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Improving Audio Performance of Microphones Using a Novel Approach to Generating 48 Volt Phantom Powering

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ABSTRACT

The introduction of the 48-volt phantom powering circuit in 1966 led to IEC 61938:1996. A key aspect of this powering circuit are the 6.81 kΩ precision resistors that are in parallel to the emitter-follower of the microphone preamplifier. These resistors act as a load on the emitter-follower which causes added distortion. A new approach is presented whereby, in series of these 6K8 resistors, an electronic circuit is placed that acts as a high input-impedance current source, which does not load the emitter-follower. By making this change, THD is decreased by 10 dB while also slightly improving the gain. Measurement results are presented comparing audio performance of a conventional 48-volt phantom power circuit and this new circuit along with circuit details.

1 Introduction

Co-author Joost Kist has been involved with recording engineering for a number of years. He also builds his own recording equipment and was not satisfied with the performance he was getting from the 48-volt phantom power supplies which use 6.81 kΩ resistors (referred to a 6K8 in the remainder of this paper). He came up with a novel design that uses a current source instead.

This paper investigates the audio performance differences when the 6.81 kΩ precision resistors, which are required by the IEC 61938 standard, are replaced with a 6K8 resistor in series with a high input-impedance current source.

2 Current Design (P48)

In the IEC 61938 standard, providing 48-volt phantom power to a condenser microphone requires two passive, high-precision 6.81 kΩ resistors (matched to within ± 0.4%)[1]. In this paper, such a design will be referred to as P48.

Figure 1 depicts a complete microphone system consisting of the condenser microphone capsule with its associated 48-volt, phantom-powered emitter follower circuit (❶), XLR cable (❷) and a 48-volt phantom power supply which is typically part of the microphone preamplifier found in a mixing console or recording converter. The P48 can also be a separate box. The emitter follower circuit (❶) is the Schoeps design from the mid 1960's.

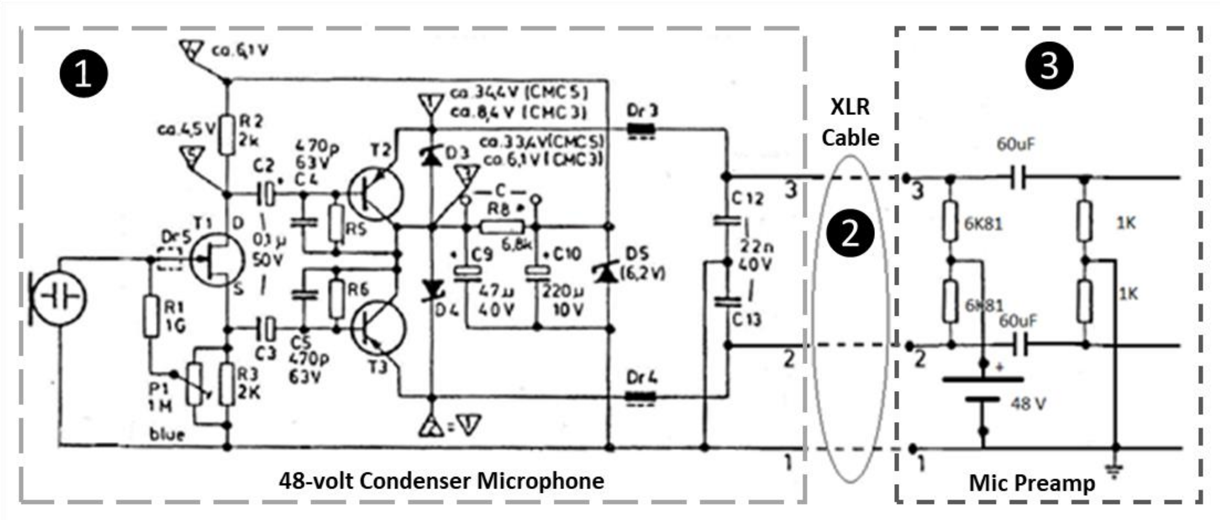

Figure 1. Complete microphone system.

For a good understanding of the new phantom power supply, it is necessary to understand standard phantom power (P48) in the first place. It is a 48-volt power supply and two 6K8 resistors, located in the preamp AND two emitter followers in the condenser microphone, on the other end of the XLR microphone cable.

Since the 6K8 resistors are in parallel with the 1 kΩ resistors of the mic preamplifier (see figure 1 section 3) , the resulting load "seen" by the emitter follower will be less than 1 kΩ per Equation 1. With R_1 being 6810 Ω and R_2 being 1000 Ω, the impedance "seen" by the emitter follower (R_{tot}) will be 872 ohms.

The ramifications of how this effects distortion will be presented later in this paper.

$$R_{tot} = \frac{R_1 * R_2}{R_1 + R_2} \qquad (1)$$

3 New Design Using Current Source

Another approach to supplying 48-volt phantom powering is to utilize a voltage-controlled current source in series with 6K8 resistors. In Figure 1, the 48 volt power supply is now replaced by two 48-volt regulated current sources. Figure 2 shows a schematic of this design which be referred to as True Phantom throughout the rest of this paper[2]. To ensure that the current sources will function properly, the voltage needs to be 14 volts *above* the 48 volts needed for phantom powering. This is why a total voltage of 63 volts is used in this design. Finally, a DC servo is used to regulate the output of the current source to be 48 volts. This design is patent protected[3].

The major benefit of this design is that the load of the emitter followers is now not 6810 Ω in parallel with 1000 Ω (mic preamp input impedance), but 2.00681 MΩ in parallel with 1000 Ω. (the Ri of the current source is 2MΩ) Per Equation 1, the load impedance as "seen" by condense microphone emitter follower is now 999.5 ohms.

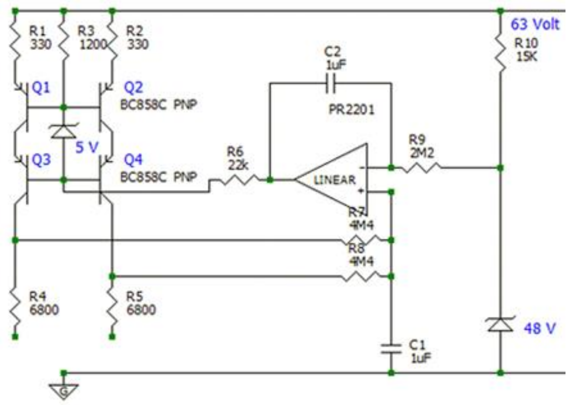

Figure 2. Current-source design – True Phantom.

Table 1 summarizes the load "seen" by the condenser microphone's emitter follower with the P48 and True Phantom designs. Note that the P48 design has the effect of changing the emitter follower load by almost 13% from 1 kΩ whereas the True Phantom design maintains the load at 1 kΩ.

Resistance	Mic Preamp Impedance	Load on emitter follower	Difference from 1 kΩ
6810Ω (P48)	1000Ω	872 Ω	12.8%
2,006,810Ω (True Phantom)	1000 Ω	999.5 Ω	0.05%

Table 1. Emitter follower load

4 SPICE Analysis

SPICE Analysis[4] was used to model the P48 and True Phantom designs regarding the distortion level of a 1 kHz sine wave at Test Point 1 (grey arrow pointing to TPdv1 in Figure 3).

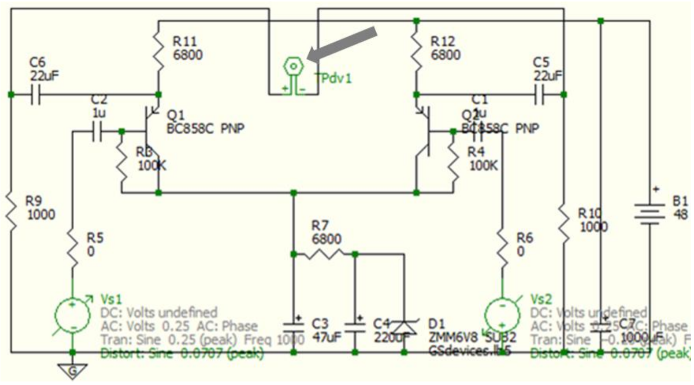

Figure 3. Circuit being modelled using SPICE

Table 2 shows the results of the modelled THD of the P48 and True Phantom designs at four different peak voltage levels. Note that the THD of the True Phantom design is basically 4 dB lower at these four different peak levels when compared to the P48 design.

1kHz level (mVp)	1kHz level dBV)	P48 THD (dB)	True Phantom THD (dB)	THD Diff (dB)
70.7	-26	-113.0	-117.1	4.1
141.4	-20	-100.4	-104.4	4.0
212.1	-16.5	-93.2	-97.1	3.9
282.8	-14	-88.0	-92.0	4.0

Table 2. THD results from SPICE Analysis

5 Measurement Results

An Audio Precision APx 555 was used to measure the distortion performance of a phantom power supply based on the IEC standard (P48) and True Phantom designs. A PCB Model 426A14 48-volt phantom powered microphone with a dummy microphone was connected to the analog output of the APx 555. Figure 4 shows a diagram of the test setup where both P48 and True Phantom external power supplies were used. The High-performance Sine Generator and High-performance Sine Analyzer settings were used in the APx 555 so as to minimize any distortion and noise from the measurement equipment itself.

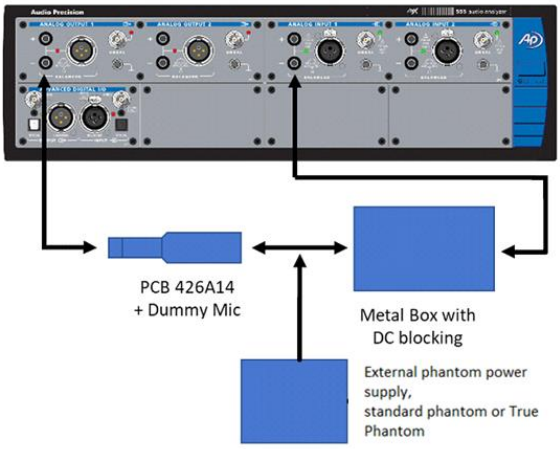

Figure 4. Test Setup

In order to create a realistic test situation, the microphone's emitter follower, in this case the PCB Model 426A14, needs to "see" a load equivalent to that of a typical microphone preamp. To replicate this, a metal box with blocking capacitors and two 1 kΩ resistors to the ground were used. The capacitors used were Panasonic 56µF Polypropylene Capacitor PP 800V dc ±10% Tolerance Through Hole EZPE Series. Figure 5 is the schematic diagram of what was inside the metal box and Figure 6 is a picture of the metal box used for these measurements.

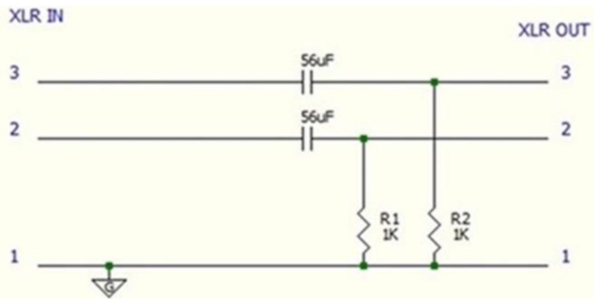

Figure 5. Schematic of DC-blocking circuit

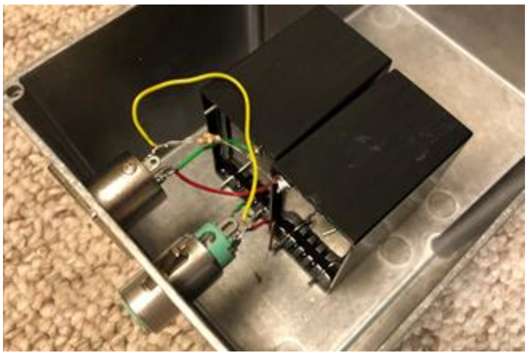

Figure 6. Metal box with DC-blocking

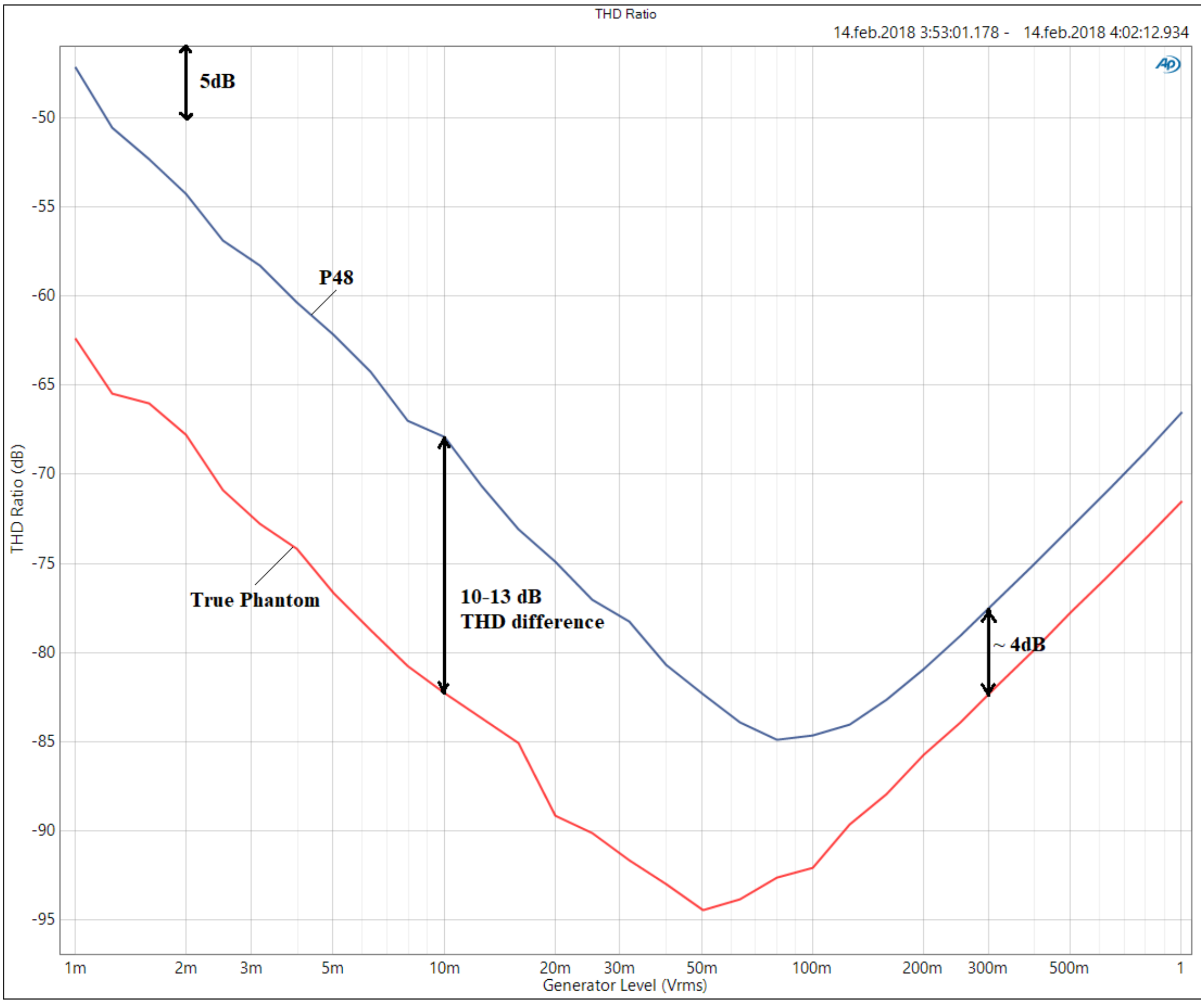

Figure 7. THD of P48 and True Phantom.

Figure 7 shows the THD of the P48 and True Phantom. The True Phantom has lower THD throughout the excitation range of -60 dBV to 0 dBV. At the lower voltage levels (-60 dBV to -25 dBV), the True Phantom has THD that is close to 13 dB lower than the P48. At levels above -25 dBV, which correspond to the levels used in the SPICE model, the THD differences match exactly with what the model predicted: 4 dB.

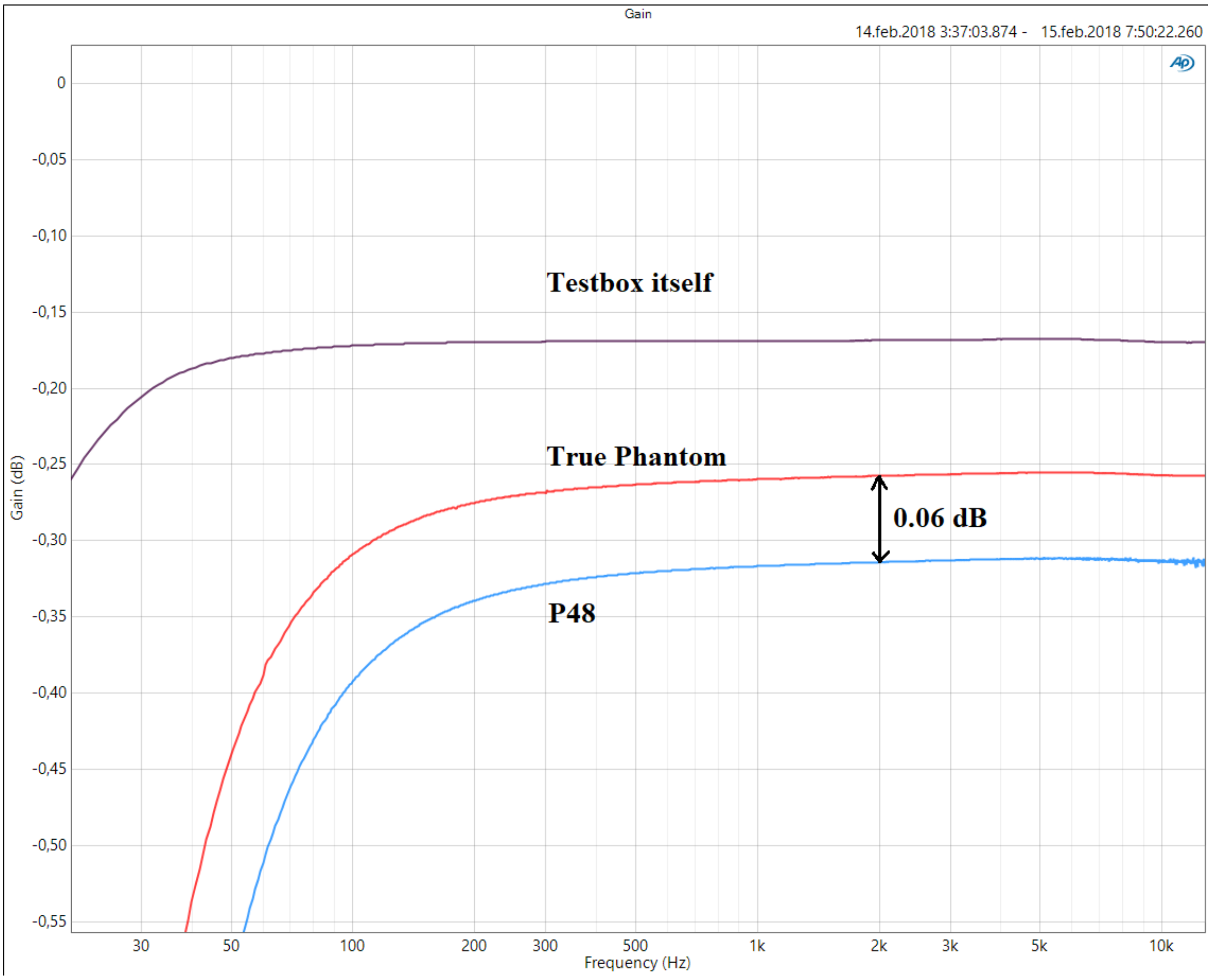

Figure 8. Gain.

Because of the difference in load, the gain is slightly higher.
Note that the roll off of the P48 and True Phantom are the result of the roll off of the testbox and the roll off of the APx 555 in series with the roll off of the PCB dummy microphone.

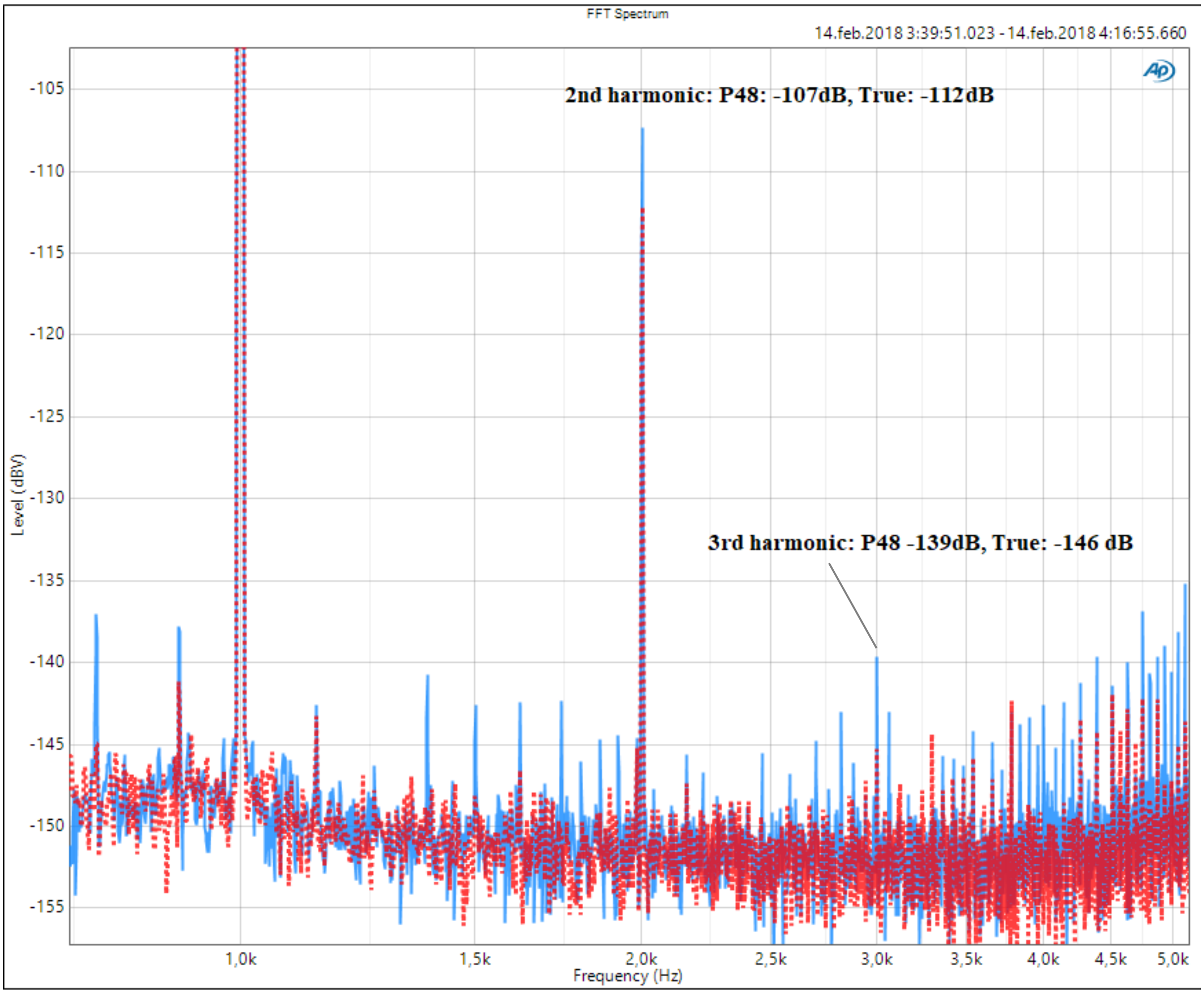

Figure 9. FFT

This FFT is made with an input of 141.1mV RMS (same as one of the used levels in the SPICE analysis) at 1000Hz. R48 is the blue trace, True Phantom: red trace. You can see that the 2nd harmonic (2k) is 5dB lower. The 3rd harmonic (3k) is 7dB lower.

6 Conclusions

1. The addition of a current source to a phantom power supply, gives a substantial reduction of the distortion of the microphone at all signal levels.
2. The gain is 0.06 dB higher.
3. The True Phantom complies to the P48 standard. This means that every microphone will work under the same DC conditions as it does with a standard power supply.

In the near future the True Phantom will be available as a chip.[5]

References

[1] See IEC 61938:1996

[2] True Phantom ® is a trademark of Phantom Sound B.V.

[3] Patent number: NL2014677

[4] 5Spice Analysis, Version 1.67.0

[5] The German chip manufacturer PREMA Semiconductor will make the chip.