

Introduction of the Next Generation Active Noise Control for the Latest Hybrid System and New Minivan

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The new premium minivan equipped with Nissan's third-generation e-POWER system was developed with the objective of providing an exceptionally quiet and comfortable cabin environment. To realize EV-like quietness, two major challenges were addressed: reducing engine-generation noise so that occupants are unaware of engine operation during power generation, and significantly reducing road noise from vehicle launch through cruising conditions. Conventional Active Noise Control (ANC) systems applied to Nissan vehicles targeted specific engine-order frequencies and were effective against booming noise only. However, both engine noise and road noise contain broadband frequency components, making a broadband ANC system necessary for further improvement in cabin quietness.

The target was to achieve EV-like quietness even when the engine was running. For engine-generation noise, the goal was to achieve cabin sound pressure levels comparable to those experienced when the engine was not operating. For road noise, the target was a segment-leading level allowing occupants to perceive smooth and refined vehicle motion even on rough road surfaces. These requirements are particularly important for the new minivan because large rear openings and sliding-door structures make low-frequency road-noise reduction difficult through passive measures alone.

The operating characteristics of the third-generation e-POWER system further emphasize the importance of broadband noise reduction. Unlike conventional ICE vehicles, the engine is dedicated to electricity generation and frequently operates at efficient, nearly constant speeds independent of vehicle speed. Although this improves fuel efficiency, engine speed tends to be relatively high during low-speed driving where background noise levels are low and engine noise becomes dominant. In addition to engine-order components, broadband noise is generated when engine is operated. Therefore, reducing both engine and road noise during low-speed cruising is essential to achieving the desired premium cabin environment.

To meet these targets, a broadband feedforward ANC system was developed. Accelerometers mounted on the vehicle body are used as reference sensors to detect vibration associated with engine and road noise, while microphones located near occupant ear positions measure residual cabin noise. Vehicle audio speakers generate cancellation sound based on these signals. High attenuation performance requires strong correlation between reference signals and cabin noise as well as sufficient speaker output throughout the control frequency range. Accordingly, six accelerometers were installed near major vibration-input locations, including the engine compartment and wheel areas, while seven microphones were positioned near occupant seating locations throughout the cabin. Speaker configurations were also optimized to avoid low-gain regions within the control bandwidth.

Vehicle evaluations confirmed that the developed system achieved its intended targets. Engine-generation noise at the driver's seat was reduced to the target level corresponding to engine-off operation, and overall road noise at the third-row seat was reduced by approximately 2 dB. These results demonstrate that the combination of third-generation e-POWER and broadband ANC successfully delivers a highly refined and quiet cabin environment suitable for a premium grand touring minivan.

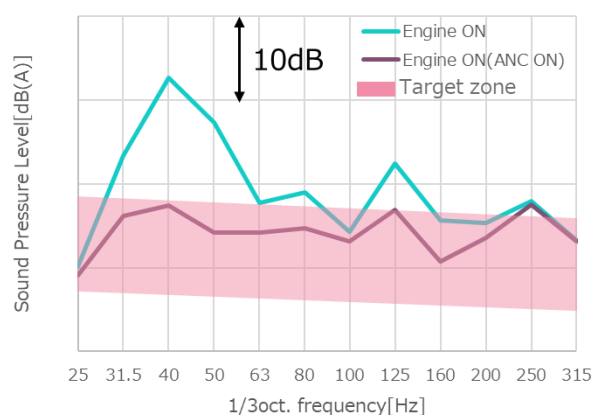


Fig. Achievement of engine noise in driver's ear

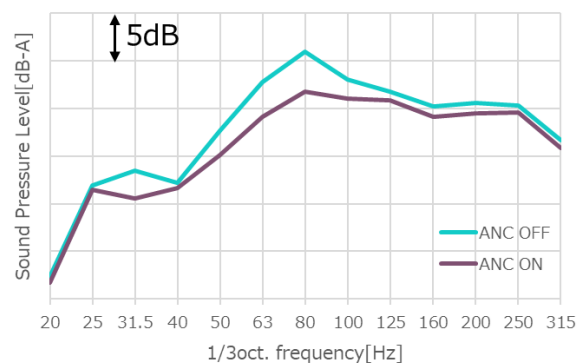


Fig. Achievement of road noise in driver's seat