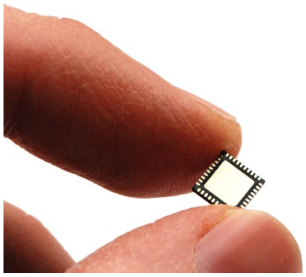
RHD/RHS

Application Note: Interfacing a Microphone



16 August 2012; updated 7 February 2020

Q:

Can I use the Intan RHD or RHS headstages to record audio signals?

A:

Yes! The bandwidth of RHD or RHS amplifiers can easily accommodate audio signals. The maximum range of human hearing is 20 Hz – 20 kHz, although most small microphones only pass frequencies from around 100 Hz up to 4 – 10 kHz. As long as the AC and DC voltage levels from a microphone are properly scaled to match the range of the RHD/RHS amplifiers, one or more channels of an Intan Technologies chip can be used to acquire audio data while the other channels remain connected to electrodes.

The circuit shown here was designed and tested by Jeff Markowitz in Tim Gardner's lab at Boston University, and is currently used to record songbird vocalizations in synchrony with 15 channels of neural signals. The microphone is a Knowles EM-23046-P16 omnidirectional electret condenser – a small (3.6 × 3.6 × 2.2 mm^3), lightweight (0.08 g) device that costs around $25 in small quantities. It is currently available through DigiKey (part number 423-1062-ND) and Mouser Electronics (part number 721-EM-23046-P16). The frequency response of the microphone is approximately 100 Hz – 5 kHz.

The microphone is powered from a DC voltage that can range from 1.3 V to 3.0 V (though in our tests, a supply voltage of 3.3 V did not seem to harm the device). The DC output voltage of the microphone is around 0.6 V, and sounds of moderate intensity produce AC fluctuations a few millivolts in amplitude. Loud sounds close to the microphone can yield amplitudes of several hundred millivolts.

A resistor divider consisting of R_1 and R_2 is used to reduce both the DC and AC levels of the microphone output voltage. The DC level should be brought to less than 0.4 V for proper interfacing with an RHD headstage, and the AC signals should not exceed 5 mV or the amplifier will saturate.

The resistor divider reduces voltage levels by a factor of $(R_{out} + R_1 + R_2)/R_2$, where R_{out} is the output resistance of the microphone, which is typically several kilohms.

Values of R_1 = 1.0 kΩ and R_2 = 100 Ω seem to work well with moderate sound levels. For louder sounds, R_2 can be changed to 33 Ω to prevent amplifier saturation (at the expense of reduced sensitivity to lower sounds). Other microphones may require slightly different values of R_2, and these values are best determined experimentally.