Understanding some of the advantages of audio transformers as compared to direct input into active electronic devices often misunderstood. The rating methods for Common Mode Rejection Ratio (CMRR) can be different. CineMag performs these tests in accordance with IEEE-389-19 as may be amended by IEEE. Companies that employ devices which do not use audio transformers ("Direct Input Companies") often ignore this test protocol thereby yielding different results.

Direct Input Companies usually rate their CMRR by adding in the gain to the unity gain CMRR. Audio transformer tests which comply with IEEE-389-19 do not factor in this gain factor.

Analog Devices MT-042 provides a useful guide of how manufacturers of integrated circuits report CMRR data. Figure 1below provides the equation often used to express CMRR for integrated circuits. While measurements with this circuit topology are very sensitive to resistor matching, the mathematics are fundamental to measurement calculations.
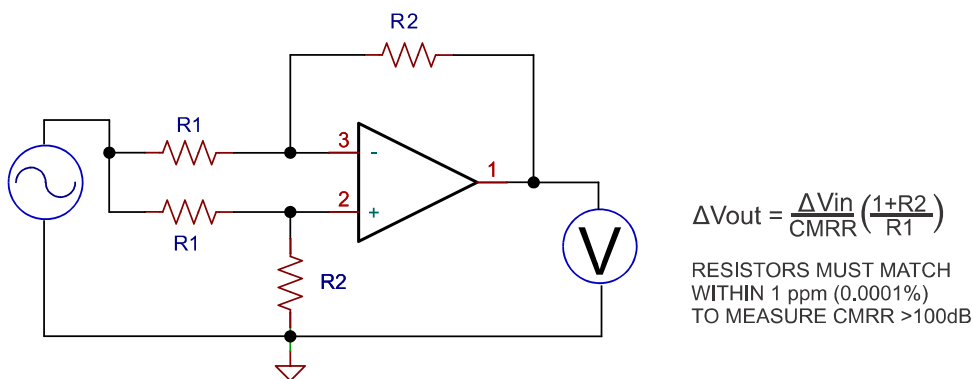

$$\Delta Vout = \frac{\Delta Vin}{CMRR}\left(\frac{1+R2}{R1}\right)$$

RESISTORS MUST MATCH
WITHIN 1 ppm (0.0001%)
TO MEASURE CMRR >100dB

Figure 1

Formula 1: (1 + R2/R1) establishes the gain of the circuit. Solving for CMRR:

$$\Delta Vout = \frac{\Delta Vin}{CMRR}\left(\frac{1+R2}{R1}\right)$$

$$CMRR * \Delta Vout = \Delta Vin \left(\frac{1+R2}{R1}\right)$$

$$CMRR = \frac{\Delta Vin \left(\frac{1+R2}{R1}\right)}{\Delta Vout}$$

Hence, the gain of the circuit is added into the published CMRR. Assuming unity gain and CMRR of 80dB with gain set to +20dB, CMRR is reported at -100dB. Formula 1 gives the result as a voltage ratio. It can be converted into decibels by multiplying the result by (-20log * CMRR). Circuit gain is added into the result with this methodology.

Transformer CMRR is measured in a different manner when performed according to the IEEE transformer standard. The step-up voltage gain is ignored.
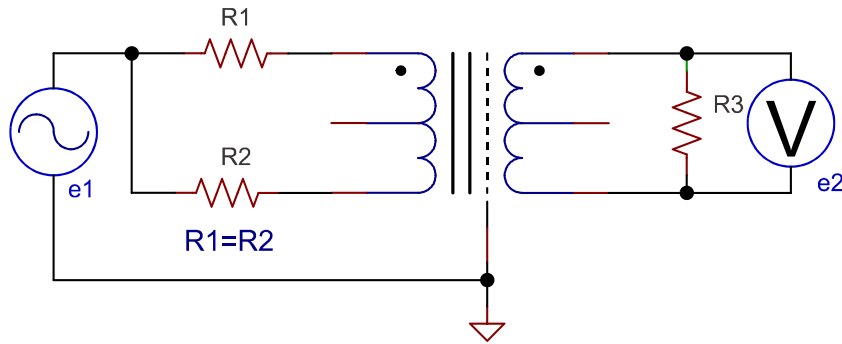

Figure 2

Formula 2 (IEEE 389-19):   CMRR = -20 log (e2/e1) [dB]

Using IEEE 389-19, the voltage gain (or loss if step-down) of the transformer in Figure 2 is not considered in the formula. Assume for illustration that the transformer voltage gain is +20dB. If the measured CMRR at a selected frequency were -80dB, the reported CMRR would ignore the 20dB and remain at -80dB. If Formula 1 were to be used for the transformer, CMRR would be -100dB.

Consider next the ancillary problem of isolating the different signal grounds between systems when they operate off of different power supplies. Power supply transformers cannot 100% isolate each system from the mains power and the systems' signal grounds. This means that each stage that has a power supply connected to the mains power will interact albeit at a low level. Because high performance audio systems are sensitive to very low level issues, these phenomena are seldom (if at all) explored from an engineering perspective. CMRR measurements ignore this additional path for interaction and interfering signal injection.

CMRR is only part of the problem of isolating different stages from other stages.

References

1)   *IEEE-389-19*
2)   Analog Devices *MT-042*
3)   *Common Mode Rejection Ratio in Differential Amplifiers*
     Ramon Pallas-Areny & John G. Webster
     IEEE Transactions on Instrumentation & Measurement, Vol. 40, No 4, August 1991