Tannoy Monitor Gold Crossover Network Inductor Measurements

Martin Ackroyd, November 2009

Summary of results

I measured the parameters of the inductive components in the crossover units of a pair of Tannoy Monitor Gold 15″ loudpeakers.

The results were as follows:

1. Autotransformer used in the HF unit highpass filter:

Voltage step up ratios: -1.5 dB, 0 dB, +1.5 dB, +3 dB, +4.5 dB.
"primary" winding (the 0dB tapping): 2.6 mH, 0.7 ohm.

2. Inductor of lowpass filter for LF unit: 2.9 mH, 0.6 ohm.

3. Inductor of high-frequency series-tuned correction circuit: 0.82 mH, 12 ohm.

This information should be sufficient to construct or to specify the inductors for constructing an equivalent crossover network. The voltage ratios given above were rounded to the nearest 0.5 dB. I estimated that the measured inductance values are accurate to within 5 per cent.

Introduction

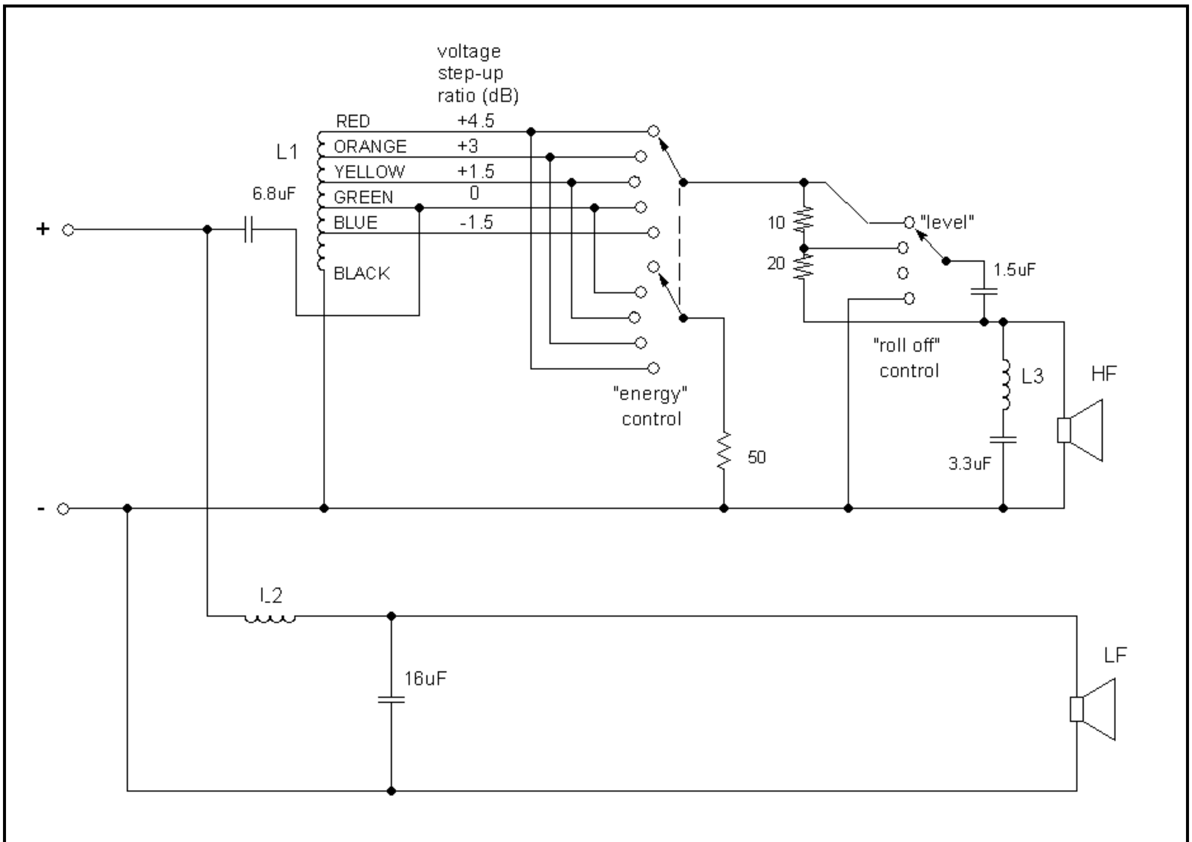
I have a pair of Tannoy Monitor Gold 15″ units in their original Lancaster enclosures. I want to build a pair of enclosures of my own design to house the Dual Concentrics but leaving the Lancaster enclosures untouched. This means I will need to construct crossover networks to install in the new enclosures.

The Tannoy circuit diagram for the crossover network for the Monitor Gold 15″ is available on the Web. The same crossover is also used for the 12″ Monitor Gold. The Tannoy circuit diagram gives the values for the capacitors and resistors but is rather coy about the inductive components. To get the information I needed, I opened the cases of the crossovers and made measurements on the inductors, as detailed below. It was clear that my crossovers had never previously been opened, so the components within are undoubtedly the originals, installed at the time of manufacture by Tannoy. The serial numbers of my speakers are 118476 and 118584.

With the cases opened, I took the opportunity of replacing the 16 uF capacitors (the only electrolytics in the crossovers) with modern plastic/foil capacitors.

The results of my measurements may be useful to other people who want to construct or to renovate crossover networks for their Monitor Golds.

<u>Monitor Gold crossover circuit</u>



Here is the circuit diagram of the Tannoy crossover. The lowpass filter feeding the LF speaker coil is a conventional second-order LC circuit. The circuit feeding the HF speaker coil consists of the following sections:

1. A second-order LC filter, consisting of the 6.8 uF capacitor and the portion of L1 between its green and its black connections

2. A voltage step-up/step-down control, using L1 as an autotransformer, with its input voltage applied between the green and the black connections and the output taken from between the black connection and one of the other five connections. This is the so-called "energy" control.

3. A tone control - the so-called "roll off" control, that gives two settings of frequency dependent high-frequency boost, one setting of little or no high-frequency boost, where there is simply a series resistance of 30 ohms feeding the HF speaker coil, and one setting of attenuation that increases with frequency. The setting that gives maximum high frequency boost is marked "level" on the Tannoy control unit.

4. A series tuned circuit, L3 in series with 3.3 uF, that reduces the current reaching the HF voice coil over a frequency range of about one octave centered at about 3 kHz

The load on the output of the highpass filter, due to the voicecoil of the high frequency driver, varies with the setting of the "energy" control. The loading due to the 50 ohm resistor varies in the opposite sense, partially compensating and reducing the total variation of load. Calculations show that a lower value of resistor would give better compensation for the variation in damping but there may be other reasons for using 50 ohms that I am unaware of.

To build an equivalent crossover network, the following information should be sufficient, together with the resistor and capacitor values:

- the inductance between the black and green connections of L1 and the winding resistance between these connections..

- the voltage step up (or step down) ratios for each of the output connections of the autotransformer, with input applied between the black and green connections.

- the inductance and resistance for the other two inductors L2 and L3.

In the results below, I also give the measured inductance between the black connection and all of the other connections for L1, although only the inductance between the black and green connections is actually needed to construct an equivalent highpass filter.

<u>Measurements</u>

I used a Marconi TF 2700 bridge for inductance measurements. I don't know the accuracy of my TF 2700 when measuring inductances, but loudspeaker crossover networks made with inductors measured by using it turn out to have characteristics very close to theory (ie within 1 dB). This suggests that, whatever its actual accuracy, it is adequate for characterising components in loudspeaker crossover networks.

I made spot checks of several inductance measurements by measuring the resonant frequencies of the inductors with a capacitor, measured at 1.02 uF, connected in parallel. I used a precision frequency counter to do this. From the measured resonant frequency, the inductance is easily calculated. Each inductance checked by a resonance measurement differed by less than five percent from the corresponding value measured using the TF 2700, so I think it is likely that my inductance measurements were accurate to at least five per cent.

I measured the inductance values for L1 for the two crossovers. The measured values for the two inductors were very close to each other. In every case, they differed by no more than 3.3%.

Here are the results of the inductance and resistance measurements for L1. I have given here the mean of the measurements made on the inductors from the two filters, although the values were so close that it makes very little difference..

black - red	8.4 mH	1.3 ohm
black - orange	5.5 mH	1.0 ohm
black - yellow	3.9 mH	0.8 ohm
black - green	2.6 mH	0.7 ohm
black - blue	1.9 mH	0.6 ohm

I also measured the voltage ratios of L1 as an autotransformer. I applied a 1 volt signal from an audio amplifier between the black and the green connections and I measured the voltage at the various tappings with a Hewlett-Packard 3400A rms voltmeter. I used a frequency of 1 kHz for the measurements and I repeated them using 10 kHz. There was no significant difference between the measurements at the two frequencies.

Here are the step up ratios I measured. I have also given the voltage ratio in decibels, rounded to the nearest half-decibel.

	measured voltage ratio	approximate dB equivalent
black - red	1.75	+ 4.5 dB
black - orange	1.42	+ 3 dB
black - yellow	1.20	+ 1.5 dB
black - green	1	0 dB
black - blue	0.86	- 1.5 dB

The voltage ratio of a transformer is directly proportional to the number of turns on its secondary winding, whereas the inductance of a coil is proportional to the square of the number of turns on the coil - assuming small leakage inductance. This means that the square of the voltage ratio should equal the inductance, to within a scale factor.

The table below shows the square of the measured voltage ratio and the inductance at each tapping, normalised to unity for the black-green tapping. There is a good match, which increases confidence in the measurements - at least, that I have not made a silly mistake somewhere.

	measured voltage ratio squared	normalised measured inductance
black - red	3.063	3.182
black - orange	2.016	2.061
black - yellow	1.440	1.508
black - green	1.000	1.000
black - blue	0.740	0.742

For L2, the values I measured were as follows.

speaker 118476	2.81 mH	0.6 ohm
speaker 118584	3.02 mH	0.6 ohm

The difference between the two measured values is about 7 per cent. A value of 2.9 mH, or 3 mH if more easily obtainable, should be fine for constructing a duplicate crossover network.

For L3, I measured values as follows for my two crossovers.

speaker 118476	0.81 mH	11.6 ohm
speaker 118584	0.82 mH	11.5 ohm

The measured values for L3 in the two crossovers are essentially identical. An inductor with an inductance of 0.82 mH would be right for L3.

Discussion of results

The inductance values I measured for L1 and L2 are significantly different from values that appear some Tannoy circuit diagrams available on the Web. I don't know the reason why these diagrams are annotated with values significantly different from what I measured. On the circuit diagrams I have seen, it is noticeable that the values were penned in a different hand from that of the draughtsman responsible for the original diagram. In contrast to the case for L1 and L2, the inductance values I measured for L3 are essentially the same at the value (820 uH) appearing on several Tannoy circuit diagrams posted on the Web.

I noticed that both L1 and L2 in my crossovers have a piece of paxolin or similar material in the gap between the 'E' and the 'I' shaped laminations which I estimated as being about 3 mm thick. Undoubtedly, if this were replaced by a piece with a different thickness, the inductance would be changed.

It might be difficult to obtain an autotransformer having both the right inductance between the two relevant connections and also having the right voltage step-up ratios. However, if a transformer with suitable step-up ratios but too large an inductance were available, this could easily be corrected by connecting an inductor in parallel, to give the correct total inductance. An autotransformer for use as a replacement in Klipsch loudspeakers is sold on eBay in the USA and this might be adaptable to the purpose.

Generally, in making crossover networks, using an inductor with less resistance than specified gives no problems. I think it safe to assume that this rule will apply to L1 and L2 so that the resistance of these inductors can be anything so long as it is not significantly more than the values I measured.

However, in the case of L3, a low resistance coil would be inappropriate. This is because it would give a sharp dip in the overall frequency characteristic at the resonance frequency of the series tuned circuit. I would suggest using a coil of the same resistance or, equivalently, connecting a resistor in series to bring the total resistance up to 12 ohms.

As I said in the introduction, the results of my measurements may be useful to other people who want to construct or to renovate crossover networks for their Monitor Golds.