National Physical Laboratory

Interference Minimisation of Antenna-to-Range Interface for Pattern Testing of Electrically Small Antennas

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Abstract

The accurate measurement of radiation patterns of electrically small antennas (ESAs) requires a reflectionless environment and minimal disturbance from the antenna support and feed cable. These influence factors constitute the "antenna-to-range interface" and hence the deviation of the antenna performance from an ideal non-invasive set-up. To eliminate the large distortion associated with the unwanted radiation from a coaxial cable an electro-optical (EO) transducer was employed. Numerical results for the radiation pattern of a dielectric resonator ESA operating at 2.45 GHz are compared with the measured results using an EO transducer or a cable.

Introduction

- ESAs inherently have near omni-directional radiation patterns.
- For reasons of space and/or cost ESAs may not have adequate baluns and are prone to excite common mode currents on cables connected to them.
- If an external power supply or data cables are needed to test such unbalanced antennas, the common mode current will radiate and distort their true radiation pattern and causing errors [1], [2].
- To address the above problem the metal coaxial line can be replaced by an optical fibre, which is not invasive to the fields being measured and will not support common mode currents. This can be achieved by the opto-electric field sensor (OEFS) system, which can greatly improve correlation with the computer model.
- The shielding effectiveness of the EO transducer is reported.

Shielding of the Electro-Optical Transducer

- The shielding effect of different transducer designs is assessed with an electrically small ultra-wide band antenna (UWB) and with a 50 Ω matched load in three different orientations, illuminated by a double-ridge horn antenna at 1 m distance.
- The transducers considered were:
  - Seikoh-Giken OEFS-PR-7G (acrylic cased) (see Fig. 1); and
  - Seikoh-Giken OEFS-6S-002 (10 mm x 10 mm x 20 mm metal case with tapered acrylic) (see Fig. 2).
- The output of the transducer was connected to an OEFS-CII-10 GHz controller, which uses an X-cut lithium niobate crystal to modulate light with an RF signal.
- In the case of the acrylic cased transducer, Fig. 3 shows the interferring signal only 6 dB less than the monopole signal, up to 6.2 GHz.
- For the metal cased transducer shown in Fig. 4, the shielding is much improved, with the signal near to the receiver noise floor up to 6.6 GHz, giving a signal-to-noise ratio of greater than 30 dB.

Figure 1: OEFS-PR-7G acrylic cased EO transducer with SMA connector.

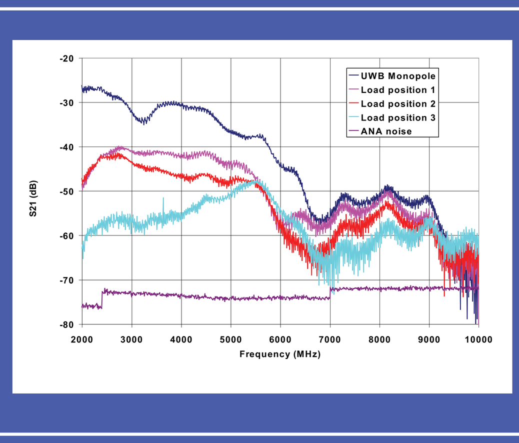

Figure 3: Signal pickup of loaded unshielded transducer OEFS-PR-7G in 3 orientations, compared to UWB monopole

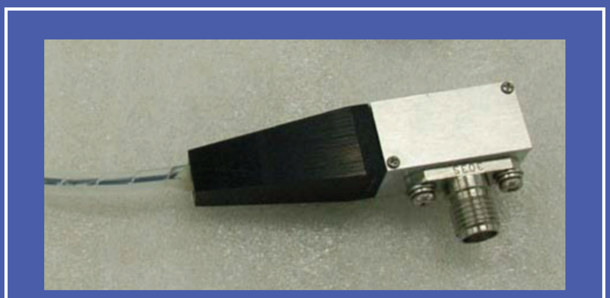

Figure 2: OEFS-6S-002 metal case EO transducer with SMA connector.

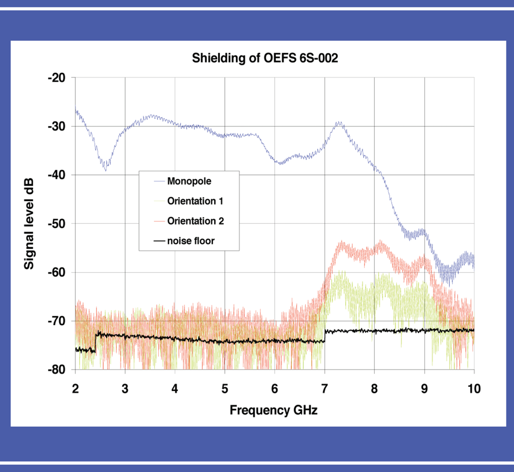

Figure 4: Signal pickup of loaded shielded transducer OEFS-6S-002 in 2 orientations, compared to UWB monopole and ANA noise floor

Experiment Setup

The NPL small antenna range is built in a screened room 7.15 m long 6.25 m high 6.25 m wide. It is fully lined with 45 cm long TDK polyethylene foam pyramidal absorber (see Fig. 5).

Spherical radiation pattern measurements for both the vertical polarisation (VP) and horizontal polarisation (HP) of the source horn were performed at 2.45 GHz to assess the difference when an Dielectric Resonator Antenna (DRA) was connected via cable or EO transducer (see Figs. 6 & 7).

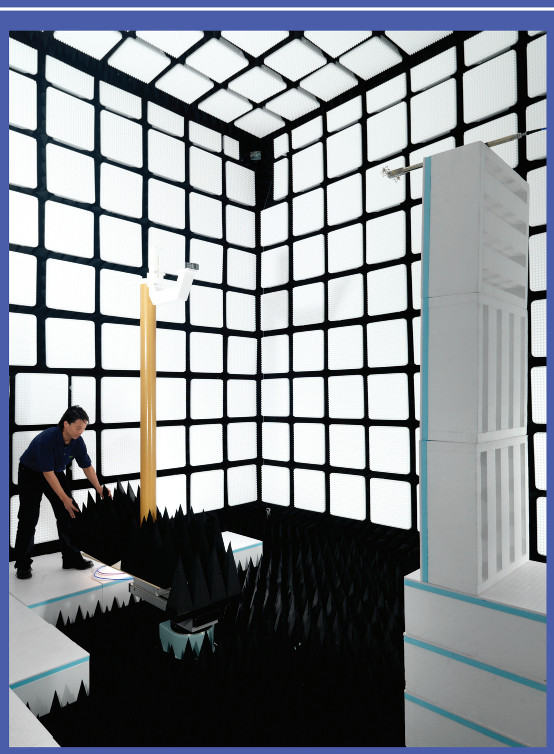

Figure 5: Orbit roll-over-azimuth positioner with thin walled Kevlar tube tower and TDK absorber and polystyrene foam tower

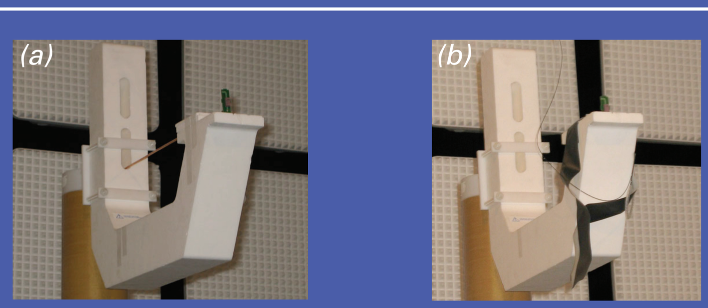

Figure 6: Photographs of the experimental setup for pattern measurements of the DRA antenna using: (a) cable, (b) fibre

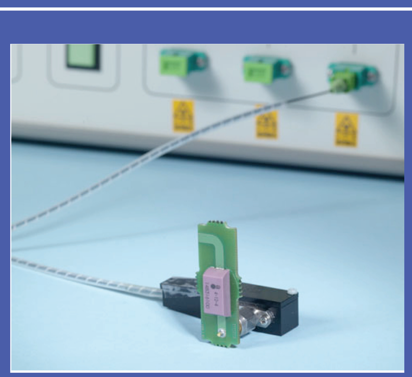

Figure 7: The DRA antenna connected directly to the OEFS-PR-7G transducer and OEFS system. .

Simulation and Measurement Results

- Simulations were performed using the commercial CST Microwave Studio.
- The DRA, the SMA adaptor and the metallic cased EO transducer were included (see Fig. 8).
- Figs. 9 and 10 show the radiation patterns of the DRA obtained from simulation and measurement with the EO transducer or a cable, for VP and HP, respectively.
- The deeper nulls on the plots for the coaxial cable connection clearly show the destructive interference of the radiation from the cable, compared to the shallower nulls for the EO transducer, where it has a better agreement with the numerical results.

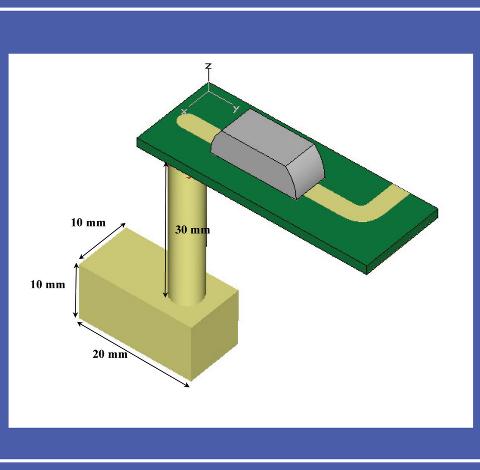

Figure 8: The DRA antenna with the SMA adaptor and the metallic cased EO transducer.

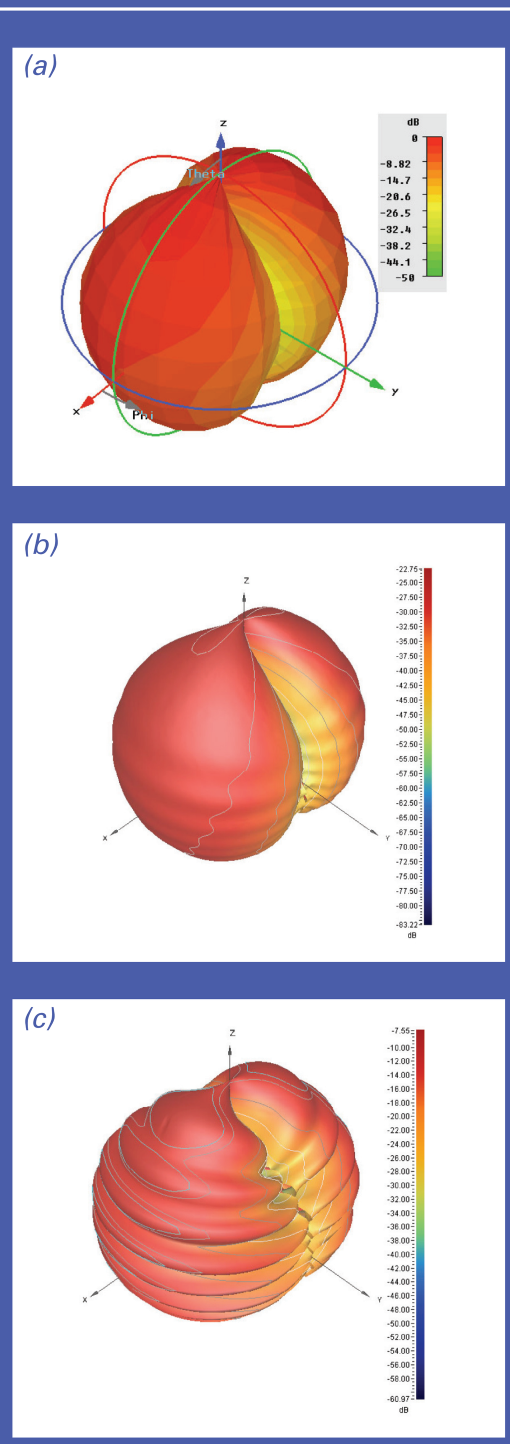

Figure 9 : The vertically polarised radiation pattern of an electrically small DRA measured at 2.45 GHz: (a) simulation results, (b) measured results using EO transducer, (c) measured results using metallic

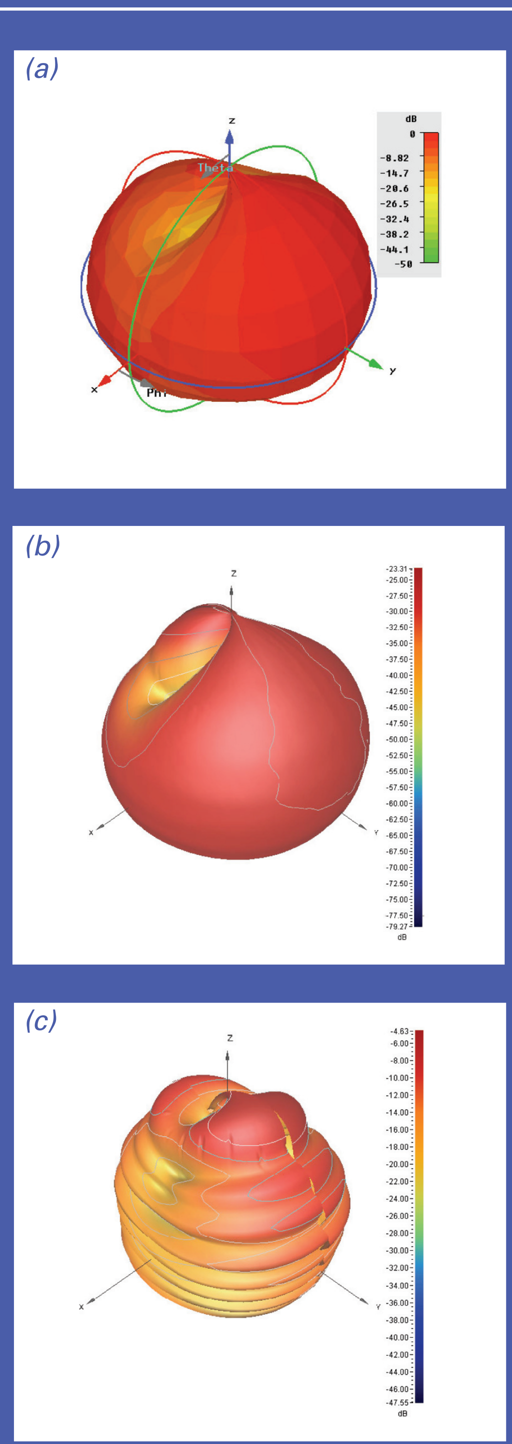

Figure 10: The horizontally polarised radiation pattern of an electrically small DRA measured at 2.45 GHz: (a) simulation results, (b) measured results using EO transducer, (c) measured results using metallic cable.

Conclusion:

- The shielding effectiveness of an acrylic cased and a partly shield metal cased EO transducers was assessed. It was found that the later achieves better than 25 dB of signal to EMI noise ratio up to 6.6 GHz.
- The measurement of the DRA showed dramatically the improvement in the pattern measurement over a sphere when the coaxial cable was substituted by the EO transducer.
- Good agreement was found between the numerical results and EO transducer measurement.
- This strongly demonstrated the improved measurement accuracy achieved by using an EO transducer to measure an ESA via optical fibre.

References

1. T. H. Loh, et al, "Small Antenna Pattern Testing – The Antenna-to-Range Interface", *EuCAP 2007*, Edinburgh, UK, Nov. 2007.
2. M. Alexander, et al, "Measurement of electrically small antennas via optical fibre", *LAPC 2009*, Loughborough, UK, Nov. 2009.

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