# SIGNAL Audio Hardware

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## Introduction

This document recommends audio hardware for use with SIGNAL. Recommendations are current as of the revision date at the end of the document.

## Microphone

A microphone used for scientific recording **must have a frequency and amplitude specification**, otherwise you can only guess at the spectral accuracy of your data, as well as the amplitude accuracy if that's of interest.

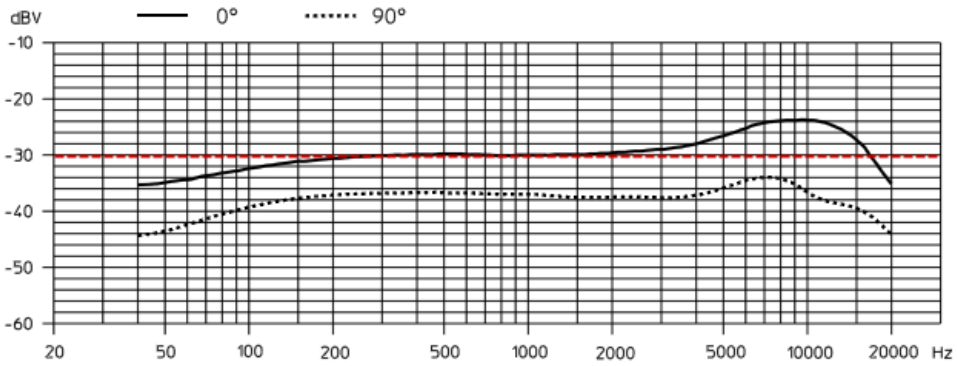
For mics below $1000, the manufacturer may provide either a specified or "typical" **frequency response** for all mics of a specified model (not the actual mic you are holding). See the Sennheiser mic below for an example.

For measurement mics above $1000, manufacturers provide the measured frequency response of the actual microphone. See the LinearX mic below for an example.

Even general specs are becoming rare, so confirm that one is available before deciding on a mic. Following are several microphone options.

### Sennheiser

One popular and affordable field mic is the **Sennheiser ME64** cardioid capsule + K6 power module. The product data sheet specifies a frequency response is 40 – 20,000 Hz ±2.5 dB and an input sensitivity of 31 mV/Pa ±2.5 dB. Note however, that the frequency response plot shows a response of frequency response 40 – 20,000 Hz ±6 dB and 100 – 15,000 Hz ±4 dB.




Street cost of capsule + powering unit can be as low as $400 – for example

http://www.bhphotovideo.com/c/product/73087-REG/Sennheiser_ME64_ME64_Cardioid_Mic.html

The same product family also includes a shotgun (hyper-directional) mic, which is also popular for field recording.

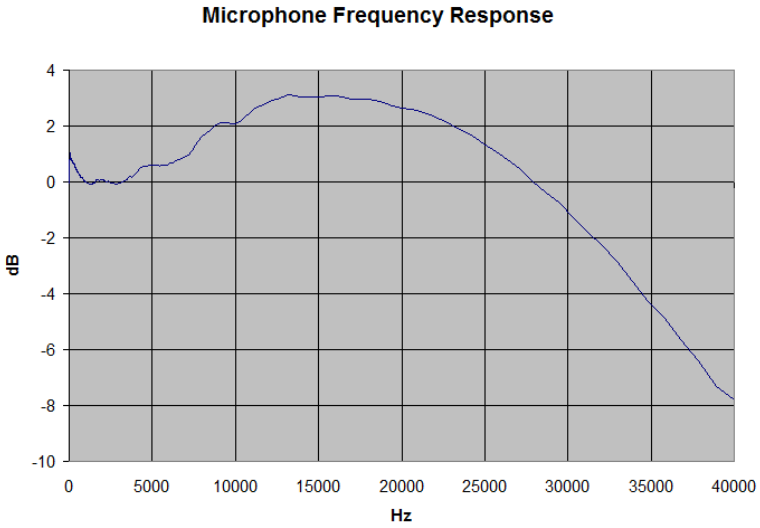
## Electret measurement mic

Measurement mic are designed for calibrated laboratory measurements, are designed for long-term stability (measurement properties don't change over time) and are normally provided with an individual calibration. This is expensive – for most mics (such as Bruel & Kjaer or Larson-Davis) well over $1000.

LinearX http://www.linearx.com offers a less expensive measurement mic. Their mics are based on an inexpensive electret capsule but are individually calibrated and provided with a calibration spec.

Capsule frequency response is typically not flat over the audio range, but the deviation is numerically specified and is adequately stable over time so in SIGNAL for example, this error can be subtractively removed from critical spectral measurements.

Engineering Design uses a LinearX mic for field consulting work in acoustic measurement. The measured frequency response of this mic is shown below. Note the spectral error is < ±2 dB over the 20 kHz audio band.




## Custom-built microphones

Raw electret capsules are inexpensive but in order to be used as measurement mics, they must be built into a housing and calibrated.

If you need a number of laboratory mics, it can be cost-effective to **custom-build measurement mics** from electret capsules, then calibrate them. Engineering Design has done this work. Your required frequency bandwidth is an important consideration. Minimum order would be about 6 mics. An Engineering Design production mic is shown below.

Engineering Design can also provide a multi-channel **instrumentation-grade measurement preamp**. This preamp is required to power the mics and amplify their output. The Engineering Design preamp shown below was designed for recording low-level fruit-fly wing sounds. It provides up to 100 dB of gain and has an extremelly low input noise of -127 dB re 1 Volt. Contact Engineering Design for details on microphone and preamp products.


# Digital recorder

A **digital recorder** is a portable instrument the size of a large cel phone containing A/D and D/A converters, a socket for flash memory cards (typically SD standard) and usually a built-in mic. The recorder also contains firmware to manage recording, playback and file storage, and to adjust recording parameters such as amplitude gain, sample rate and output file format.


Recorder output is typically delivered as a sound file in the Wave or MP3 format. **MP3 is a lossy format (sound information is irrecoverably discarded) and should never be used for scientific recording.**

As with the mic, in order to produce scientific recordings, you must know or assume the frequency and amplitude calibration of the recorder. Unfortunately, the digital recorder manufacturer may not specify these (for example, the Samsontech H2 does not). However, current electronics (including A/D and D/A converters) can be expected to deliver reasonably flat frequency response up to at least 18 kHz. Input gain (digital bits out per input Volt) will be unknown. **Note:** this does not appy to the built-in microphone, which **should not be used without calibration.**

Popular recorders are made by Marantz, Sony and Samsontech (shown here). In general, all reputable recorders will have similar technical performance – frequency bandwidth, negligible distortion, industry standard memory cards (e.g., SD). Models may differ in ruggedness and the usability of their software. Engineering Design uses a Samsontech H2 recorder for field consulting work.

Recorders typically store audio data on **SD family flash memory cards**. At 44.1 kHz sample rate and 16-bit stereo, the recorder will consume 4 * 44,100 bytes/sec or 600 MB per hour, for about 6 hours per 4 GB SD card. Typical battery life is 4 hours.

# Audio monitors

Reasonably accurate monitor speakers are an essential part of a sound analysis system. One's ears are an important tool in validating and analzying acoustic data.

As with the other components, knowing the speakers' frequency response is important. Monitors from the M-Audio company are provided with a crude frequency spec, and are recommended for their overall quality. **Model BX5a** powered monitors, about $240 at Amazon are specified over the range 56 Hz - 22 kHz.

http://www.m-audio.com/products/en_us/StudiophileBX5aDeluxe.html


The less expensive AV40 model compromises low-frequency response unacceptably, and is specified over the range 85 Hz - 20 kHz.

http://www.m-audio.com/products/en_us/MAudioAV40.html

Don't forget that while low-frequency energy may not be important in the signal of interest (for example, in songbirds), you still need to be aware of whether low-frequency **noise** is present. Low-frequency noise can corrupt broadband amplitude measurements, or simply create masking effects in your own audition of the sounds.

# Computer

Thought not part of the audio system, the computer is an integral part of the SIGNAL analysis system. The following Engineering Design document describes hardware requirements and recommendations for a SIGNAL computer, including memory, disk, monitor, etc.

http://www.engdes.com/sigwin/support/download/docs/CPU_specs.pdf