plated input tags

Unit Dimensions



A - Overall diameter	110mm
B - Magnet/Chamber diameter	76mm
C - Flange thickness	3mm
D - Overall height	66mm
E - Magnet/Chamber depth	63mm
F - Mounting holes location diameter	100mm
G - 6 Mounting holes, at 60º interval,	
inner hole diameter	Ø 3.7mm
pocket	h 1mm, Ø 7mm





This model replaces former Morel MDT-33 model. Faceplate finish available in either Black or Silver

Morel operate policy of continuous product design improvement, consequently specifications are subject to alteration without prior notice.

Figure Q- Tweeter Datasheet ET338