Applying the ACAM 120 Acoustic Array to Locate Acoustic Noise Sources in Electronic Assemblies

Acoustic noise is a problem in many electronic assemblies, including high-volume consumer products. This application note illustrates how acoustic imaging can be used to find acoustic sources in a consumer-grade WiFi router. The information can be relevant to testing for a wide variety of products.

The image on the right uses color to show acoustic noise emitted from the router. This acoustic image was created using an ACAM 120 Acoustic Array from Signal Interface Group, with BeamformX software from OptiNav.

Acoustic noise should be considered early in any product development. People vary widely in their sensitivity to noise, and some tones can be very annoying. Even subtle noises can hurt sales. Customers complain on social media, other customers notice, and prospective customers may select a competing product.

Figure 1: Acoustic image showing broadband noise from a router

Acoustic Problems in a WiFi Router

When power is applied, the router has a period of high frequency noise, including a strong peak above 20kHz. Figure 2 is the spectrum view output of the array, where two relatively strong peaks are clearly visible. The measurements shown here were made in an office in the presence of background noise, not in an acoustic test chamber.

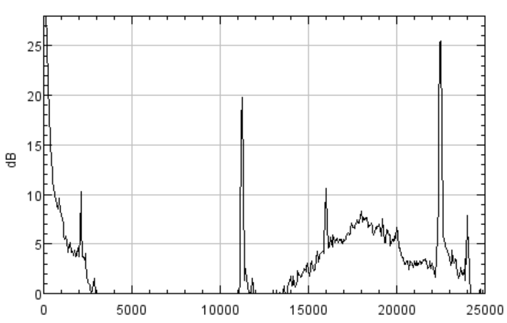

Figure 2: Spectrum with two strong peaks

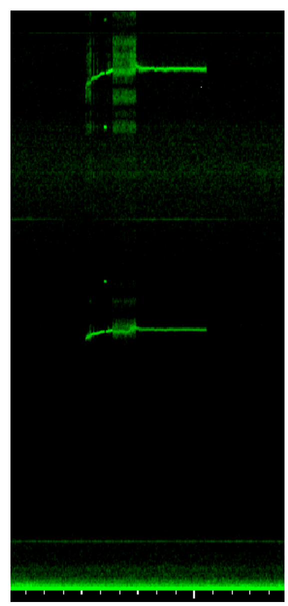

Figure 3: Spectrogram view

The spectrogram view, with time on the x-axis and frequency on the y-axis, shows the overall sound intensity as bright green regions.

Figure 3 shows the spectrogram during the period of start-up noise from the router. There are strong signals at two different frequencies. Both appear at the same time, then increase in frequency over the next few seconds. Before stabilizing, there is a period with signals spread across a wider frequency range, seen as the broadband noise in Figure 1. Finally there are two constant tones, with the two green lines corresponding to the peaks in Figure 2.

The acoustic images show that the broadband noise and both tones emanate from vents in the router housing. In each image the sound pressure level of a source is represented by color. Frequency and focus distance are shown at the top left of the image, and the dB scale is shown in the lower right corner. Notice the different peak levels in the dB scale for each image.

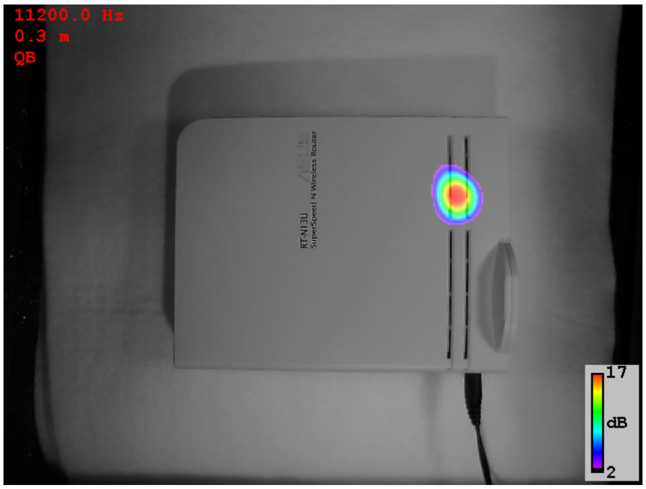

Figure 4: Acoustic Image at 11.20 kHz

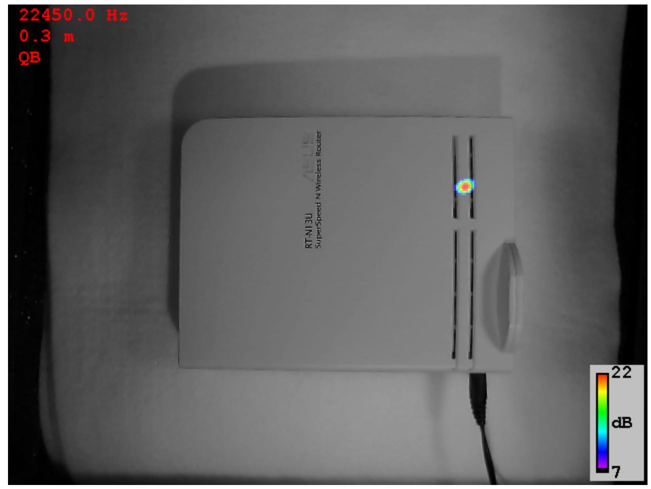

Figure 5: Acoustic Image at 22.45 kHz

Acoustic Sources

Acoustic noise in an electronic assembly typically comes from power supplies in the device or from a power brick attached to the device. Acoustic imaging identifies whether the source is in the device, in the power supply, or in both. Switching power supplies usually operate at frequencies far above the audible frequency range, but some load conditions cause modulation into the audible range.

Power supply noise typically comes from discrete components mounted to a printed circuit board (PCB). Noise sources include multi-layer ceramic capacitors (MLCCs), inductors, and transformers. An MLCC contracts and expands in response to voltage changes. That change in shape is transmitted to the PCB, causing the PCB to vibrate. Magnetic coils in inductors and transformers generate audible noise through movements in the windings and contractions in the cores. The ACAM 120 Acoustic Array identifies both MLCC sources and coil sources on this WiFi router.

While a router may on have a few dozen components, it is not unusual for a single PCB to have hundreds of MLCCs connected to a number of power supplies, with many MLCCs connected in parallel to each power supply; it might be that only a single capacitor on a power supply is generating noise.

Processors and gate arrays operate at frequencies from hundreds to thousands of MHz, so we don't usually think of them as noise sources in the audible range. Software or firmware, though often leads to bursts of activity modulating the power supplies at audible frequencies. Some of the most difficult problems come from software and firmware, because the noise is application-dependent and intermittent.

Finding Sources

The following images show the router with the case opened; the camera image has been set to black and white to make the color of the acoustic images more visible. Note the dB scales and the two distinct sources. At 11.2 kHz with the cover removed the source is shown to be a large power supply MLCC at the bottom right corner; at 22.45 kHz the primary source is a small MLCC connected to the flash memory in the upper right.

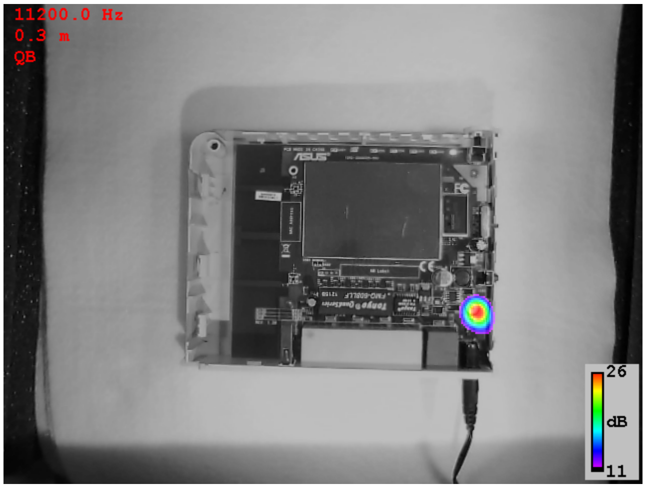

Figure 6: Source on a power supply capacitor

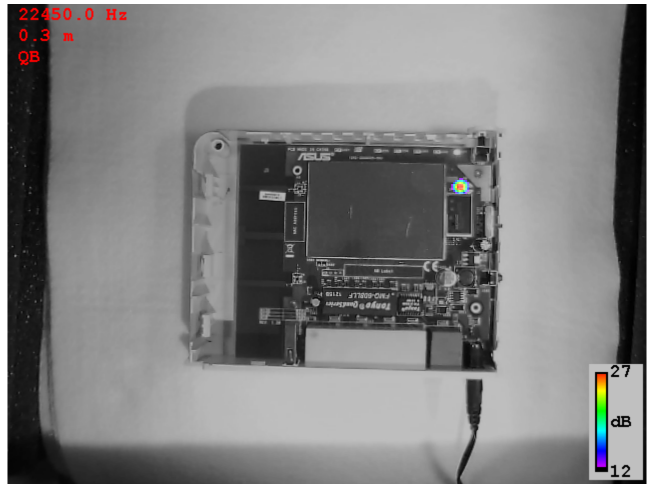

Figure 7: Capacitor connected to the flash

The spectrum appears nearly unchanged with the case removed - the same two strong signals are visible with slightly increased amplitudes. Without the enclosure, the ACAM 120 Acoustic Array can identify the distinct physical sources of the two tones seen in the initial measurement. From this information it is possible to make design changes that push the peak dB levels down.

Using ACAM 120 for Mitigation

Reducing acoustic noise in an electronic assembly is an iterative process: locate the noise sources, make design changes to eliminate or reduce the noise, then repeat. Mitigation techniques include: replacing standard components with equivalent low-noise components, redesigning the PCB, modifying the circuit design, modifying software and firmware, and adjusting vent placement and other enclosure characteristics.

To locate acoustic sources in an electronic assembly, initial tests should be performed in real time while varying parameters for the device under test. Then a recording can be used to identify the most important sources.

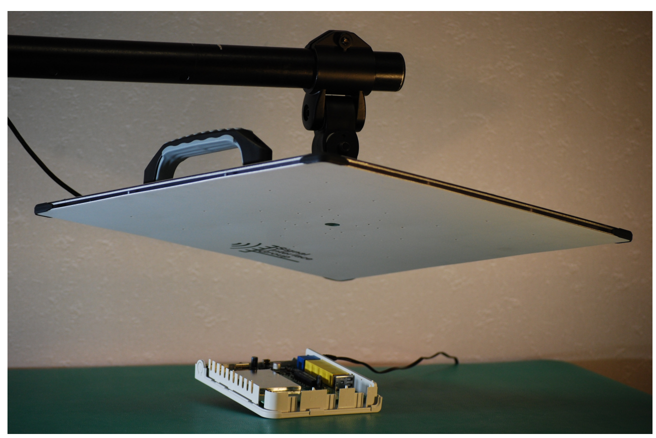
Figure 8: Test configuration with ACAM 120 Acoustic Array mounted above the router

Many noise sources are intermittent, so it is convenient to record the raw acoustic data for a few seconds and then play back the raw data for analysis at various times and frequencies, and with various parameters. BeamformX software has a higher resolution mode when working from logged data that allows for more accurate component identification.

The ACAM 120 Acoustic Array is a tool not only for pinpointing noise, but also for reducing the costs and delays associated with mitigation. With each change to the device the ACAM 120 Acoustic Array should be used to examine the sound sources and confirm the success or failure of any modifications.

The ACAM 120 Acoustic Array

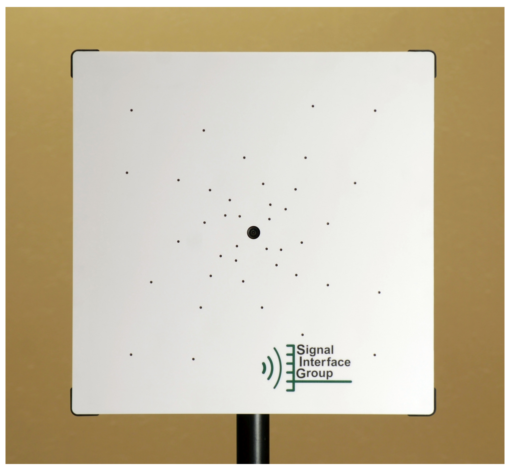

Figure 9: ACAM 120 Acoustic Array

The ACAM 120 Acoustic Array has 40 microphones and an optical camera embedded in a 40 cm x 40 cm plate. Its low noise floor makes it especially useful for this application, allowing measurements outside of an acoustic test chamber for faster turnaround time on design changes. The ACAM 120 Acoustic Array is connected to a laptop or PC with just a single USB cable for both power and data.

Signal Interface Group manufactures the ACAM 120 Acoustic Array in Bellevue, Washington, USA.

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