White Paper No. 2

Amplification of voltage or current

Introduction

The purpose of an amplifier is to convert a small signal at the input into a large signal at the output. In the most cases the input and output signals are some kind of voltage. Therefore, the equipment used is referred to as voltage amplifier and voltage-controlled voltage source.

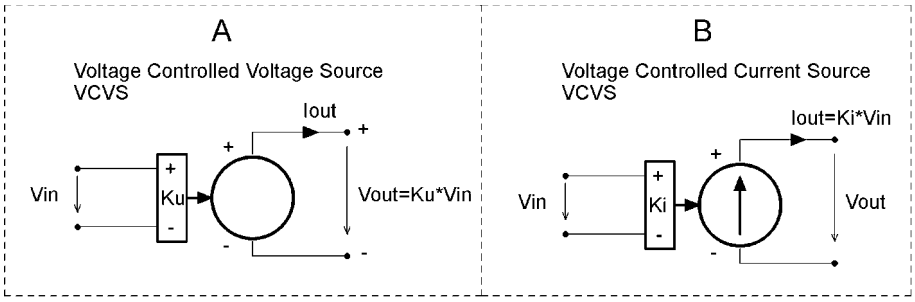

Figure 1: Voltage Controlled Voltage- and Current Sources

Figure 1, image A visualizes this correlation. The small signal V_{in}, weighted by a factor k, controls the large signal V_{out}

Example: V_{in} = 1 V, K_u = 10 → V_{out} = 10 V. The output voltage V_{out} is proportional with the input voltage V_{in} and not dependent on the load; the output current I_{out} is load-dependent and therefore not consistent.

However, the large signal may also be a kind of current. In that case we refer to the equipment as current amplifier and voltage-controlled current source. Image B in Figure 1 clarifies this correlation. In this case, the small signal V_{in} controls the large signal I_{out}.

Example: V_{in} = 1 V, K_I =10[A/V] → I_{out} = 10 A . Here, the output current I_{out} is proportional with the input voltage V_{in} and not dependent on the load; the output voltage U_{out} is not consistent.

The models from the HUBERT A1110-X-XE amplifier range can be operated either as voltage controlled voltage sources (VC mode) or voltage-controlled current sources (CC mode). These different operating modes shall be briefly referred to as voltage amplifier and current amplifier.

Depending on the type of application, it is better to use a voltage amplifier or a current amplifier.

Voltage amplifier vs. current amplifier

Voltage amplifier

The output voltage of a voltage amplifier is largely independent of the connected load due to its design. It is very flexible and easy to operate.

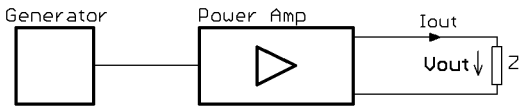

Figure 2: Power Amp Setup

Figure 2 shows a typical application of the power amplifier. A signal source (generator) is connected to the input of an amplifier. A load Z is connected to its output.

With resistive loads (Z = R) the output current is proportional with the output voltage and thus also with the input voltage. Through this correlation, a required current value flowing through the load can be set by means of the corresponding input voltage.

$I_{out} = U_{out}/R = k*V_{in}/R$

For these kinds of purposes the voltage amplifier is ideally suited.

In case of a resistive-inductive load $Z = R + j\omega L$, Z and thus also I_{out} is frequency-dependent. With an increasing signal frequency the current is reduced at a consistent output voltage. Proportionality of the output current and the output voltage is frequency-dependent.

Current amplifier

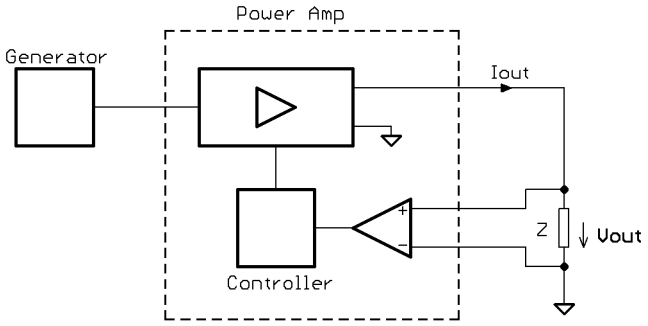

Figure 3: Current Controlled Power Amp

Figure 3 outlines the principal structure using a current amplifier.

With increasing impedance, the controller increases the output voltage U_{out} (or vice versa) and thus ensures a constant, largely frequency-independent current Strom I_{out}. Since in this operating mode the load represents an integral part of the control concept, the amplifier must be compensated by means of an RC network adapted to the load for stability reasons. The power amplifier is optimized for stable operation at largest-possible band widths and thus is “specialized” for such purposes.

For commissioning a load must always be connected. Current flow would not be possible in an open circuit. The controller reacts and attempts unlimited increase of the output voltage or until the operating voltage limit is reached. This condition is not permissible for operation of the amplifier (protective circuit is activated) and may represent a potential hazard for the user in case of contact with the output terminals. Please act with great care!

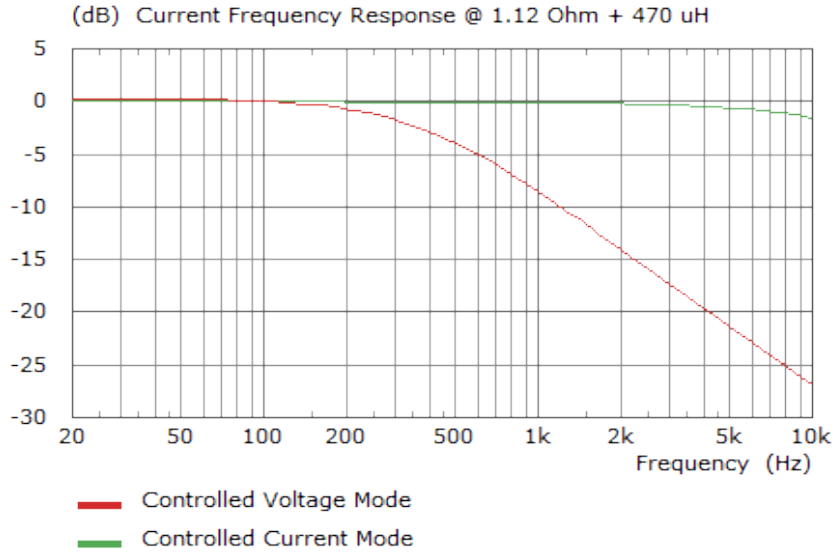

Figure 4: Current Frequency Response at different Operation Modes

In Figure 4 the frequency response of the current is illustrated by the complex load Z = 1.12 R + jω470 uH.

When using a voltage amplifier (Controlled Voltage Mode) the amplitude significantly drops at approx. 450 Hz (-3dB) already. In contrast, the optimized current amplifier (Controlled Current Mode) ensures a nearly straight frequency response up to 10 kHz.

The output current is proportional to the input voltage up to 10 kHz.

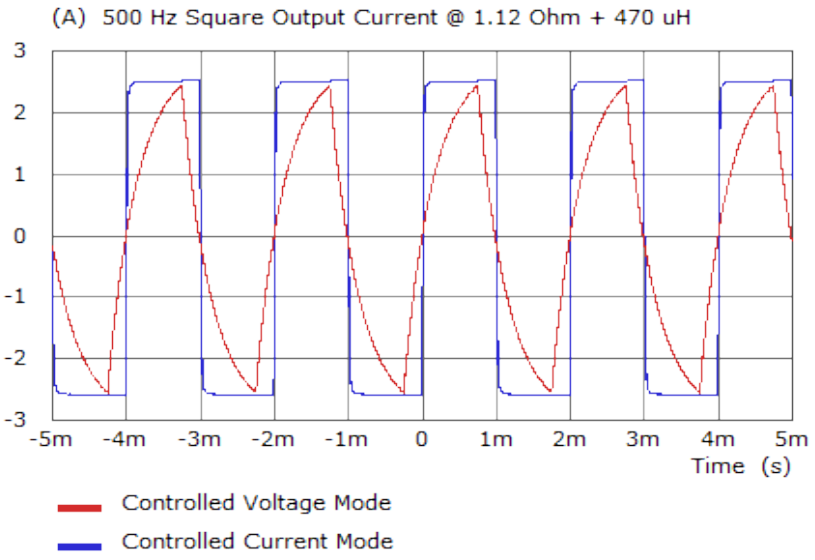

Figure 5: Current Step Response at Different Operation Modes

The step responses of the current, as shown in Figure 5 reveal that there are no overshoots for the current amplifier and thus emphasize its stable control.

With the A1110-X-XE product range it is possible to configure six RC networks for six different inductive loads (see Table 1) and be easily selected through the PC software by means of a graphical user interface.

The following networks are available as factory settings:

No	Load	Rc	Cc	Current Range
1	1 Ohm + 500 uH	100 kOhm	10 nF	high
2	0,1 Ohm + 200 uH	68 kOhm	4,7 nF	high
3	1 Ohm + 1 mH	150 kOhm	22 nF	high
4	4 Ohm + 1,8 mH	200 kOhm	1 nF	high
5				
6				

Table 1: Available Compensation Networks

We will be happy to help you with implementing a suitable network for your specific applications.

Conclusion

Whether a voltage amplifier or a current amplifier is preferable used, is a matter of the load type. With resistive loads, the voltage amplifier is the device of your choice. Current amplifiers must be considered for inductive loads in connection with sine wave signals.

Devices from the A1110-X-XE product range are suitable for both application scenarios.

We will be happy to assist you with your decision.

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