

Figure 1: Amplifiers with Loads and Decoupling Capacitors

The common-source amplifier is constructed with a $1\mu\text{F}$ decoupling capacitor and 500Ω load at the output. The decoupling capacitor ensures that the output has a DC bias of $0V$ since any DC voltage simply charges the capacitor and does not make it to the resistor. The gain is determined at different frequencies. Again, the gain degrades at higher frequencies due to the parasitic capacitances of the MOSFET acting as a low-pass filter, which cuts down on the signal's amplitude. Because of the attached load, only $\frac{R_L}{r_{out} + R_L} V_{in}$ ends up appearing at the output, where r_{out} is the amplifier's output resistance. Since R_L is comparable in magnitude to r_{out} , the voltage division effect causes the gain to be much lower than an ideal open circuit gain, measured in part 2.



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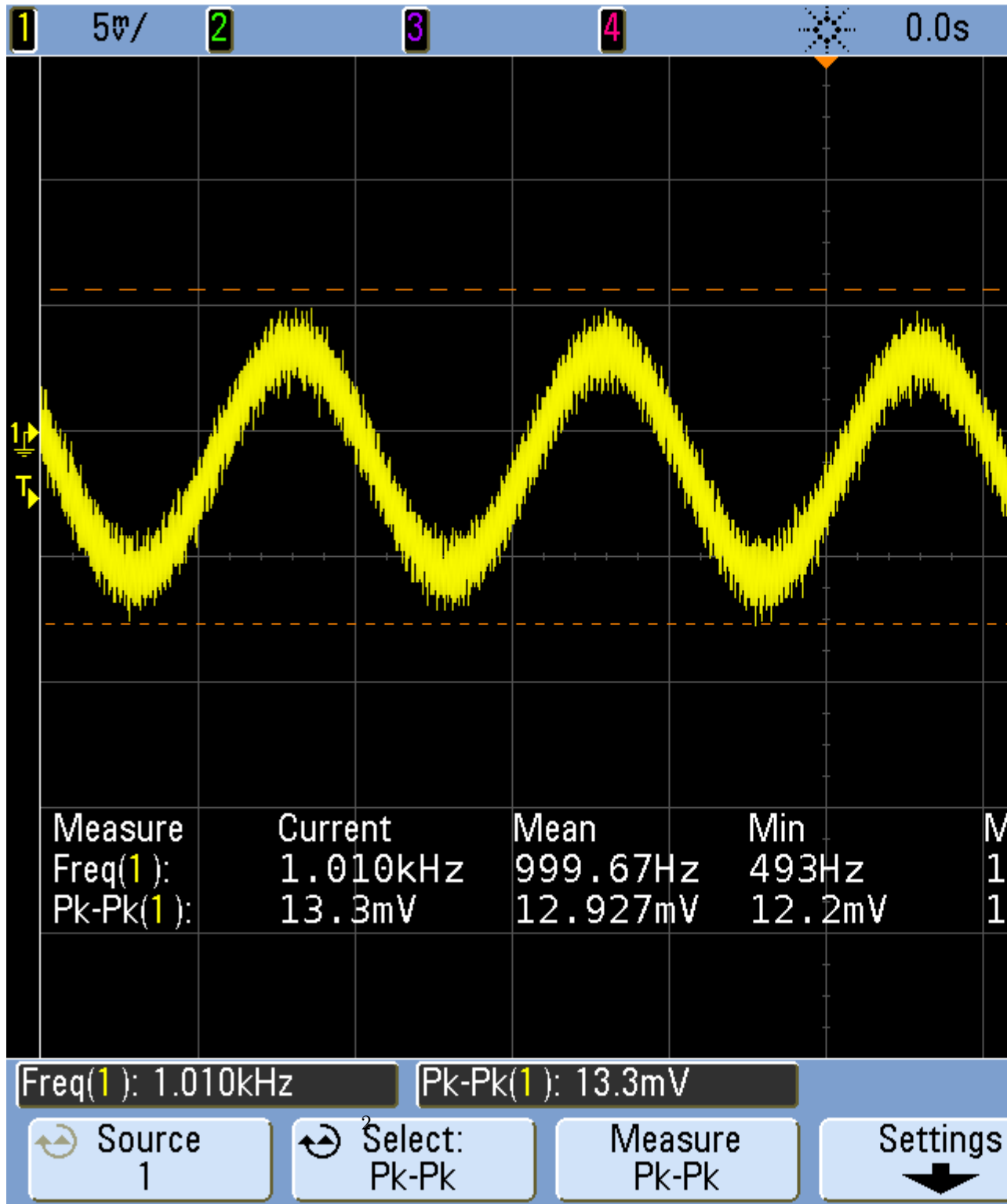


Figure 2: Common-Source Amplifier with Load and Decoupling Capacitors, 1kHz Input



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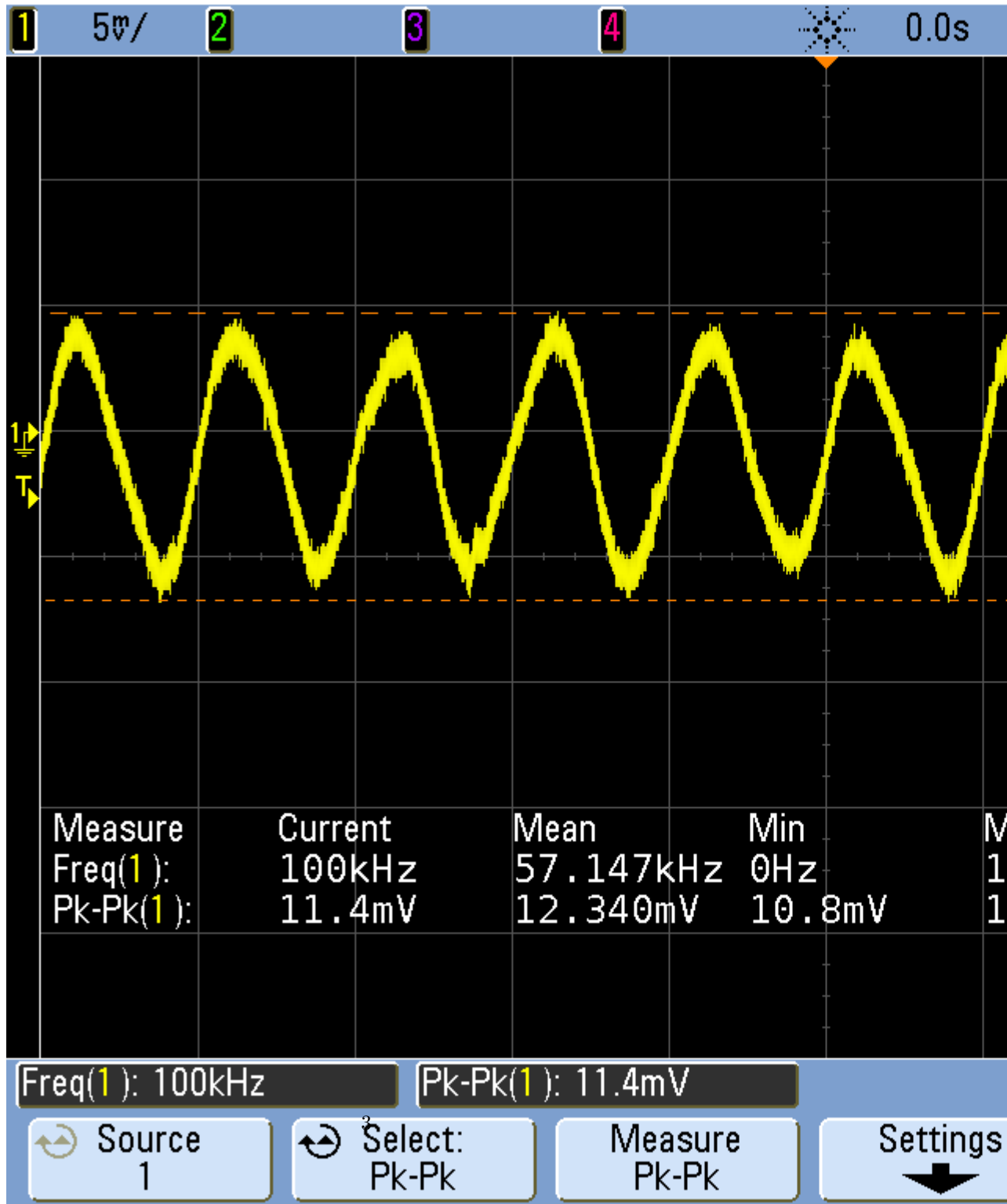


Figure 3: Common-Source Amplifier with Load and Decoupling Capacitors, 100kHz Input



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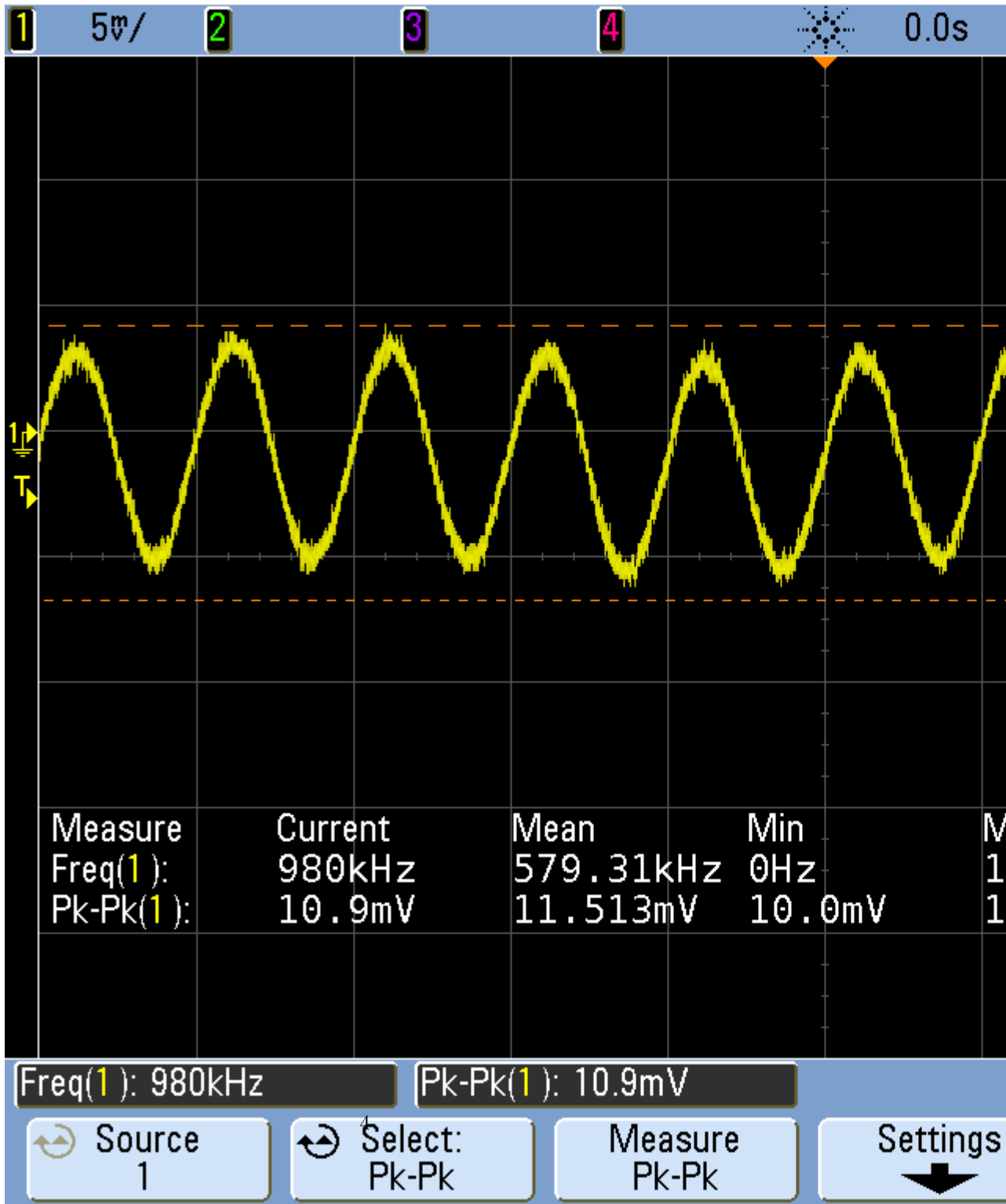


Figure 4: Common-Source Amplifier with Load and Decoupling Capacitors, 1MHz Input

Table 1: Common-Source Amplifier with Decoupling Capacitor and Load Gain

Frequency [kHz]	Gain [V/V]
1	-0.665
100	-0.570
1000	-0.545

A common-drain amplifier is then connected to the output of the common-source amplifier. The common-drain amplifier's output resistance is given by $r_{out,CDA} = R_S || r_o || \frac{1}{g_m}$. Assuming r_o is very large, $r_{out,CDA} \approx R_S || \frac{1}{g_m}$. The common-source amplifier's output resistance is given by $r_{out,CSA} = R_D || r_o$. Making the same assumption about r_o , $r_{out,CSA} \approx R_D$.

In this specific case, $R_S = R_D = R$. Expanding $r_{out,CDA}$, the equation can be rewritten as:

$$r_{out,CDA} = \frac{R}{1 + g_m R} \quad (1)$$

Likewise, $r_{out,CSA}$ can be written as:

$$r_{out,CSA} = R \quad (2)$$

Assume $R > 0\Omega$ and $g_m > 0\frac{mA}{V}$. $g_m R > 0$ must then be true. This further implies that $1 + g_m R > 1$ and that $\frac{1}{1 + g_m R} < 1$. Because $R > 0\Omega$, $\frac{R}{1 + g_m R} < R$. Invoking equations (1) and (2), $r_{out,CDA} < r_{out,CSA}$.

Therefore, in this configuration, the cascaded amplifier should have a lower output resistance since the output is presented with $r_{out,CDA}$ and not $r_{out,CSA}$. As a result, for the same load, the gain should be higher since R_L is now relatively larger in the voltage divider. This claim is corroborated by the data at various frequencies. The gain magnitude increases.



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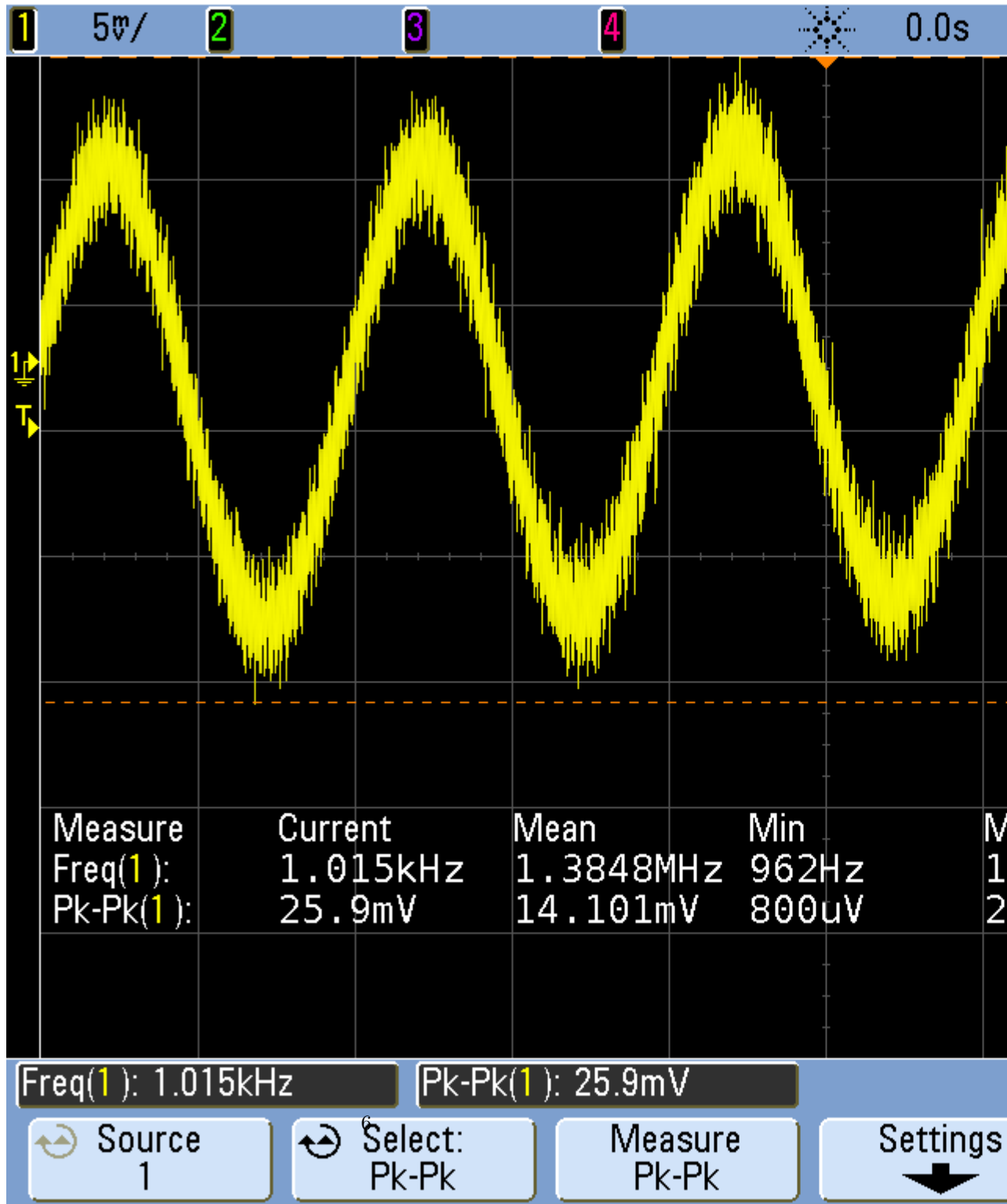


Figure 5: Two-Stage Amplifier with Load and Decoupling Capacitors, 1kHz

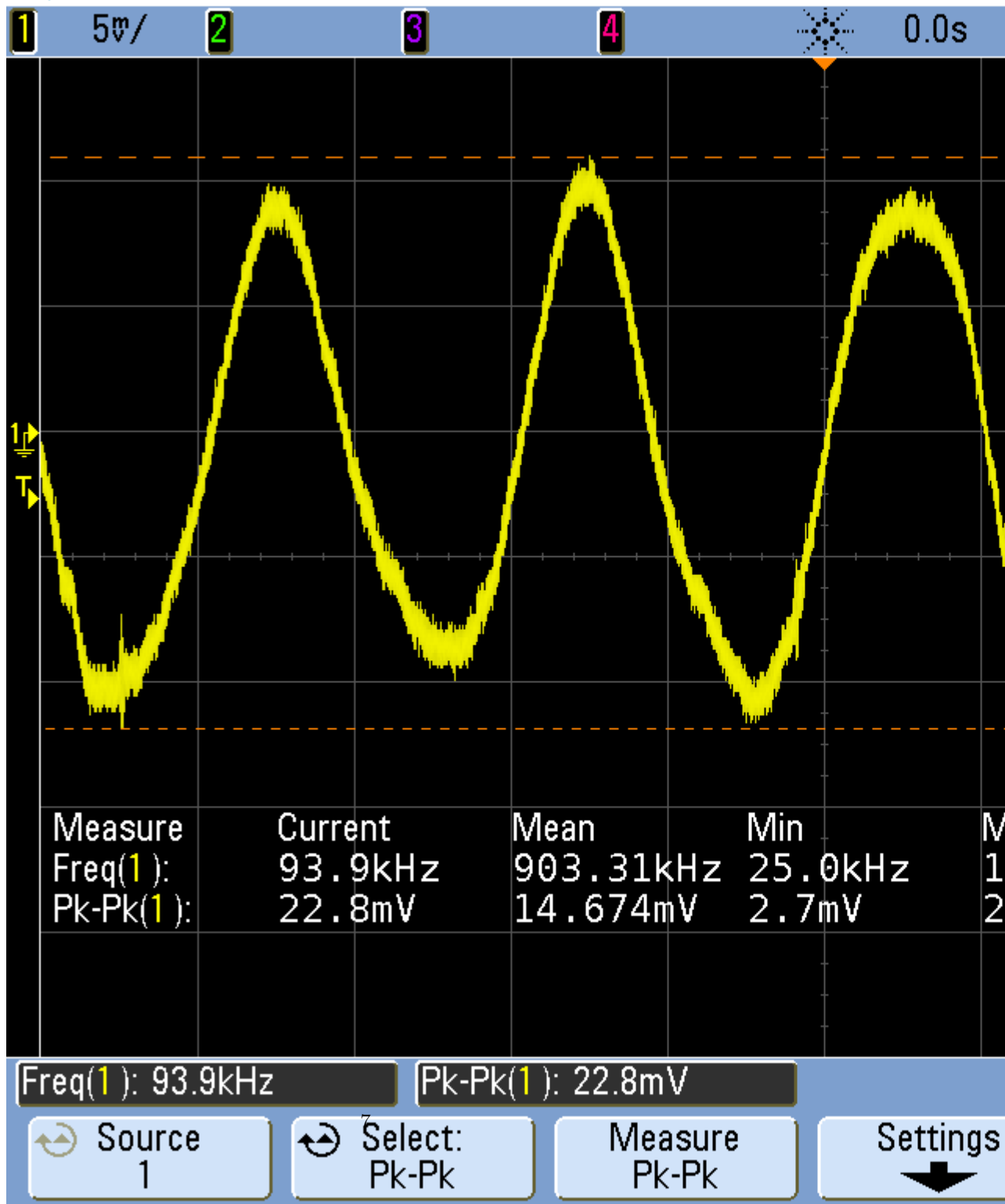


Figure 6: Two-Stage Amplifier with Load and Decoupling Capacitors, 100kHz



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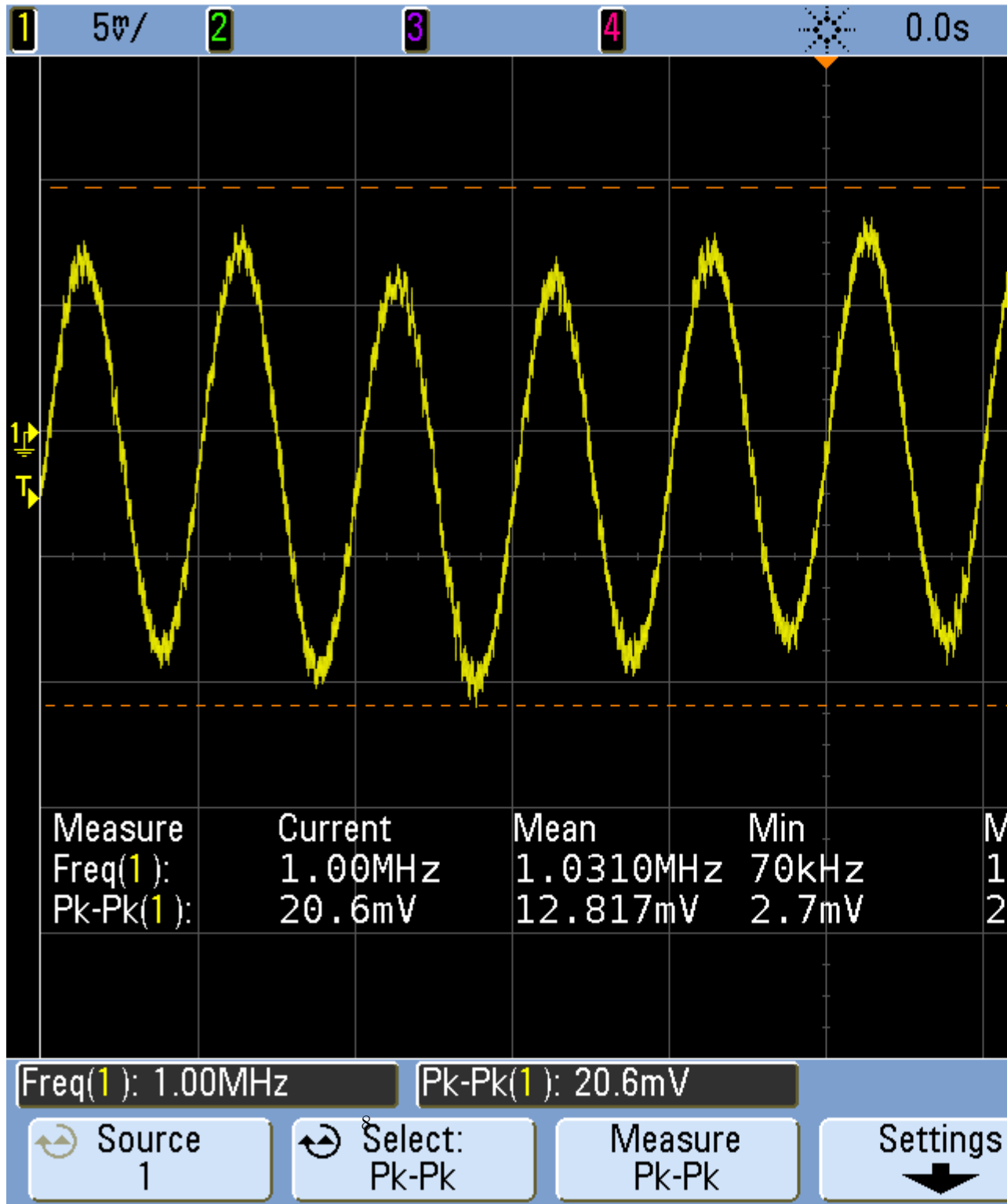


Figure 7: Two-Stage Amplifier with Load and Decoupling Capacitors, 1MHz

Table 2: Two-Stage Amplifier with Decoupling Capacitor and Load Gain

Frequency [kHz]	Gain [V/V]
1	-1.30
100	-1.14
1000	-1.03