UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

RESMED CORP.,
Petitioners,

v.

FRACTUS, S.A.,
Patent Owner.

Case No. IPR2026-00191
Patent 11,031,677

SECOND SUPPLEMENTARY DECLARATION OF HOSSEIN HASHEMI, Ph.D.

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1. As understood by the person of ordinary skill in the art, the conventional far-field radiation pattern is normally defined with reference to and characterized in the "far field" of the antenna. This is because in the far-field region the angular distribution of the radiated field is substantially independent of the distance from the antenna. In other words, the far field allows the POSITA to characterize the antenna radiation pattern without the pattern changing merely because the measurement point was moved farther away.

2. The far field is the region sufficiently far from an antenna in which the electromagnetic radiation has essentially formed a propagating wave and the angular distribution of the radiation pattern no longer depends on the distance from the antenna. In this region, the electric and magnetic fields are approximately transverse to the direction of propagation, and the electric and magnetic fields have the relationship characteristic of a plane wave. For an antenna with a maximum physical dimension D, a commonly used criterion for the beginning of the far-field (Fraunhofer) region is:

$$r \gg D, r \gg \lambda, and\ r > \frac{2D^2}{\lambda},$$

where *r* is the distance from the antenna, *D* is the maximum dimension of the antenna, and λ is the operating wavelength for which the far field is being determined.

3. In the far field, the radial component of the electric field, E_r, becomes negligible in the far field and the field is transverse. This follows directly from far-zone Maxwell-field relationships. In the far field, the electric field may be expressed as

$$\mathbf{E}(r, \theta, \emptyset) \approx {e^{-jkr}}/{r}\left[F_\theta(\theta, \emptyset)\widehat{\boldsymbol{\theta}} + F_\emptyset(\theta, \emptyset)\widehat{\emptyset}\right] = E_\theta(\theta, \emptyset)\widehat{\boldsymbol{\theta}} + E_\emptyset(\theta, \emptyset)\widehat{\emptyset}$$

where θ and ϕ are angular coordinates and r is the radial distance. The amplitude dependence and propagation phase represented as ${e^{-jkr}}/{r}$ are separated from the far-field radiation pattern $F_\theta(\theta, \emptyset)$ and $F_\emptyset(\theta, \emptyset)$, which depends only on the angular coordinates θ and ϕ.

4. The quantities $F_\theta(\theta, \emptyset)$ and $F_\emptyset(\theta, \emptyset)$ can be obtained from an electromagnetic simulation, antenna measurement, or an analytical solution for the particular antenna. The far-field pattern may then be expressed in terms of field strength, power density, gain, directivity, or normalized radiation intensity.

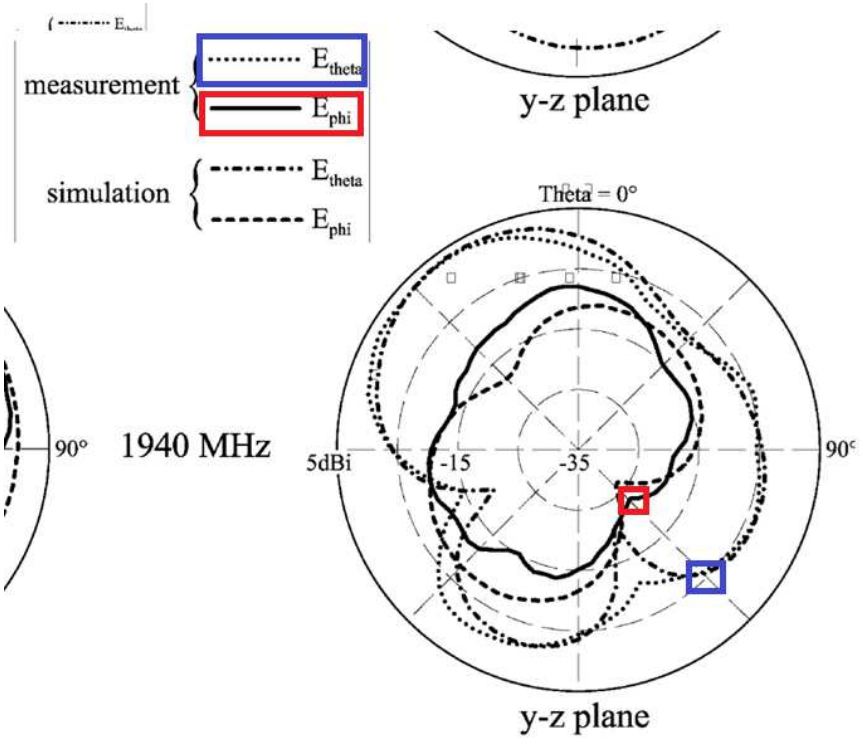
5. Because $E_\theta(\theta, \emptyset)$ and $E_\emptyset(\theta, \emptyset)$ are orthogonal components of the electric field, the overall magnitude of the transverse electric field is obtained by taking the root-sum-square of the two components. Thus,

$$|E_t| \approx \sqrt{E_\theta(\theta, \emptyset)^2 + E_\emptyset(\theta, \emptyset)^2}.$$

6. This relationship is particularly important when evaluating the total far-field electric-field radiation from an antenna. $E_\theta(\theta, \emptyset)$ and $E_\emptyset(\theta, \emptyset)$ represent two orthogonal components (corresponding to orthogonal polarizations) of the electric field at the observation point. Neither component, by itself, necessarily represents the total electric-field strength. The total electric field magnitude accounts for both components simultaneously. Thus, for purposes of determining the magnitude of the total far-field electric field, both $E_\theta(\theta, \emptyset)$ and $E_\emptyset(\theta, \emptyset)$ should be considered.

7. Applying these concepts to the Ciais Quadband radiation patterns illustrates why the radiation patterns are described therein as "quasi-omnidirectional" or "omnidirectional." Consider, for example, the y-z radiation pattern provided in Ciais Quadband. Even though the Ciais-Quadband antenna may exhibit a lower ϕ-polarized gain in particular directions (annotated in red below) the stronger orthogonally polarized component in those directions (annotated in blue) means that a reduction in

one polarization component does not necessarily correspond to a comparable reduction in the total electric-field magnitude or total gain.



8. Ciais's published 2-D magnitude cuts are insufficient by themselves to establish that a particular reorientation of two Ciais antennas would provide useful pattern diversity.

9. Diving deeper into diversity, the plane-cut approach for diversity analysis is, in some instances, an over-simplification. Diversity can be analyzed considering the radiation pattern over the entire spherical angular domain surrounding the antenna. The plane-cut analysis provides two-dimensional gain cuts and does not necessarily provide the complete three-

dimensional complex E_θ and E_ϕ fields, including phase, needed for certain specific far-field diversity analyses.

10. The Envelope Correlation Coefficient (ECC) is a commonly used metric for evaluating the diversity performance of multiple antennae. When calculated from the antennae far-field radiation patterns, ECC measures the degree of correlation between their radiation responses, taking into account both the spatial radiation patterns and their polarization characteristics. A lower ECC indicates less-correlated antenna responses and, consequently, greater potential diversity.

11. For the commonly used isotropic-environment formulation, the far-field ECC between two antennae may be expressed as:

$$ECC=|\iint(E_{\theta1}E_{\theta2}^{*}+E_{\phi1}E_{\phi2}^{*})d\Omega|^2/([\iint(|E_{\theta1}|^2+|E_{\phi1}|^2)d\Omega]\ [\iint(|E_{\theta2}|^2+|E_{\phi2}|^2)d\Omega]).$$

As it can be seen from this expression, both the magnitude and the phase of the E_θ and E_ϕ components are taken into account in the evaluation of the ECC, rather than only the magnitude-only gain cuts presented by Ciais. Moreover, the fields are integrated over the entire solid angle, *i.e.,* over all directions on the sphere. Consequently, this ECC formulation accounts for the full three-dimensional complex vector radiation patterns of the antennas, including the relative phase between their corresponding field components. Accordingly,

the two-dimensional magnitude-only gain cuts presented by Ciais do not provide all of the information required for such a full three-dimensional correlation analysis.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct.

Date: August 25, 2026 By:__ _____

Hossein Hashemi, Ph.D.