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Analysis of Coupling Mechanism and Decoupling between Inductor and Active Filter in Hybrid EMI Filter

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Introduction: The converter switching frequency is greatly increased, and serious EMI noise is generated due to its higher du/dt and di/dt during conduction and turn-off. As one of the main measures to solve the EMI problem, filters need to be placed at the inputs and outputs of electronic devices that are severe or very sensitive to external interference, so that the EMI is attenuated.There are two main types of EMI filters: PEF and AEF. PEF mainly uses inductors and capaci-tors to attenuate EMI, while AEF mainly uses transis-tors and operational amplifiers to inject compensating voltages or currents into circuits to attenuate EMI. due to the volume limita-tion of the PEF and the high frequency loop gain limitation of the analog AEF, the integration of passive and active EMI filters is a feasible solution for EMI suppression, This paper analyzes the possible instability of HEF and proposes a solution to increase the stability of the system.

HEF stability analysis

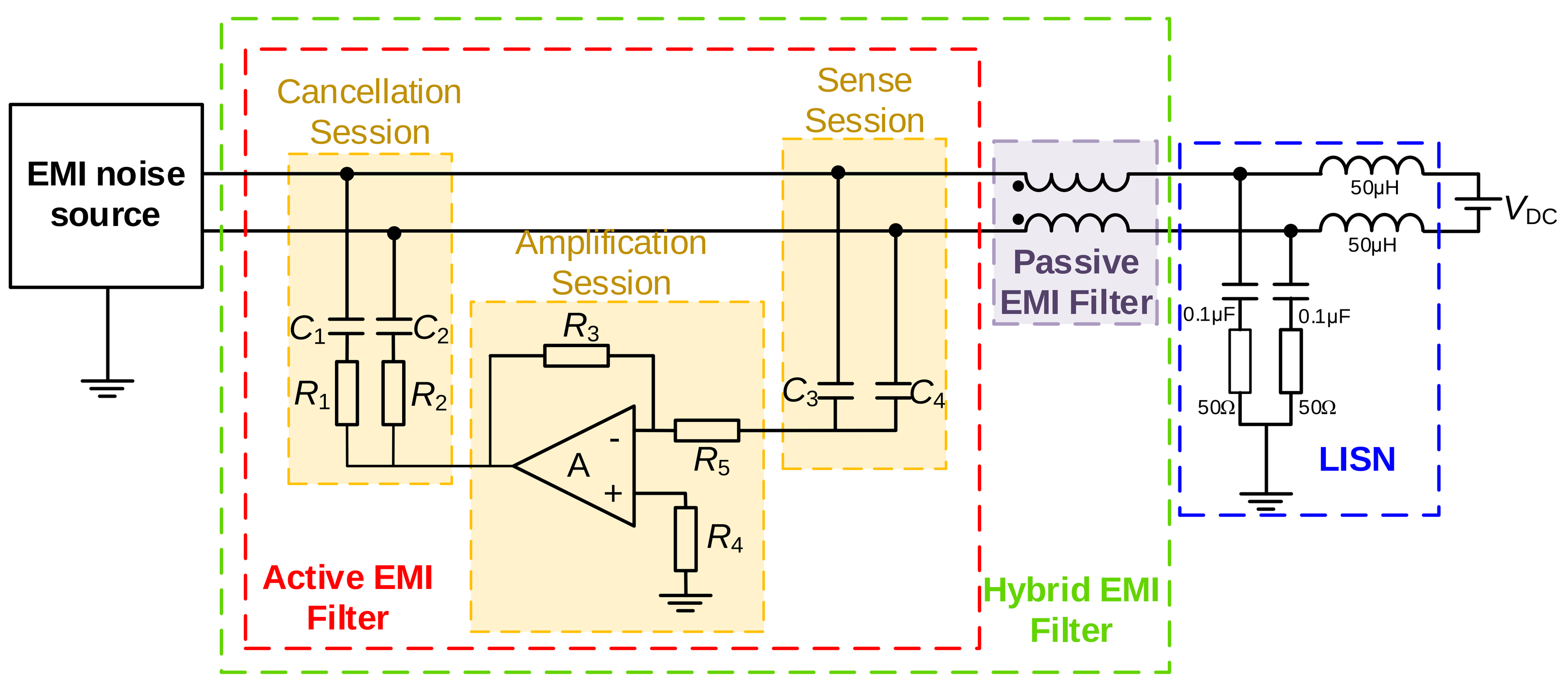

Fig. 1 Active EMI filter under investigation

$$G_1 = \frac{sC_3R_5}{sC_3R_5+1} \quad G_2 = \frac{2\pi f_t}{(1+G_2')s+2\pi f_t}\frac{R_3}{R_5} \quad G_3 = \frac{sC_1}{sC_1R_1+1}$$

The VSCC feedback active filtering topology is equivalent to a low-impedance passive device, and the common mode impedance of the LISN is generally considered to be low impedance, add a high impedance device between the AEF and the LISN to can be consistent with the principle of impedance mismatch.

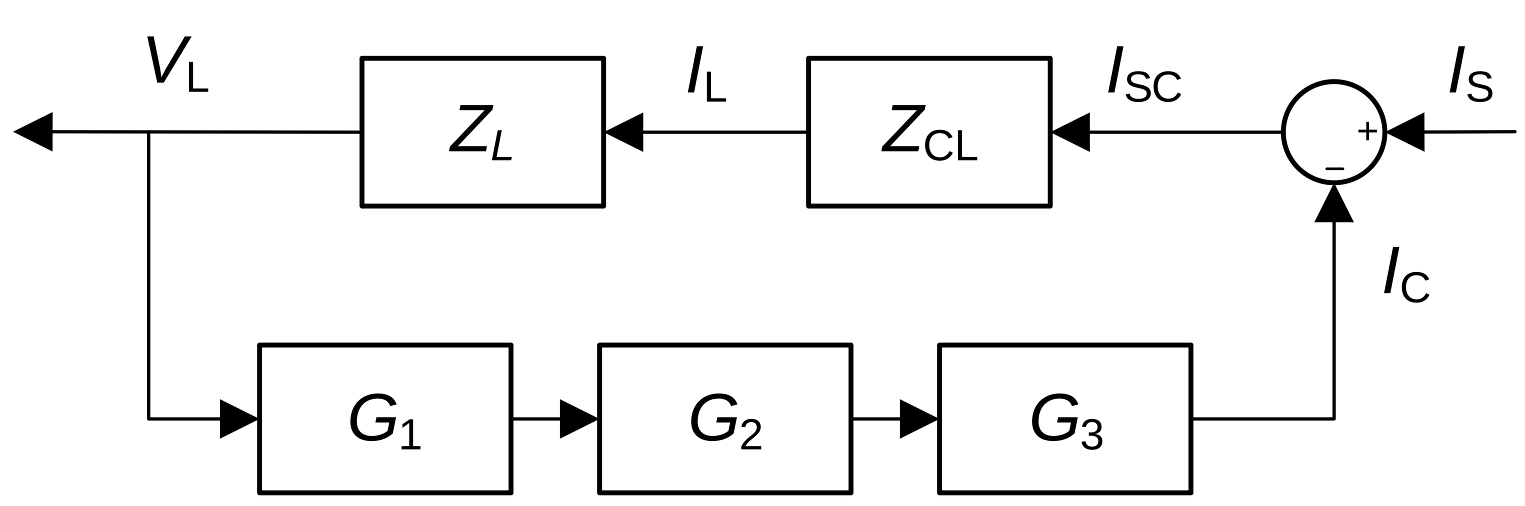

Fig. 2 Signal flow diagram

it can be seen in bode diagram that there are low-frequency poles in the system, the phase is greater than 180 ° when the gain is over 0, This phenomenon can make the system unstable. At this time the op amp feedback state is uncertain, not only will not compensate for EMI noise, but even inject noise.

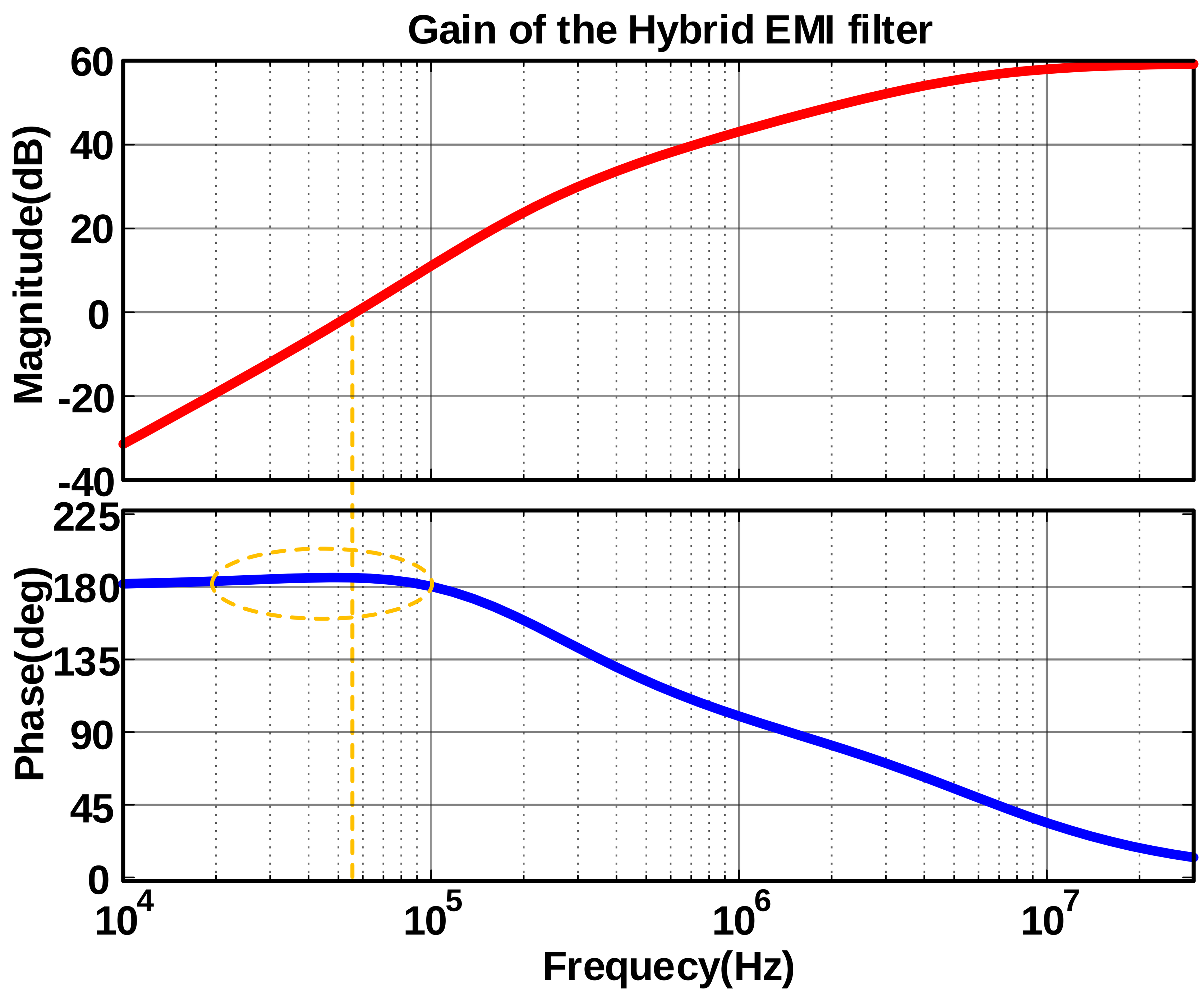

Fig. 3 Loop gain of HEF

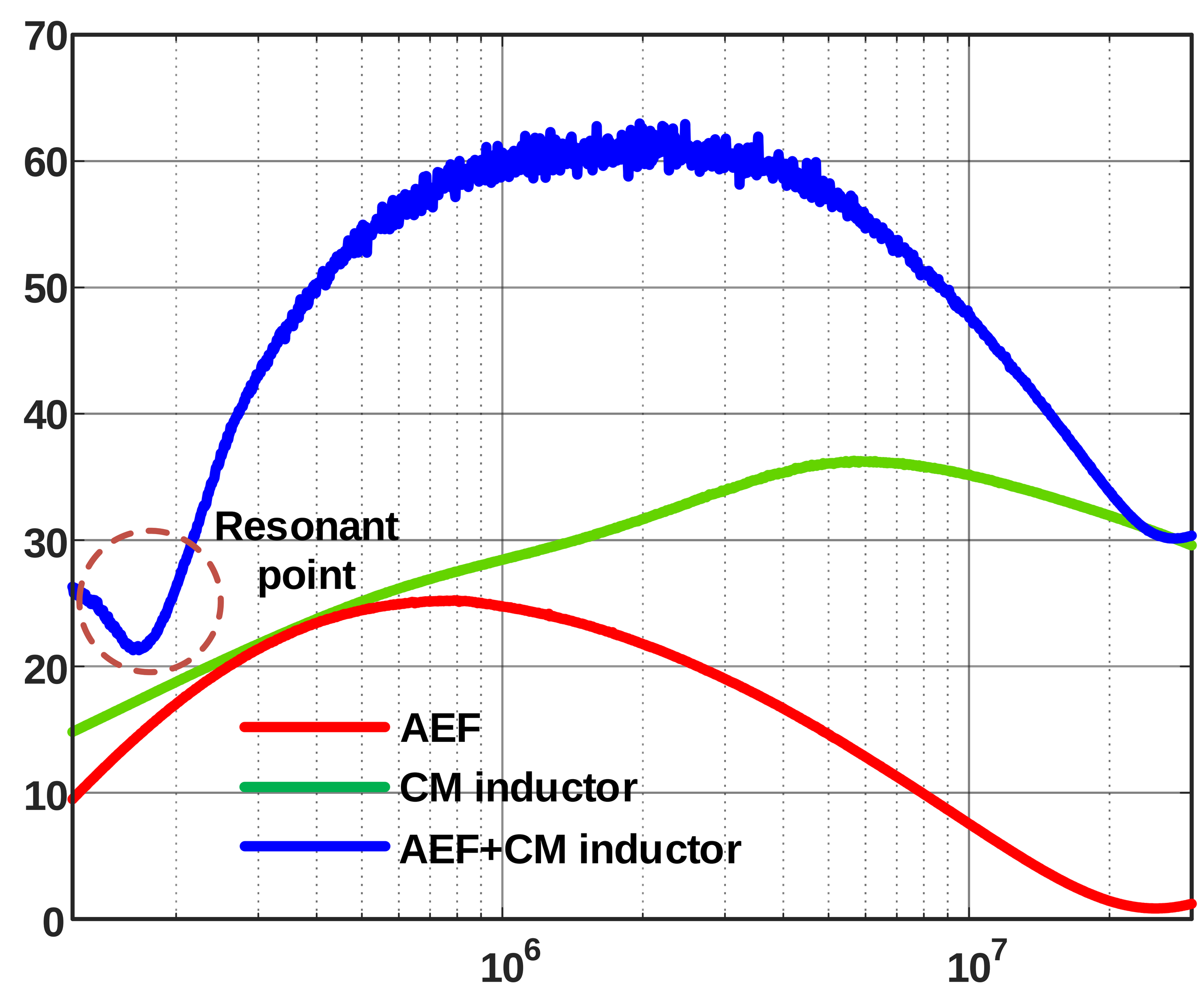

Fig. 4 Insertion loss obtained by using a VNA

Design and analysis of decoupling

the hybrid EMI filter is unstable in the low-frequency band, and by analyzing the filter structure, this phenomenon is mainly due to the LC resonance between the CM choke and the cancellation capacitance, pcim ASIA

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In order to solve the stability problem of the filter, a decoupling circuit in the cancellation circuit

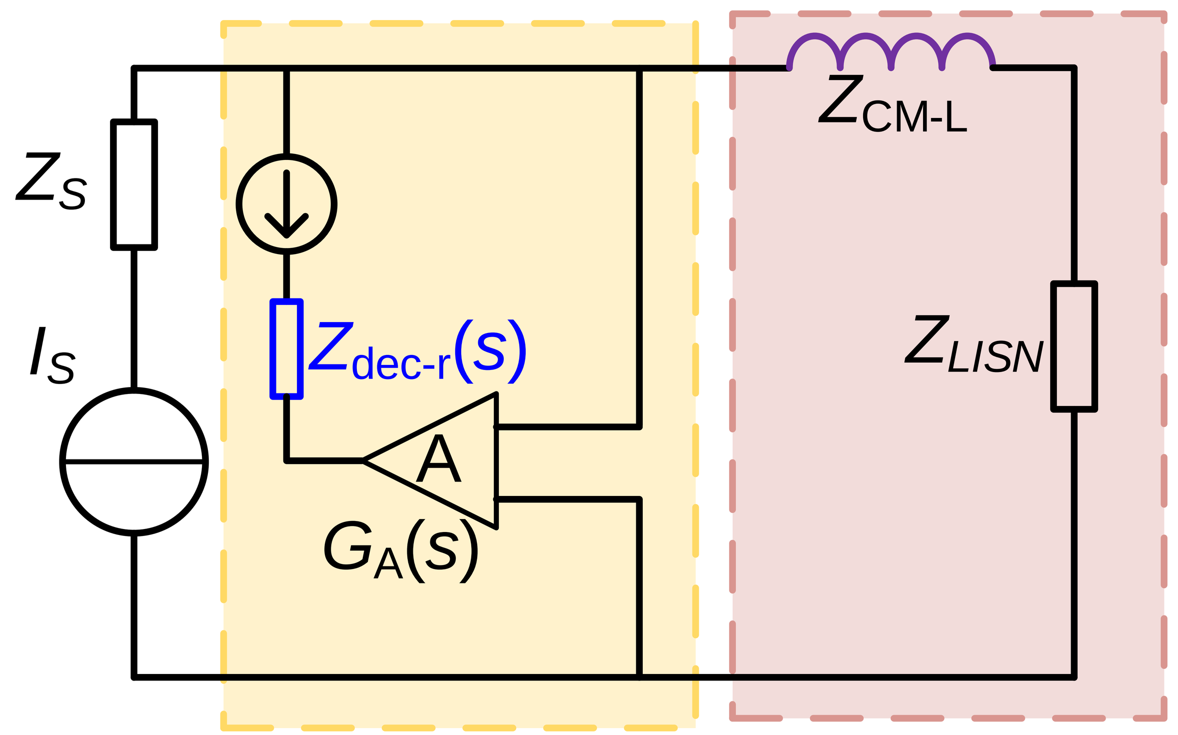

Fig. 5 HEF including cancellation session decoupling

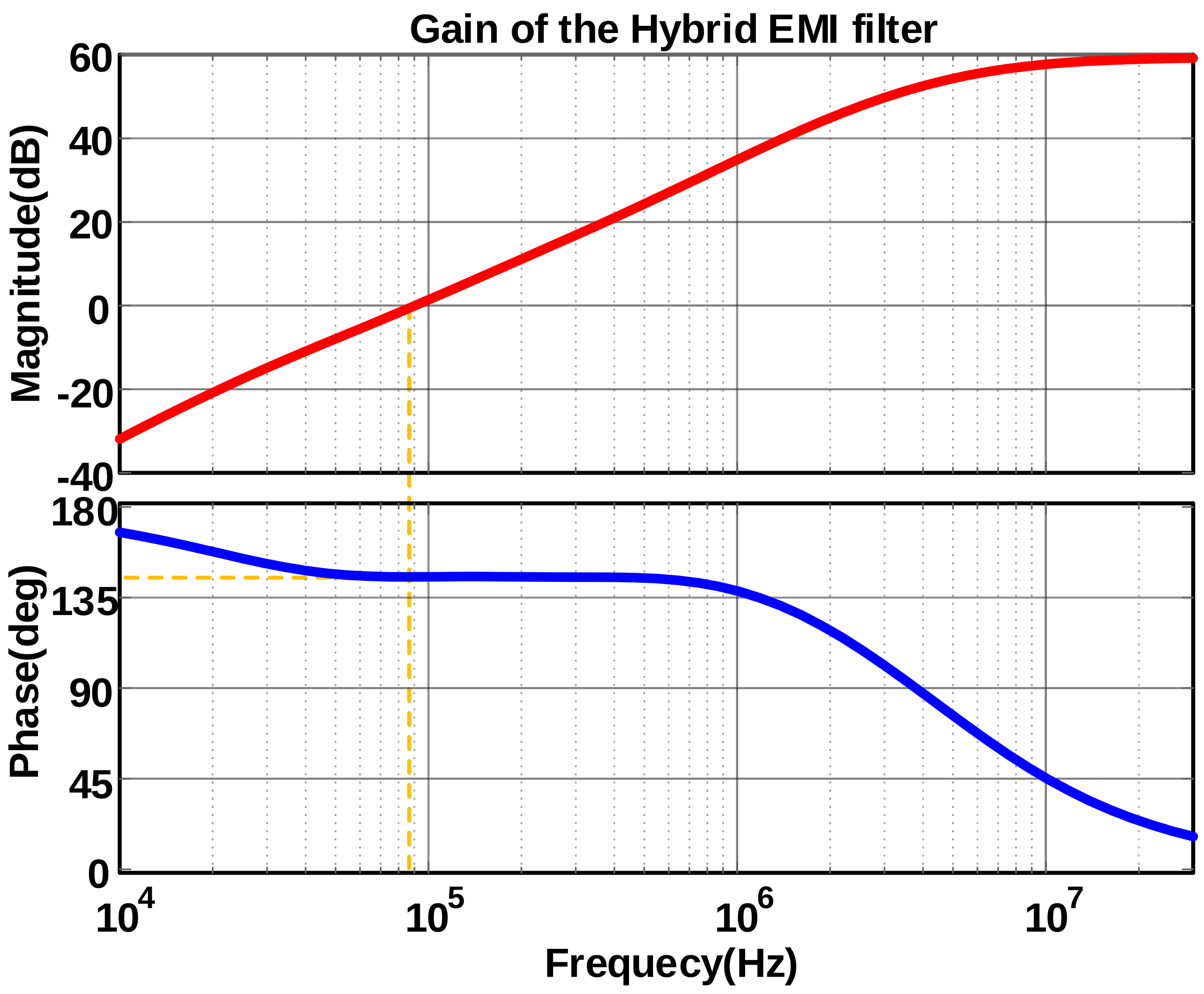

Fig. 6 Loop gain after cancellation circuit compensation

the system is more stable operation, but at this time the value of the decoupling resistor reaches 1.2k, which will lead to the AEF compensation current ability to become weaker.

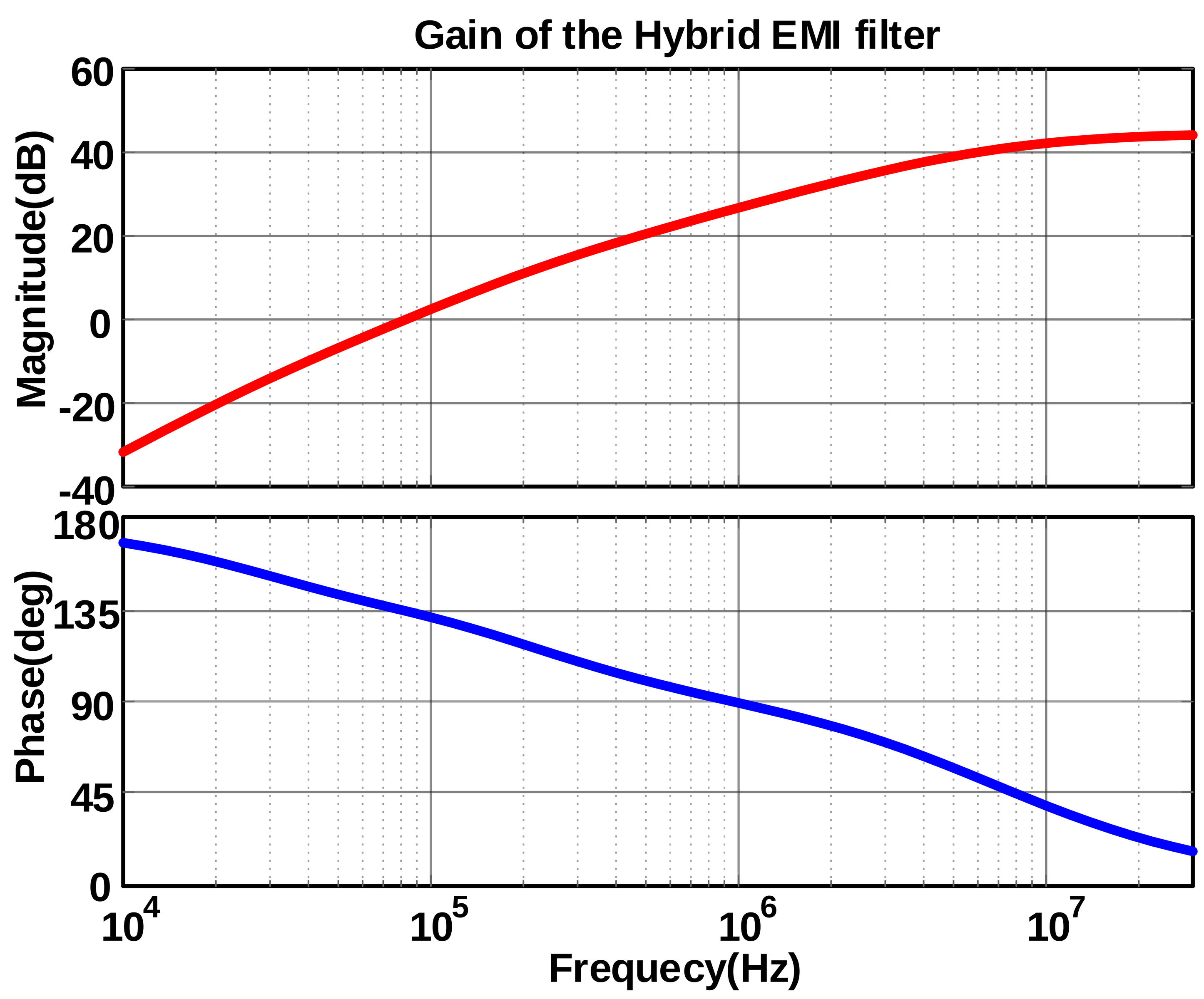

Fig. 7 Loop gain after double compensation

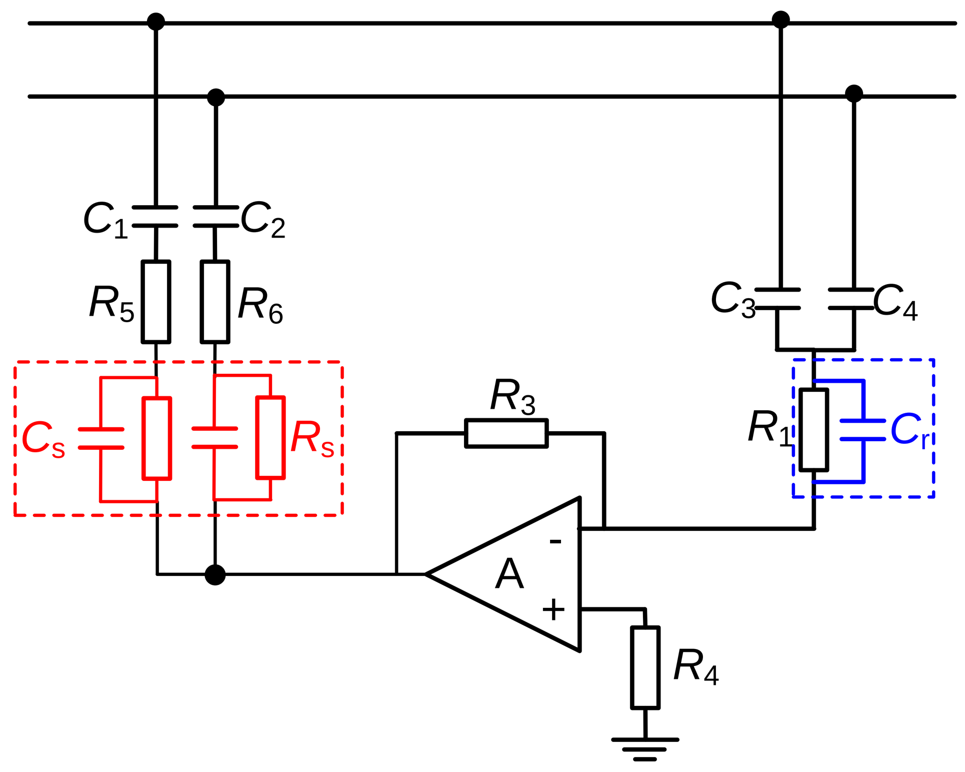

Fig. 8 AEF with decoupling circuit

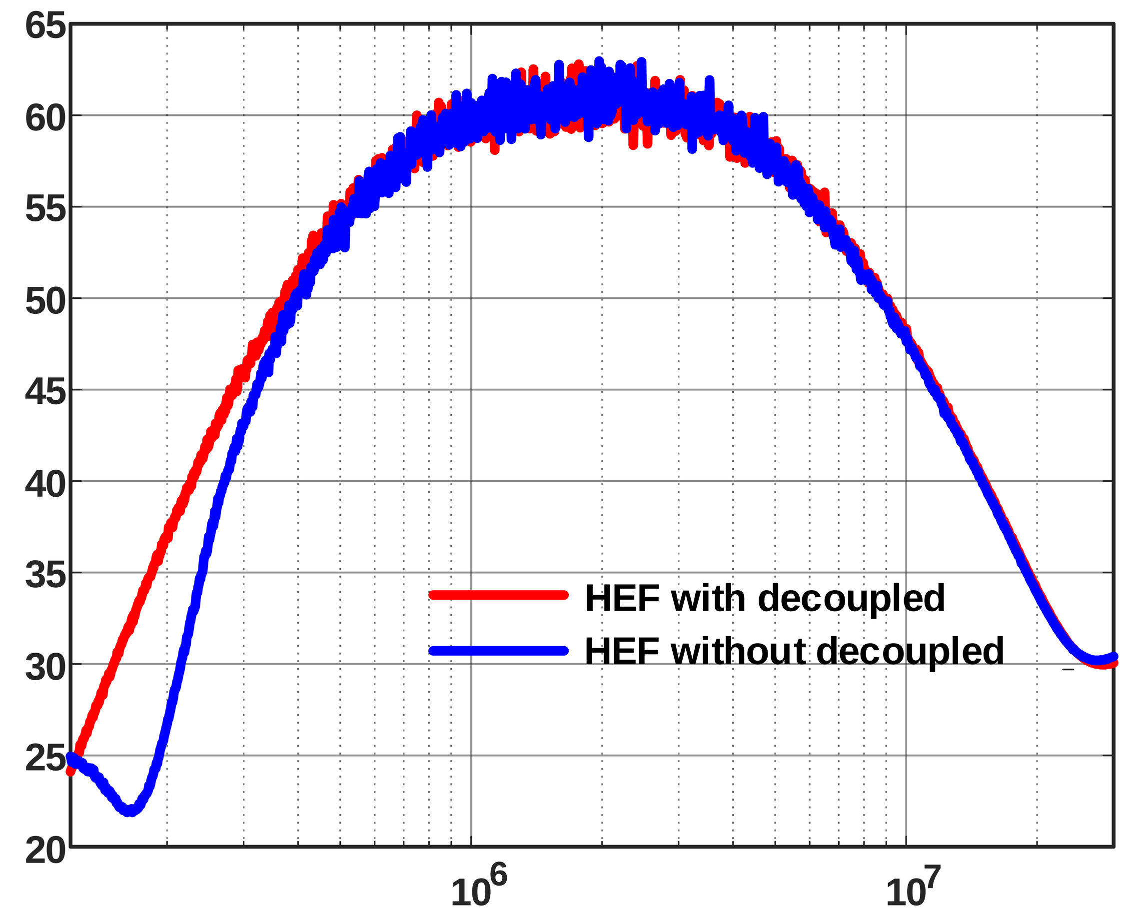

Fig. 9 IL obtained by using a VNA

Experimental results

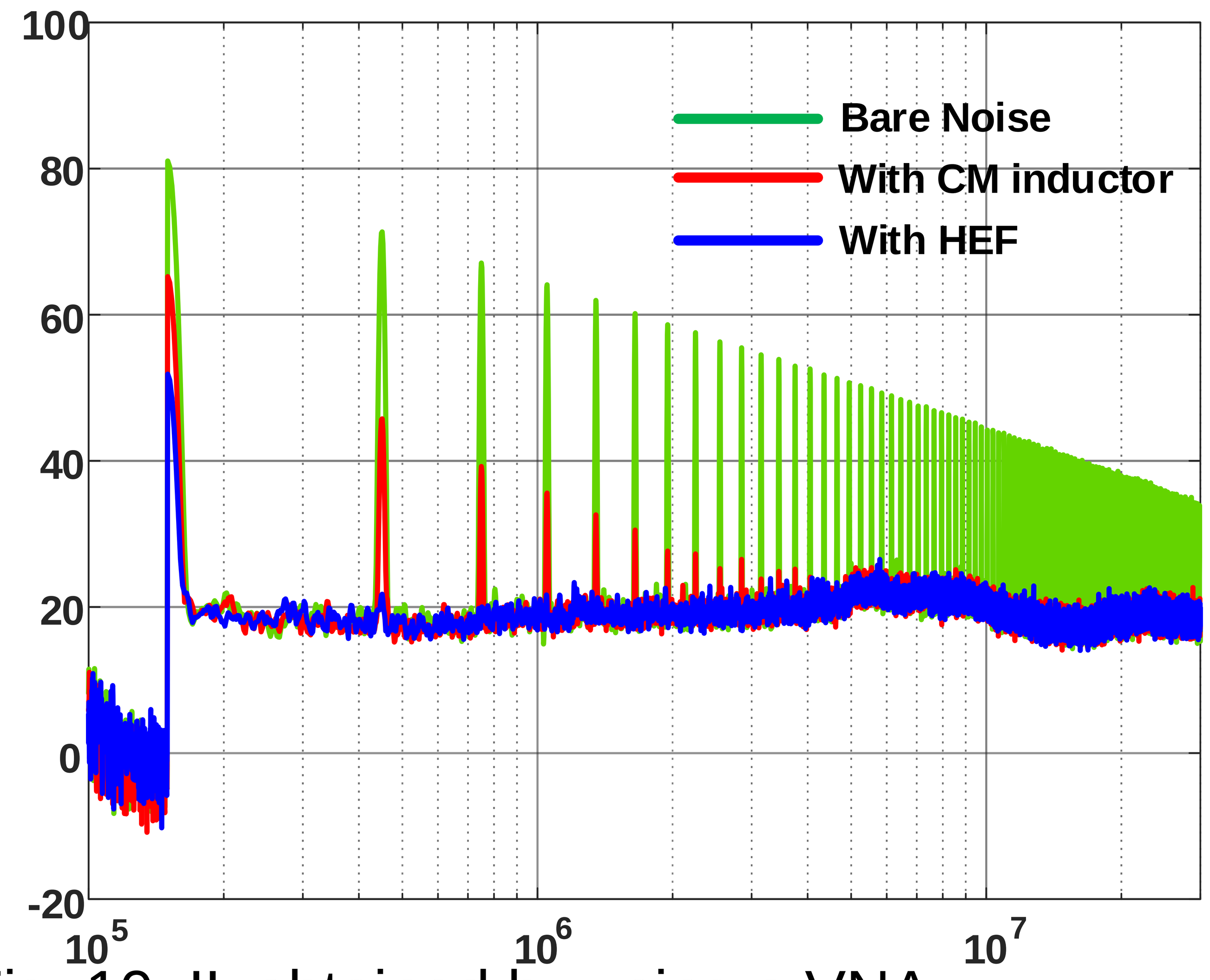

Fig. 10 IL obtained by using a VNA

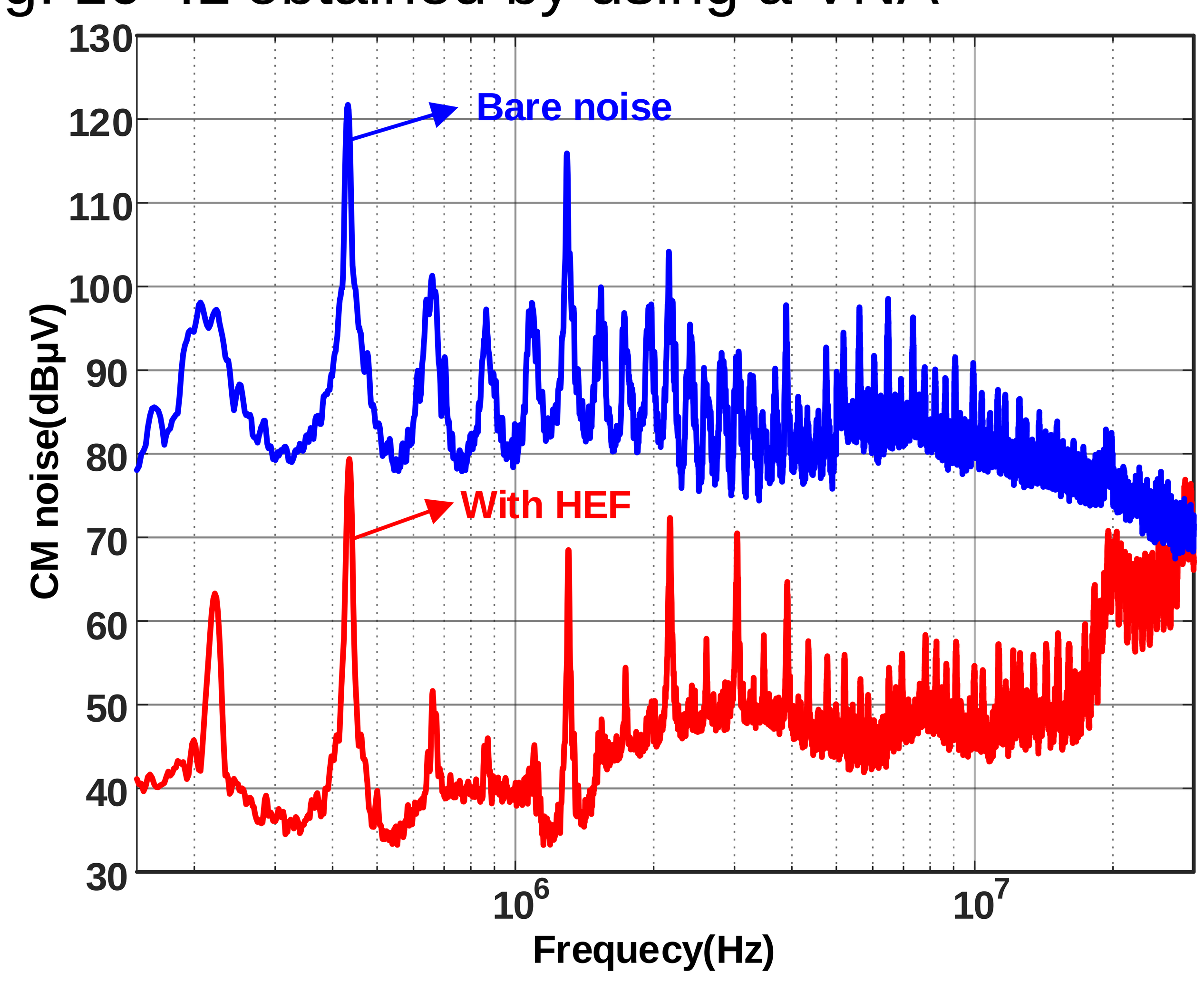

Fig. 11 Conducted CM noise spectrum