

# Parametric Speaker

By Paul Noel

217 Prospect St

New Haven CT, 06510

(989)450-9465

[paul.noel@yale.edu](mailto:paul.noel@yale.edu)

## Abstract

The Parametric Speaker allows one to project highly directional audible sound through the use of modulated ultrasonic transducers. The modulated ultrasound is then demodulated when it passes through a nonlinear medium (air). This occurs due to the high sound pressure level (SPL) and frequency, and the fact that the air compression and relaxation take different amounts of time. This produces a wave that interacts with itself, creating waves of the sum and difference (heard).

## Construction of Apparatus

The Parametric Speaker consists of a transducer array, a drive circuit, and audio source (phone, radio, computer, etc.). The drive circuit takes a 40 kHz carrier input which is then modulated with the audio source. After amplification, it is sent to the transducer array. The input audio signal might need to be separately amplified depending on the source.

The transducer array can also be used as a 2D acoustic trap as shown by UPNALabs on Instructables.com where they review the software, circuit, and technique.

## Drive Circuit

The drive circuit can be constructed in multiple ways depending on the available components and skill level of the builder. The simplest approach is to use a waveform generator that can modulate a signal. The output of this waveform generator then needs to be amplified. This can be achieved with an ordinary PA amplifier (70 V). The audio signal might need to be amplified as well and can be done using any small low distortion voltage amplifier. To build the simple drive circuit, four parts are needed.

1. A modulator: This can be something as simple as a 555 timer IC or a TL494 (pulse width modulation PWM IC).
2. An H-Bridge (L293 or IR2111 IC), which helps separate the inductive load from the modulating chip.
3. The amplifier: This can be accomplished with a pair of IRF540 MOSFETs.
4. A 24V power supply. This can be built from scratch, but buying or finding a power supply is quicker and easier. In Appendix I, two sample drive circuit schematics are shown.

Some modulation techniques yield more total harmonic distortion (THD) than others. A good rule of thumb is the more complicated the modulation technique, the less THD. This

means that PWM is the easiest to prototype but has a lot of THD. Other forms of modulation, in order of more THD to less are: basic double side band AM, root square AM, and recursive single side band AM. FM, like PWM, works but can yield distortion, with phase modulation working the best of the frequency modulation methods.

Preprocessing can be done to counter some of the distortion and give better sound, but this is extremely complex. If desired it is possible to do this with a good programable audio chip like Adu1701 or with some fast microcontroller.

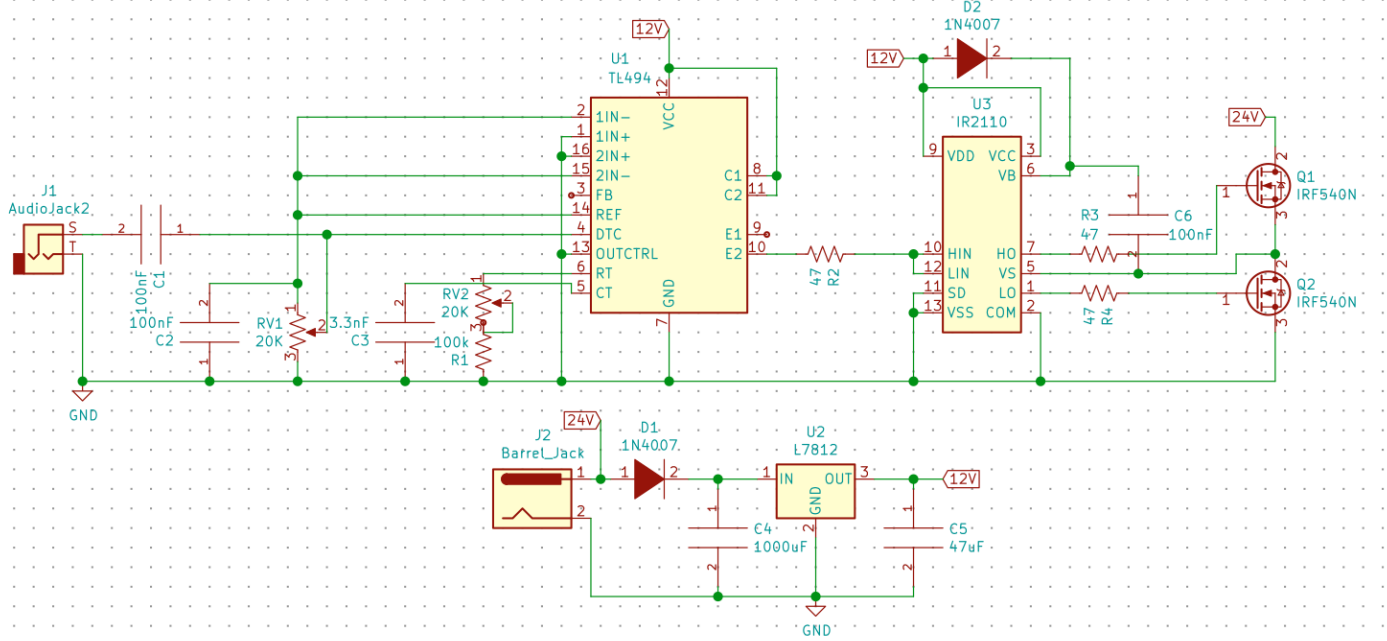
## **Uses**

The Parametric Speaker is best as a demo for small to medium size groups (1-50 people). To demonstrate it, point the speaker at a large group and move it around. Try pointing it at the ceiling and walls and ask where the sound is coming from. It is also nice to use a reflector (poster board) to direct the sound beam around the room.

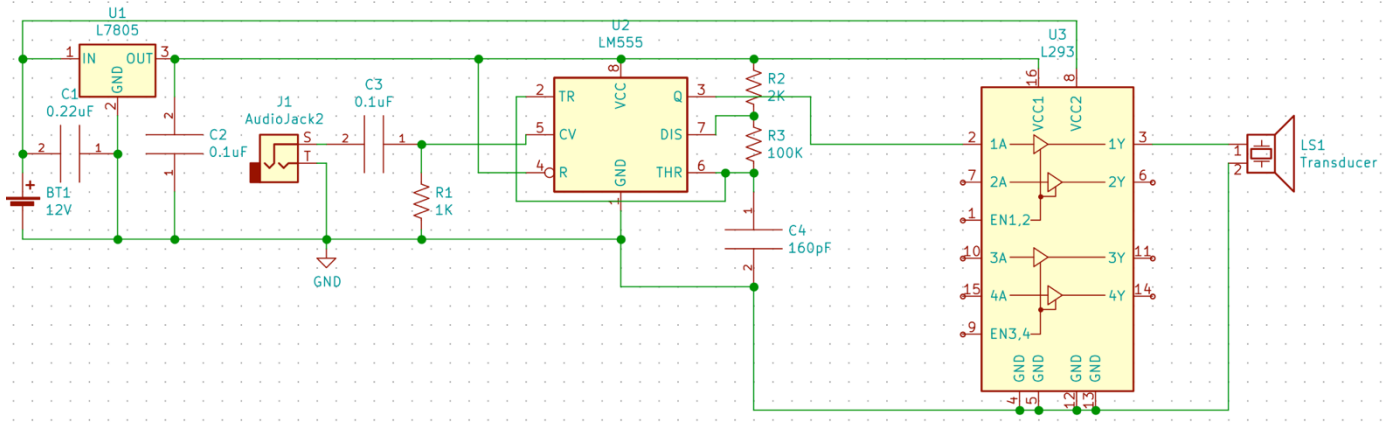
## **Safety**

The SPL of the ultrasound needs to be very loud (120-140 dB), the max 8-hour exposure for 40kHz is 120dB. At 120dB, the audible sound will be 60-70dB. Don't worry though as higher frequency sound waves attenuate more in air (40kHz the wave losses 1dB/m). More information can be found at [https://github.com/penoel/Parametric\\_Speaker](https://github.com/penoel/Parametric_Speaker).

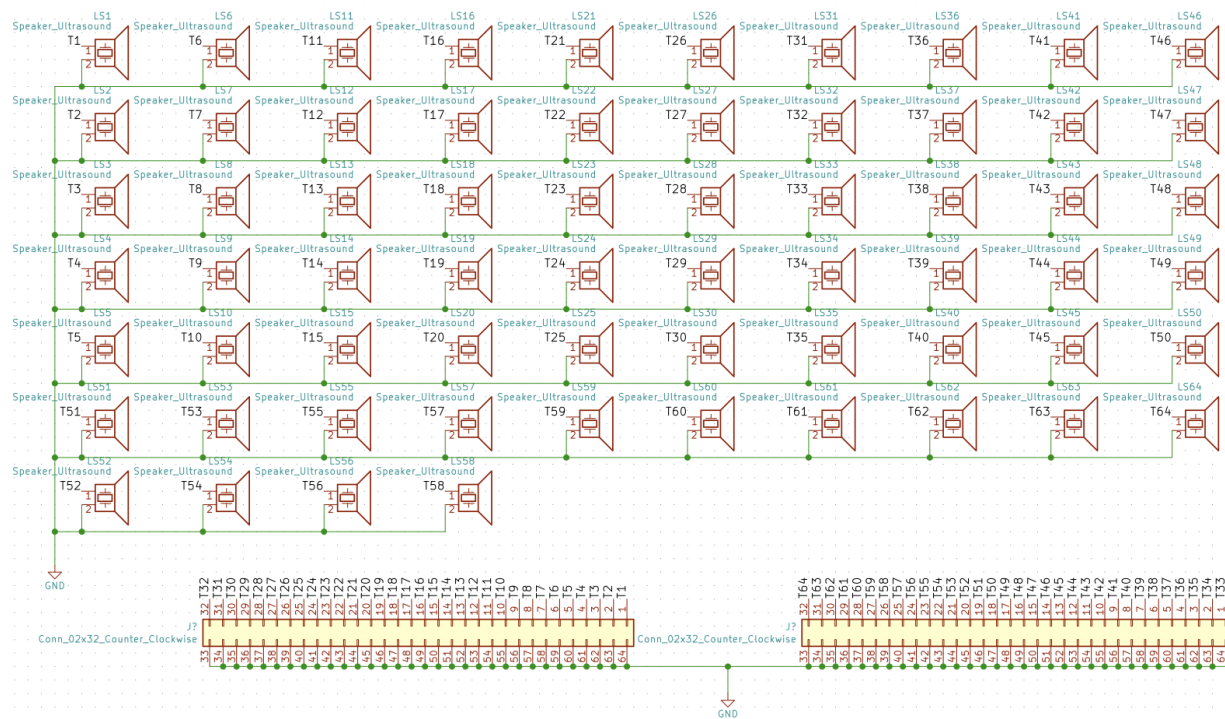
# Appendix I:



Drive circuit using a TL494



Drive circuit using 555



Transducer array that allows for both the parametric speaker and a 2D acoustic trap to function from one board.

## Appendix II:

Vendor	Part Number	Description	Unit Price \$	Quantity	Price \$
Aliexpress		40 kHz 16 mm transmitter TRANSDUCER	0.50	64	32
JLCPCB		CUSTOM PCB	0.2	1	0.2
Digikey	364-1283-ND	POWER SUPPLY 24V	9.98	1	9.98
Digikey	IRF540ZPBF-ND	IRF540	1.06	2	2.12
Digikey	IR2111PBF-ND	H BRIDGE IR2111	2.97	1	2.97
Digikey	296-10194-5-ND	DC DC SWITCHING CONTROLLER	0.74	1	0.74
Digikey	497-1452-5-ND	12V REGULATOR	0.45	1	0.45
Digikey	CP1-3515N-ND	HEADPHONE JACK	1.08	1	1.08
Digikey	S47QCT-ND	47Ω RESISTOR	0.1	3	0.3
Digikey	CF18JT470RCT-ND	100K RESISTOR	0.1	1	0.1
Digikey	3386P-203TLF-ND	20K POTENTIOMETER	2.48	2	4.96
Digikey	641-1312-1-ND	1N4007 Diode	0.11	2	0.22
Digikey	BC2686CT-ND	CAP CER 0.047UF 50V X7R RADIAL	0.19	2	0.38
Digikey	BC1075CT-ND	CAP 3.3nF 50V	0.25	1	0.25
Digikey	478-2472-ND	CAP 100nF 50V	0.2	4	0.8
Digikey	732-8823-1-ND	Cap 47uF 25V	0.1	1	0.1
Digikey	493-1065-ND	Cap 1000uF 25V	0.49	1	0.49
					57.14