hummble Noise cancelling technology. Case studies

How active noise cancelling technology reduces tonal noise in ducted air-source heat pumps

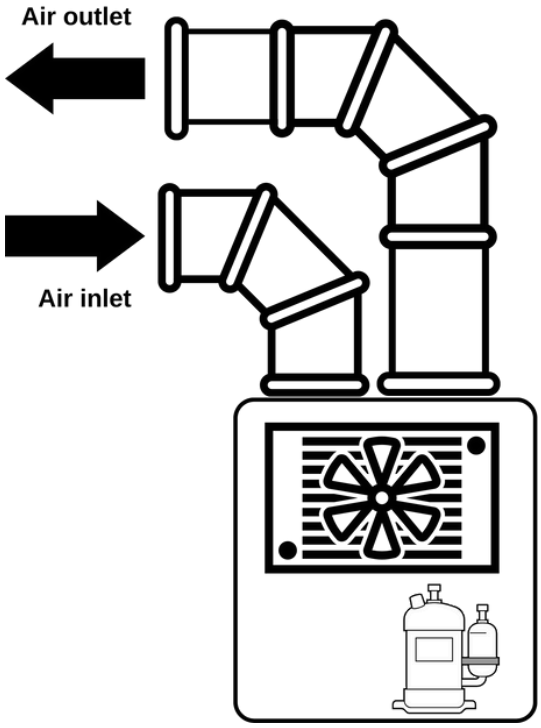
A case study showing how Hummble ANC technology reduces tonal noises in ducted air-source heat pump systems.

Ducted air-source heat pumps

In the realm of air-source heat pumps, it's common to find models that operate entirely indoors. A notable advantage of these indoor heat pumps is the elimination of the need for an outdoor unit. Instead, the heat exchange occurs within the indoor unit itself. Air is circulated through the system using a system of ducts, with one duct serving as the air inlet and another as the air outlet.

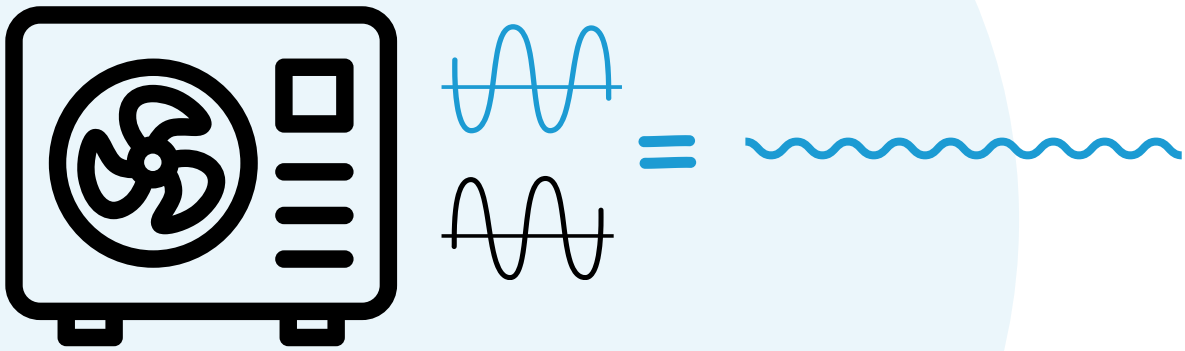
Photo: KRONOTERM Archives

These units are commonly located in apartment buildings, semi-detached houses, compact and closely populated residential areas, offices and small commercial buildings and more.



Air intake and exhaust are led through the facade or roof of the building. These models are designed to fit the properties where physical exterior space is limited.

The noise mentioned in these set-ups is mostly associated with airflow through the system, which is a broadband noise. However, the tonal low-frequency components of the compressor are equally so transmitted through the duct system. In this case study, we will demonstrate how effective is the tonality reduction in ducted air-source heat pumps using active noise cancelling technology.



Although we remain focused on tonality in this case study, the active noise cancelling technology in one-dimensional acoustic fields can be very effective even for broadband noise reduction.

Patent pending.

Our approach to this case study

The primary objective of this case study is to assess the effectiveness of using Hummble ANC technology for use in ducted air-source heat pump systems.

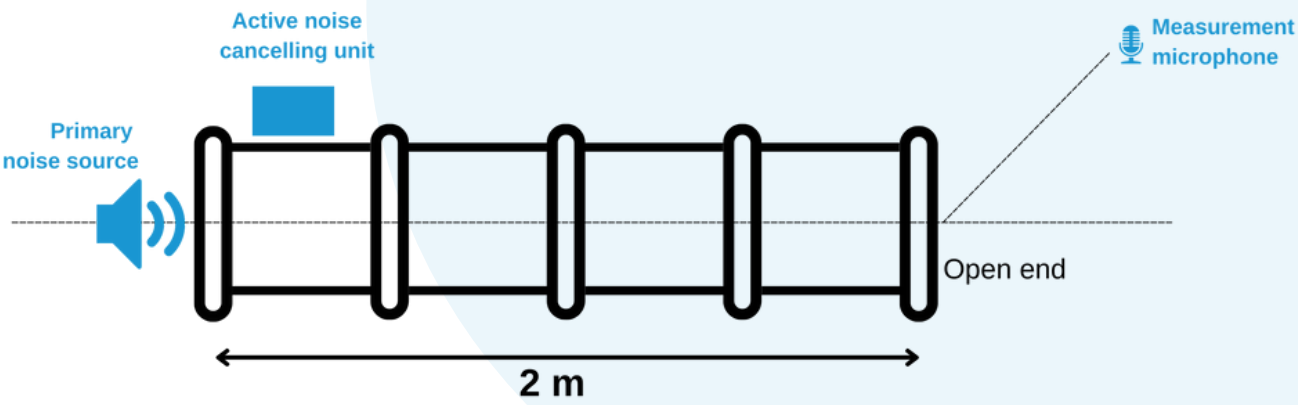
In duct applications, the acoustics of emitted noise is related to:

- Original noise source acoustic footprint
- Air flow and noise that occurs due to vortex shedding and turbulence
- Duct geometry
- Duct vibration

We have acquired a 2m long rectangular duct of 10cm x 5cm cross sectional area, placing a primary noise source on one end, and leaving the other end open.

The set-up remains consistent with control-at-source approach, but instead of an enclosure, it exploits acoustical properties of narrow channels.

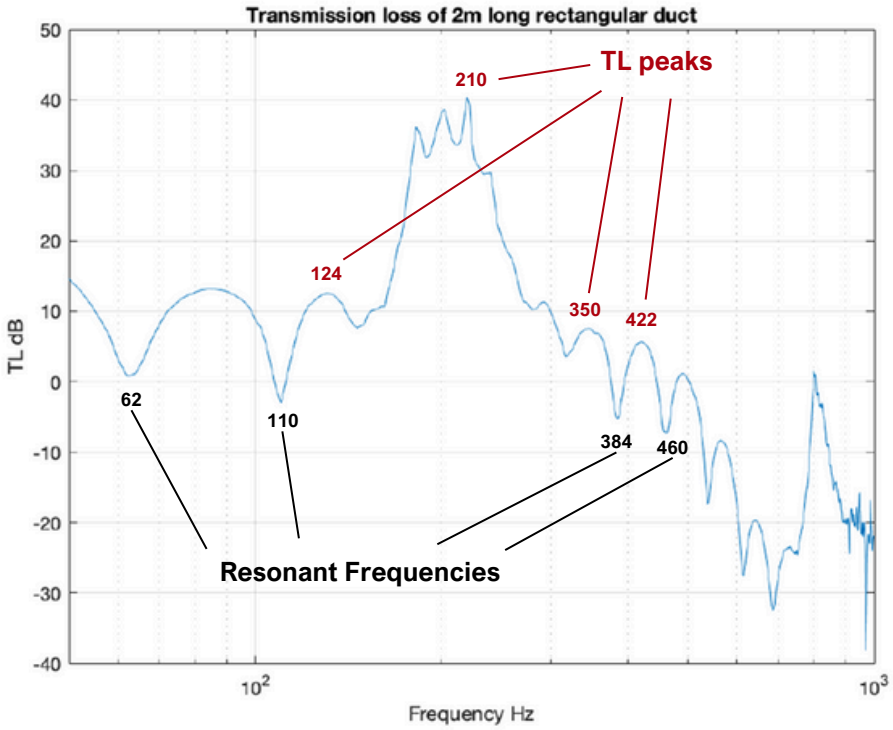
It is anticipated that the ducted applications will have a higher frequency range than enclosure-based applications and can perform equally well across the range.



To characterize the noise reduction associated with Hummble ANC system, we first characterized the transmission loss profile of the duct. This indicates how the transmitted inbound noise will be affected purely due to the fact that it travels through the pipe.

The regions above 0 dB line indicate transmission loss (i.e. sound reduction), while regions below 0 dB indicate amplification.

Transmission loss was measured right at the outlet, on-axis.



- The transmission loss (TL) is high at around 200Hz elevated region (high TL means less noise is radiated; low TL means all noise at that frequency is passing through and is loud on the outside)
- The duct seems to have amplified the noise at higher frequencies (TL < 0dB)
- Local minima/dips are duct resonant frequencies. the sound radiation is typically higher here.

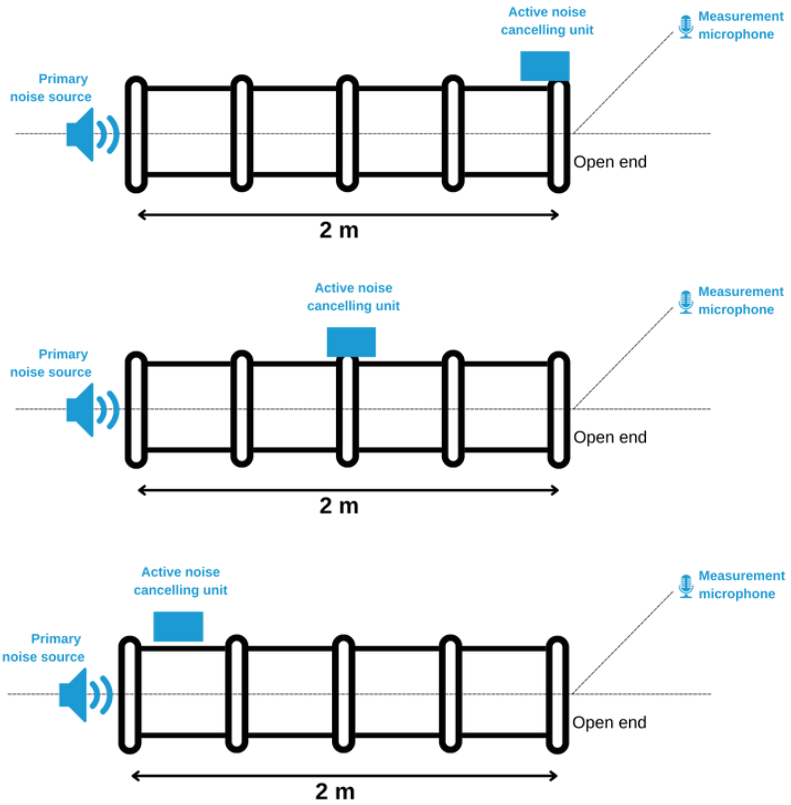
Sound reduction based on unit positioning

We will attempt to influence the pipe noise transmission at selected frequencies by applying active cancelling technology.

Hummble was applied at local minima, and elevated regions in order to increase the transmission loss at regions where the duct itself is amplifying and test whether reduction can be further improved at places where the pipe is already attenuating and test whether reduction can be further improved at places where the pipe is already attenuating..

Performance was analysed at three different positions of the cancelling unit, relative to the primary source, as indicated on the right side.

Reduction was measured at a 45° angle to the longitudinal axis of the pipe. The system was tested up to 500 Hz.



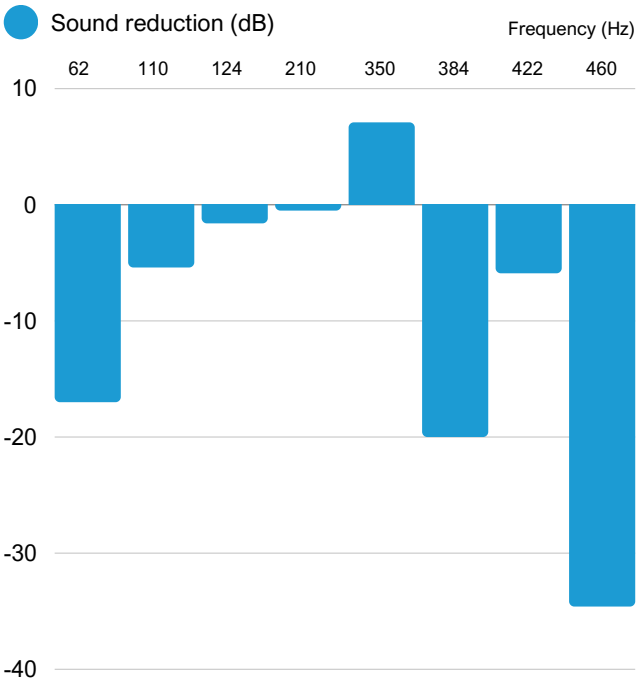
Control at termination (top), in the middle (middle) and at the source (bottom)

Results

Performance was analysed for three unit positioning options at all TL peaks and resonant frequencies as indicated on the TL curve above.

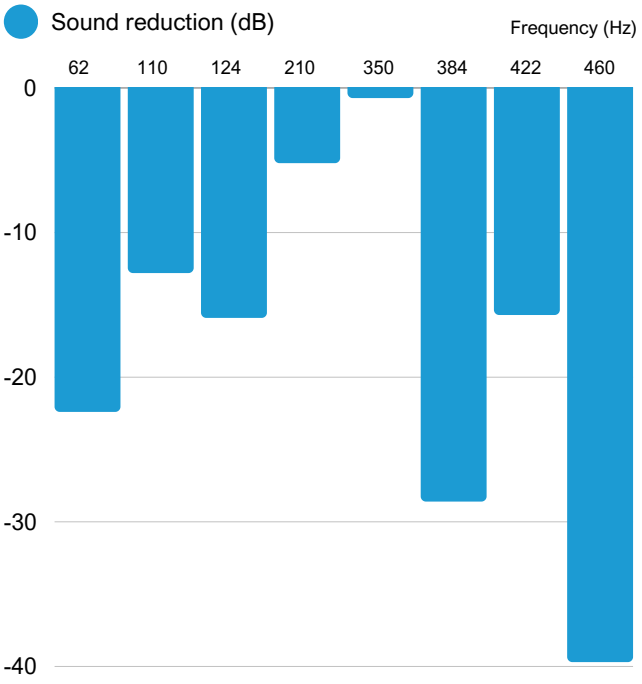
ANC unit at termination

Frequency (Hz)	Cancellation (dB)
62	-17.0
110	-5.4
124	-1.6
210	-0.5
350	7.1
384	-20.0
422	-5.9
460	-34.6



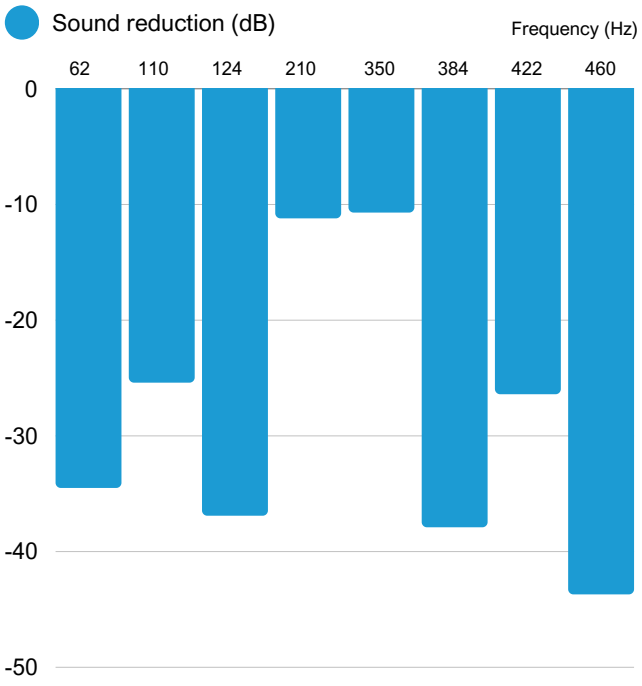
ANC unit in the middle

Frequency (Hz)	Cancellation (dB)
62	-22.4
110	-12.8
124	-18.9
210	-5.2
350	0.7
384	-28.8
422	-15.7
460	-39.7



ANC unit at the source

Frequency (Hz)	Cancellation (dB)
62	-34.5
110	-25.4
124	-36.9
210	-11.2
350	-10.7
384	-37.9
422	-26.4
460	-43.7



Conclusion

The study on the Hummble system demonstrated significant noise cancellation at various tonal frequencies when measured outside the duct outlet at a 45° angle. The effectiveness of noise cancellation improved when the cancellation source was positioned close to the primary noise source.

The findings of this case study support the use of the Hummble ANC system as an effective solution for addressing tonal noise in ducted systems.

Additionally, the system is designed for easy installation and retrofitting to existing ducts, making it a practical solution for noise control without extensive modifications.

Importantly, the Hummble system does not interfere with the heat pump's technical features or its electromagnetic compatibility (EMC) certification requirements. This ensures that the system can be implemented without necessitating further regulatory approvals.

Next steps

Future technical validations should consider several factors to optimize the system's performance. These include testing with different duct geometries, which will help define the frequency range for effective noise cancellation, and evaluating the influence of airflow on the system's efficacy. Addressing these aspects will help refine the system for broader applications and enhance its reliability in various operational environments.

Given the promising results in this case study, we are planning to move beyond tonal control towards broadband noise reduction in ducted heat pump systems.

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