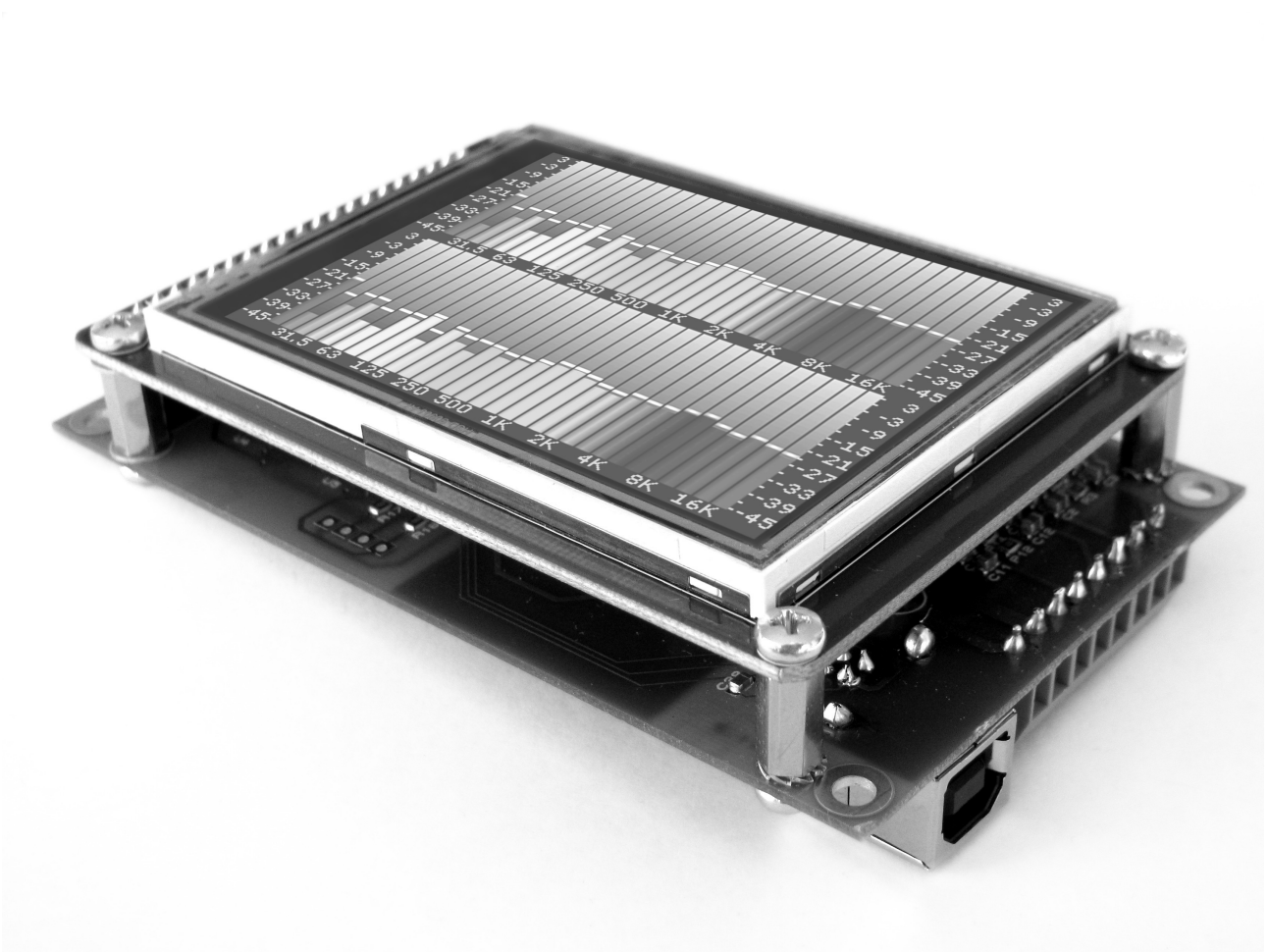


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EVOR04

Application note: Measure power



Overview

In many audio applications is need to measure the true output power of amplifier, independently of load characteristics. Also opposite case is common - to measure the power produced by speakers, without considering amplifier type. Subject of measurement can be the average rms power or peak power over a very short time. Since firmware revision 1.1 EVOR04 provide a way to achieve such measurements over a single channel.

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Theory of operation

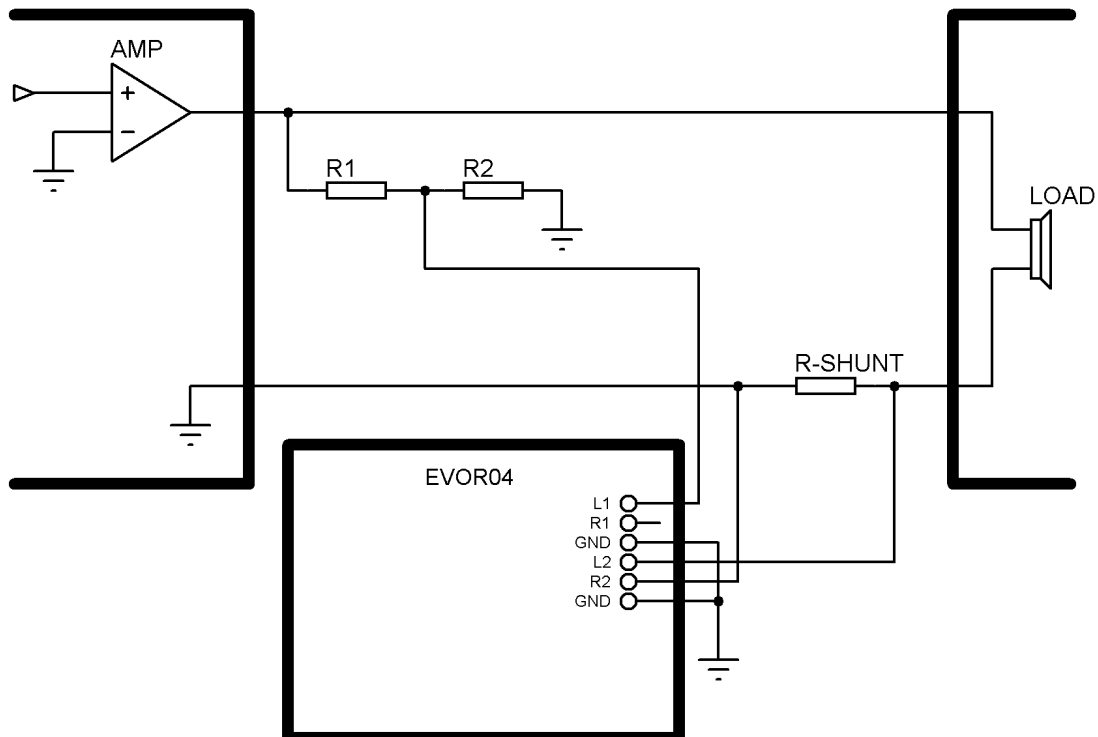
To obtain the power of amplifier or over load is need to get the voltage across it and the current passing between amplifier and load. EVOR04 module has 2 channels input and dedicating one for voltage and other for current is possible to process and display the rms or peak power of single source. Also one of the channels can be switched in differential mode and using the extra inputs can measure the voltage over a bridged mode amplifier.

The effects able to work in power mode are VU meter and Analog VU meter. They are able to display exact power in watts on their scale.

From ground connection point of view exist 2 types of power amplifiers:

Normal mode

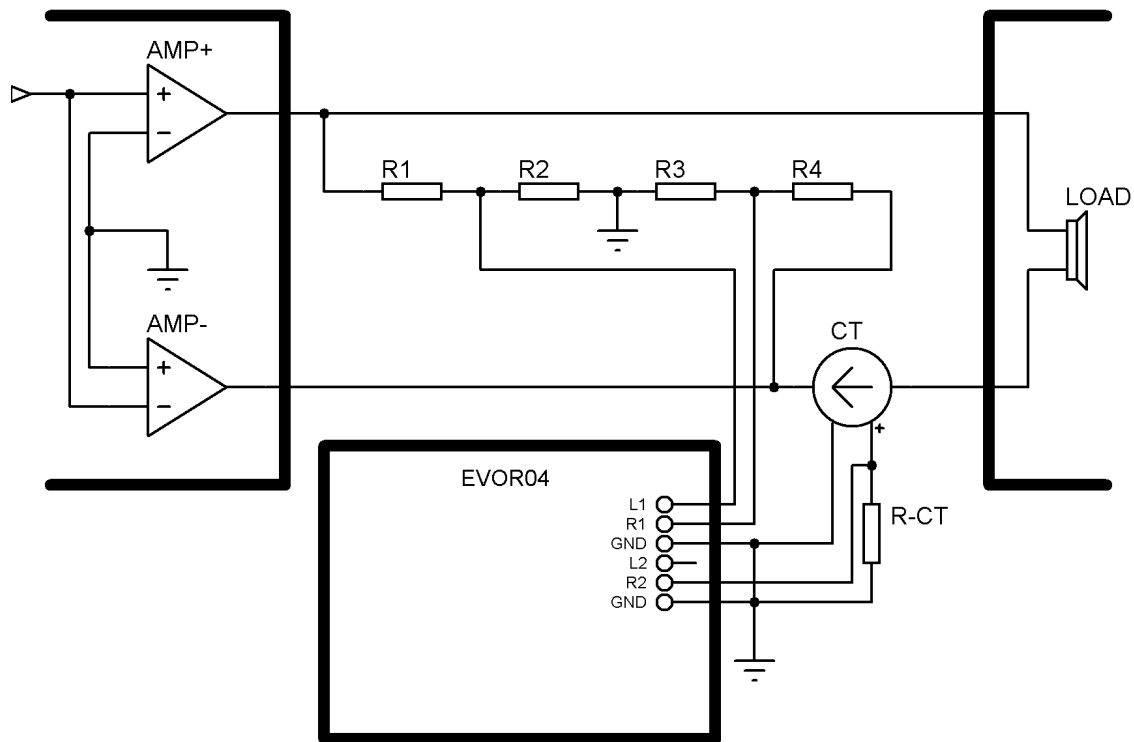
Here the amplifier and load share a common, system ground over the one of the wires and the other is floating across the supply voltage according to the input signal.



The voltage divider network R1-R2 lower the output voltage range to acceptable level. The voltage across shunt resistor is proportional to the current passing trough it. That voltage is passed in differential mode to EVOR04. This prevent a error from voltage drop over the wires or eventual current monitor inside the amplifier. Shunt resistor should be placed over the ground wire to keep the voltagess across it close to ground. A special care should be taken to keep the shunt resistor always connected to ground, because lack of such connection can cause a high voltagess to appear on EVOR04 inputs. If is convenient, shunt resistor can be replaced by current transformer or hall effect current sensor.

Bridged mode

The both sides of load are floating across the supply voltage, powered by 2 internal amplifiers driven in opposite phase. That circuit produce doubling of output voltage.



Here are need two voltage dividers - R1-R2 and R3-R4, for each side of the bridge. The signal from them is measured in differential mode from EVOR04. The current passing trough load is measured with current transformer or hall effect current sensor.

Bridged mode schematic is possible to be used in normal mode system, as reading of 0V from one side will not affect the final measurement.

If EVOR04 module not share a common ground with other components, also normal mode schematic can be used for bridged mode system. A special care should be taken to not share a ground trough a power supply or USB cable for example, thus it will cause a serious damage.

Current sensing

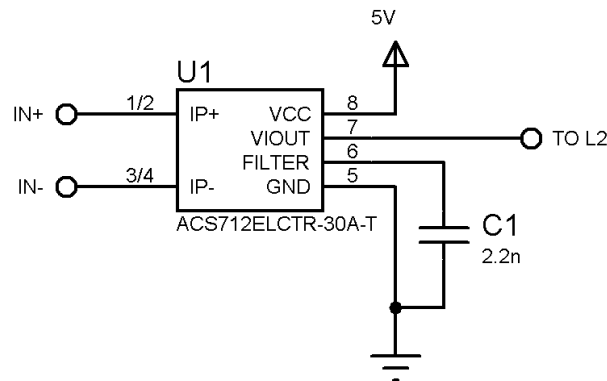
In all schematics, key point is to convert the current into proportional voltage.

Shunt resistor is most simple and cheaper solution. Main drawback of it is, that to get bigger voltage across it, means a bigger power looses over it which can heat it to very high temperatures. Also to keep voltages across it low, one of its sides should be always connected to ground, which make it unacceptable for bridged mode.

Current transformer can be used for very high currents, without any heat or power looses over it. It need just a extra resistor that will control the voltage drop across it. Main disadvantage is its limited frequency response. Usually they are produced for power lines of 50-400Hz and finding a model for audio applications can be harder.

Hall effect current sensor solution seems to be most reliable option. It has wide frequency response and handle heavy currents. Only need to consider that it need external power and some

extra components. A very popular sensors of that type are ACS712 and ACS756 ICs. Below is given a sample schematic with ACS712ELECTR-30.



Selecting voltage divider and current rating

Wide range of amplifiers power and load impedance gives very wide range of output voltage and currents. Tables below gives what should be the rms voltage and current for a given amp power and load.

Vamp RMS voltage by power and load

$$U = \sqrt{P \cdot R}$$

	25 W	50 W	100 W	150 W	200 W	250 W	500 W	750 W	1000 W
2 Ω	7,1 V	10,0 V	14,1 V	17,3 V	20,0 V	22,4 V	31,6 V	38,7 V	44,7 V
4 Ω	10,0 V	14,1 V	20,0 V	24,5 V	28,3 V	31,6 V	44,7 V	54,8 V	63,2 V
6 Ω	12,2 V	17,3 V	24,5 V	30,0 V	34,6 V	38,7 V	54,8 V	67,1 V	77,5 V
8 Ω	14,1 V	20,0 V	28,3 V	34,6 V	40,0 V	44,7 V	63,2 V	77,5 V	89,4 V
16 Ω	20,0 V	28,3 V	40,0 V	49,0 V	56,6 V	63,2 V	89,4 V	109,5 V	126,5 V

Iamp RMS current by power and load

$$I = \sqrt{\frac{P}{R}}$$

	25 W	50 W	100 W	150 W	200 W	250 W	500 W	750 W	1000 W
2 Ω	3,5 A	5,0 A	7,1 A	8,7 A	10,0 A	11,2 A	15,8 A	19,4 A	22,4 A
4 Ω	2,5 A	3,5 A	5,0 A	6,1 A	7,1 A	7,9 A	11,2 A	13,7 A	15,8 A
6 Ω	2,0 A	2,9 A	4,1 A	5,0 A	5,8 A	6,5 A	9,1 A	11,2 A	12,9 A
8 Ω	1,8 A	2,5 A	3,5 A	4,3 A	5,0 A	5,6 A	7,9 A	9,7 A	11,2 A
16 Ω	1,3 A	1,8 A	2,5 A	3,1 A	3,5 A	4,0 A	5,6 A	6,8 A	7,9 A

Voltage divider

EVOR04 accept input signals from 2.2mV up to 2V. Very low voltages will impact the signal to noise ratio. Levels between 0.2V to 2V are acceptable for best performance. The formula for ratio

between R1 and R2 is $\frac{R1}{R2} = \frac{Vamp - Vtarget}{Vtarget}$. If select Vtarget to be 1Vrms, the ratio between

resistors is just Vamp-1.

In bridged mode R1=R4 and R2=R3.

Using a lower resistor values is better for noise performance and accuracy, but will increase the losses across them. For safety operation select R1 range depending on Vamp voltage.

Vamp	≤30 V	≤60 V	≤90 V	≤120 V	≤150 V
R1	10 - 47 kΩ	33 - 100 kΩ	82-180 kΩ	150-330 kΩ	220-680 kΩ

Example: If $V_{amp} = 54.8V$, the ratio $R1/R2 = 53,8$. We should select $R1$ between 33 and 100 k Ω . Selecting $R1=33k\Omega$ and $R2=620\Omega$ gives the closest ratio to the needed.

Current rating

For current sensing is not always possible to select a shunt that perfectly match the maximum current of the amplifier. There should be installed always a shunt for bigger current and right calibration to be made trough EVOR04 gain setup.

Typically resistor shunts give 75mV for their maximum rated current, but also a 50mV and 100mV versions can be found. Key parameter, used in following calculation is their sensitivity. A shunt of 20A 75mV has sensitivity of $0.075/20 \text{ V/A} = 3,75 \text{ mV/A}$.

For current transformers are specified their turns ratio and rated burden resistance. Dividing the values gives us the sensitivity. For example a 750:1 turns ratio and 33 Ω rated resistance gives a $33/750 \text{ V/A} = 44 \text{ mV/A}$ sensitivity.

Hall effect sensors have given their sensitivity in their datasheet. For example ACS712ELECTR-30 has 66mV/A.

Knowing the nominal current of amplifier and sensitivity is easy to find what will be the voltage of EVOR04 input for that current. For example 11,2A nominal current and 44 mV/A sensitivity gives a 0.493V on input. Next step is to find required gain correction for that voltage, using following formula: $G=20 \cdot \log\left(\frac{2}{V_{in}}\right)$. For $V_{in}=0.493V$ required gain is $G=12.2 \text{ dB}$. From interface can be selected closest value of 12 dB.

Using current or hall effect sensor is possible the output voltage of them to be higher than maximum allowed voltage of 2Vrms for EVOR04. In this case can be easy added a resistor divider network and adjust sensitivity according it.

Setup of EVOR04 parameters

Chanel A boost and gain should be 6dB if $V_{target} = 1V_{rms}$. Or $G=20 \cdot \log\left(\frac{2}{V_{target}}\right)$ if used different target voltage.

Chanel B boost and gain should be the value calculated from “Current rating” section.

For normal mode

Channel A input is L1

Channel B input is Differential

Differential source is L2-R2

For bridged mode

Channel A input is Differential

Channel B input is R2

Differential source is L1-R1

Nominal value of “Power mode” inside VU or Analog VU effects is the amplifier rated power from where calculations start. Because the resistor divider ratio and gain selection cannot always match perfectly the calculated values, it is better to calculate exact power, eliminating these errors, according following formula:

$$P = 10^{\frac{-G_{chA}}{20}} \cdot 2 \cdot \frac{R1 + R2}{R2} \cdot \frac{10^{\frac{-G_{chB}}{20}} \cdot 2}{CTsensitivity(V/A)}$$

Example result according previous calculations:

$$P = 10^{\frac{-6}{20}} \cdot 2 \cdot \frac{33000 + 620}{620} \cdot \frac{10^{\frac{-16}{20}} \cdot 2}{0,044} = 620,6 \text{ W}$$

In interface can be set 621W.