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Compact Antenna Test Range Configuration for Two-way Radar Antenna Radiation Characterization

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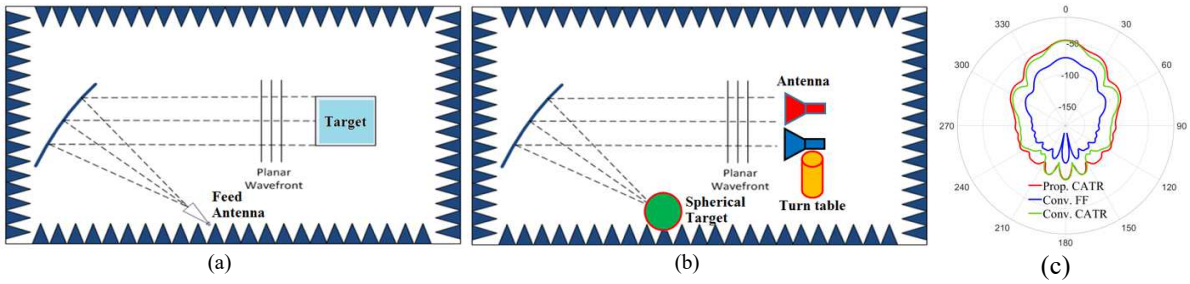
Radar systems utilize transmission and reception, referred to as a TX/RX radar system [1], to detect targets. The system works by emitting a radar signal from a transmitter, which then bounces off an object and is received by a receiver for target identification and detection. The receiver analyzes the received signal to calculate the object's distance, velocity, and position. These systems are commonly used in traffic management, weather forecasting, navigation, and missile guidance [2]. The relationship between distance and the antenna under test (AUT) in traditional radar testing environments is crucial. To meet the needs of plane wave illumination, the testing distance is usually far away to accurately measure the performance of the radar system. Therefore, it is difficult to realize inside an anechoic chamber. A compact antenna testing range (CATR) [3] is a good solution to reduce its range size. The TX and RX antennas are placed at the focal point, as shown in Fig. 1(a). Standard reflector targets such as metal spheres or small trihedral reflectors are placed in a quiet zone as the testing targets. The phase and amplitude changes in the quiet zone are relatively stable at less than 22.5 degrees and 1 dB. When attempting to measure the two-way radiation performance of the combined TX and RX antennas, the large antenna size can cause deviations from the focal point of the CATR reflector, resulting in inaccurate measurement results.

In this work, we propose a new configuration for compact antenna testing setup, as shown in Fig. 1(b). The setup reverses the positions of the TX/RX antenna and the reference target compared to traditional setups in Fig. 1(a). In this case, since the focus region can accommodate very small reference targets, it is possible to achieve a situation where the characteristics of the TX/RX antenna can be measured simultaneously. In addition, the TX/RX antenna is placed in the common quiet zone facing the compact reflector, eliminating size constraints. Conceptually, only the rays parallel to the reflector axis are converted into spherical waves. The ray path is focused at the focal point under the transmission mode of the TX antenna. The feasibility of this configuration is demonstrated through simulations and analysis of the two-way radiation pattern, as shown in Fig. 1(c), and frequency responses of the reference target with antenna pair in four scenarios, including the conventional far-field measurement setup, the conventional CATR setup, and the proposed CATR setup using electromagnetic simulation software FEKO. Additionally, the optimal positioning of the TX/RX antenna and CATR reflector within the test environment is discussed to improve the focusing ability and accuracy of the signal capturing. Lastly, this novel design is a very effective setup for TX/RX antenna characterization at a low cost and compact size.



(a) (b) (c)

Figure 1. (a) (b) Configurations of compact ranges for antenna and target RCS characterization in radar applications. (c) Two-way patterns of the TX/RX antenna pair with respect to the angular variation when the configurations of three different setups are used, where a metal sphere is employed as the target.

References

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