VISHAY PRECISION GROUP

CASE STUDY

Product Group: Vishay Foil Resistors

Precision active current probe for power amplifier diagnosis

UNIVERSITY OF CAMBRIDGE

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This device is designed as part of the fourth year undergraduate project under the Electrical Engineering Division. The aims of the project are to undertake a major piece of work of engineering significance and exercise real life research, design, and problem solving skills.

Industry/Application Area Electronic Instrumentation / Current Sensing

Product Used VCS1625 0.01R and 0.1R, 1% TCR

The Challenge

The core aim of the project is to design and build an audio power amplifier to commercial standards using standard components. This amplifier adopts a linear Class-G topology which is gaining popularity in the audio industry due to its superior efficiency compared to traditional Class-B amplifiers when operated at moderate output power. Class-G refers to the output stage configuration; this has an additional pair of supply rails and corresponding power transistors to “switch-in” just enough additional voltage to the main transistor pair when the output exceeds the lower supply. This technique greatly reduces the quiescent power consumption when listening to music, which has low to moderate amplitude most of the time, with occasional peaks.

During the build and test of the amplifier prototype, parasitic oscillations were observed in the Class-G transition regions. To diagnose the cause of this problem, it is desirable to observe the currents in key areas of the circuit. But commercially available current probes suitable for observing currents at high frequencies are extremely prohibitive in cost; an alternative solution is to build a custom current measurement device.

The Solution

Commercial current probes allow measurement of currents with almost any common-mode voltages since they measure the magnetic field around the conductor without physical contact. However, these devices require a complex excitation circuit when measuring DC currents since they produce a static

magnetic field. The only economical solution suitable for the project timeframe is to use a current shunt resistor coupled with an IC amplifier capable of operating in high common-mode voltages (Figure 1). Since currents as high as 5 A will flow in the power amplifier, there is a need for stable and low temperature coefficient high-power shunt resistors. The VCS1625 surface-mount Bulk Metal® Foil resistors from Vishay Precision Group are ideal for this purpose due to their small size and non-inductive/capacitive properties, theoretically reducing disruption when it is connected to critical current paths of the prototype.

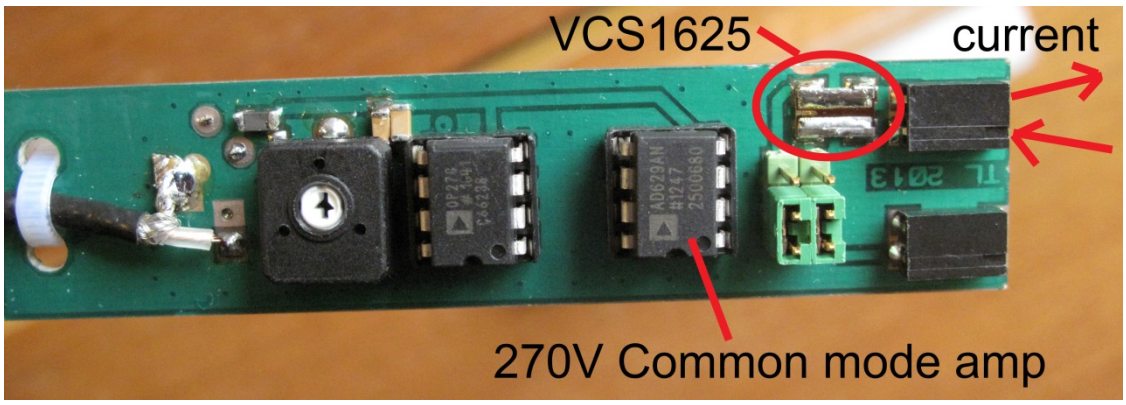

Figure 1: The complete current probe utilizes a ±15 V supply and allows direct observation of current waveforms using an oscilloscope.
The probe output is 2 V/A, improving the ease of observing small and large currents.

The User Explains

After multiple design revisions of the current probe, other solutions to the parasitic oscillations were found and the final current probe was re-purposed for observing the current waveform at the power supply nodes instead. Another important reason for this is the final front end amplifier chosen only has ~20 kΩ of resistance to ground, prohibiting its use on most circuit nodes.

Measurements

SPICE waveforms show the expected current waveforms at the power supply outputs when supplying a 20 kHz sine wave into an 8 Ω load at 33 W, where the rail switching is most prominent (Figure 2). The exact waveforms were observed on an analog oscilloscope when the actual current probe was used on the circuit. The current probe was also connected to a precision bench multimeter to give a low-drift averaged current reading.

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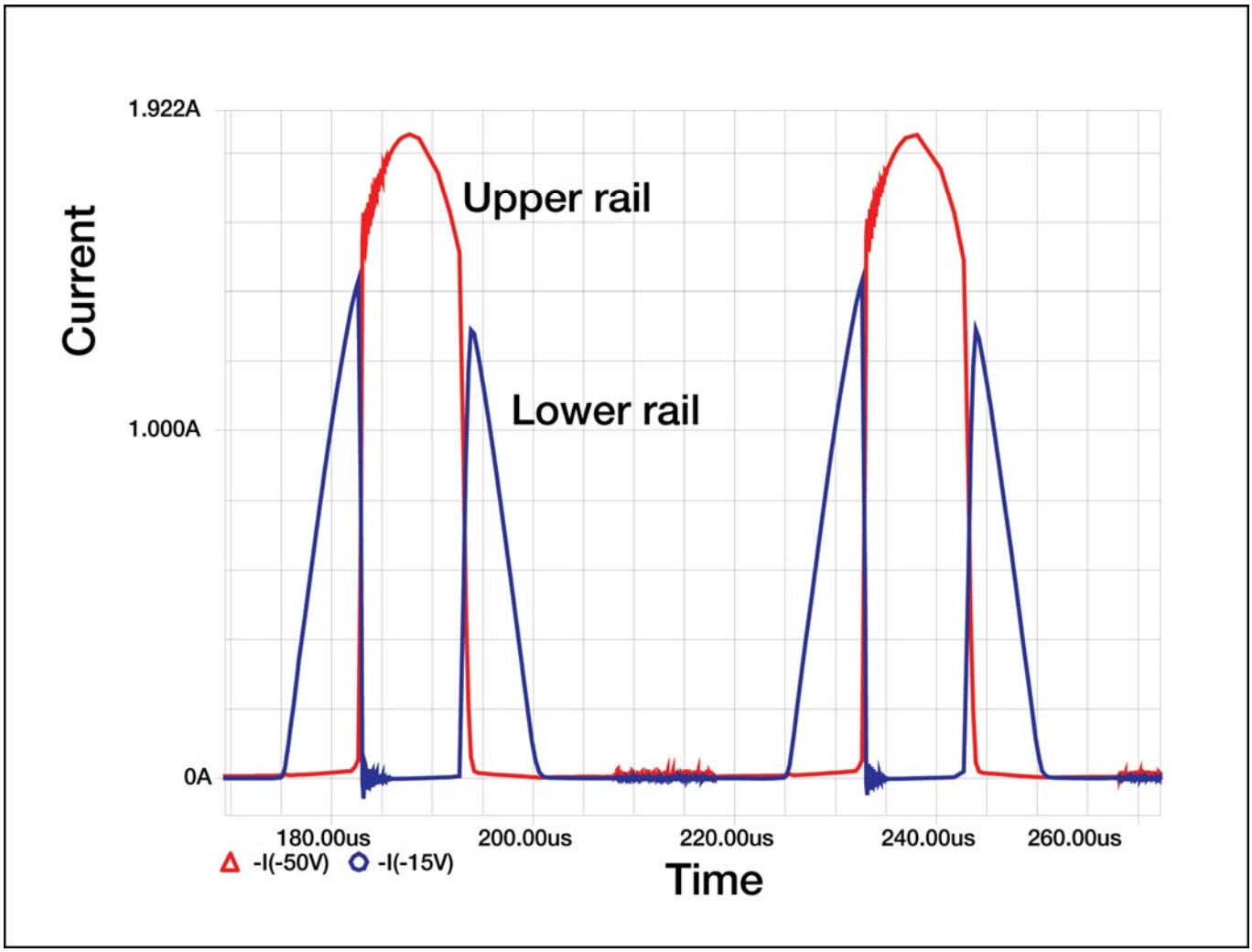

Figure 2: SPICE waveforms showing the expected current waveforms at the power supply outputs when supplying a 20 kHz sine wave into an 8 Ω load at 33 W, where the rail switching is most prominent.

"VPG's Bulk Metal Foil current sensing resistors are ideal for observing and measuring highly non-linear currents in high frequency power circuitry due to their very low drift and kelvin sensing capability."

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