The University of Queensland

PHYS3051 - 2020 - Semester One

Dipole Antenna

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Abstract

Introduction

The present necessity of antennas in combination with the broad settings in which they are found have given rise to a plethora of different designs. Interestingly however, the fundamental principles of their operation remain the same and so it is of considerable benefit to study their simplest possible variant; the dipole antenna. Here we hope to measure the half power beamwidth (HPBW) and directivity (D) of a dipole antenna at a range of lengths relative to the target wavelength. Our aim will be to gain insight into antenna radiation in addition to further experience with the characteristics and peculiarities of experimentation in classical electromagnetic theory.

We will conduct all experiments on the one base apparatus, consisting of a microwave horn transmitting to a variable length dipole antenna on a rotating platform. The proportionality of electric field intercepted by the dipole antenna is measured automatically by a computer and stored for later use. Given our discretion regarding the distance between the microwave horn and dipole antenna we also take the chance to investigate the far field condition, a common and widely applicable approximation in classical field theories.

Theory

Discussing the relevant theoretical content in the reverse order in which it was introduced, we begin with considering the dipole antenna in the far field regime. Here our distance from the dipole is sufficient that it appears to us to be a point source such that its ends are indistinguishable. Another way of framing this is to say that we find the angular distribution of radiation to be independent of our distance from the source (Orfinidis, 2011). We note that this is the same condition as in the Fraunhofer far field diffraction regime.

Making use of the equivalence of antenna radiation and reception patterns (from here on to be referred to as radiation patterns regardless of context), we can picture our antenna as an aperture through which electromagnetic waves pass. Approaching this 'aperture' from the far field, we can expect Fraunhofer diffraction to occur regarded the aperture is of the order of magnitude of the wavelength. Luckily, this is the case for our experimental apparatus. Given Fraunhofer diffraction is described by the Fourier transform of the field in the plane of our aperture, which we can approximate as a (thin) pulse function, we can express the expected radiation pattern ($R(\theta)$) parallel to the dipole axis as below.

$$R(\theta) \propto \mathscr{F}[\Pi(x)] \propto \operatorname{sinc}^2(\alpha\theta)$$

We note that here θ is the angle of the observer perpendicular to the dipole, x is the coordinate describing the dipole axis and the term α is a constant. Taking from this that our reception will be best when the dipole antenna is placed horizontally parallel to the microwave horn (so that the primary radiation and reception lobes are aligned), we have successfully characterised the ϕ coordinate of our radiation pattern.

Method

Discussion

Conclusion

Appendices

Python Software

References

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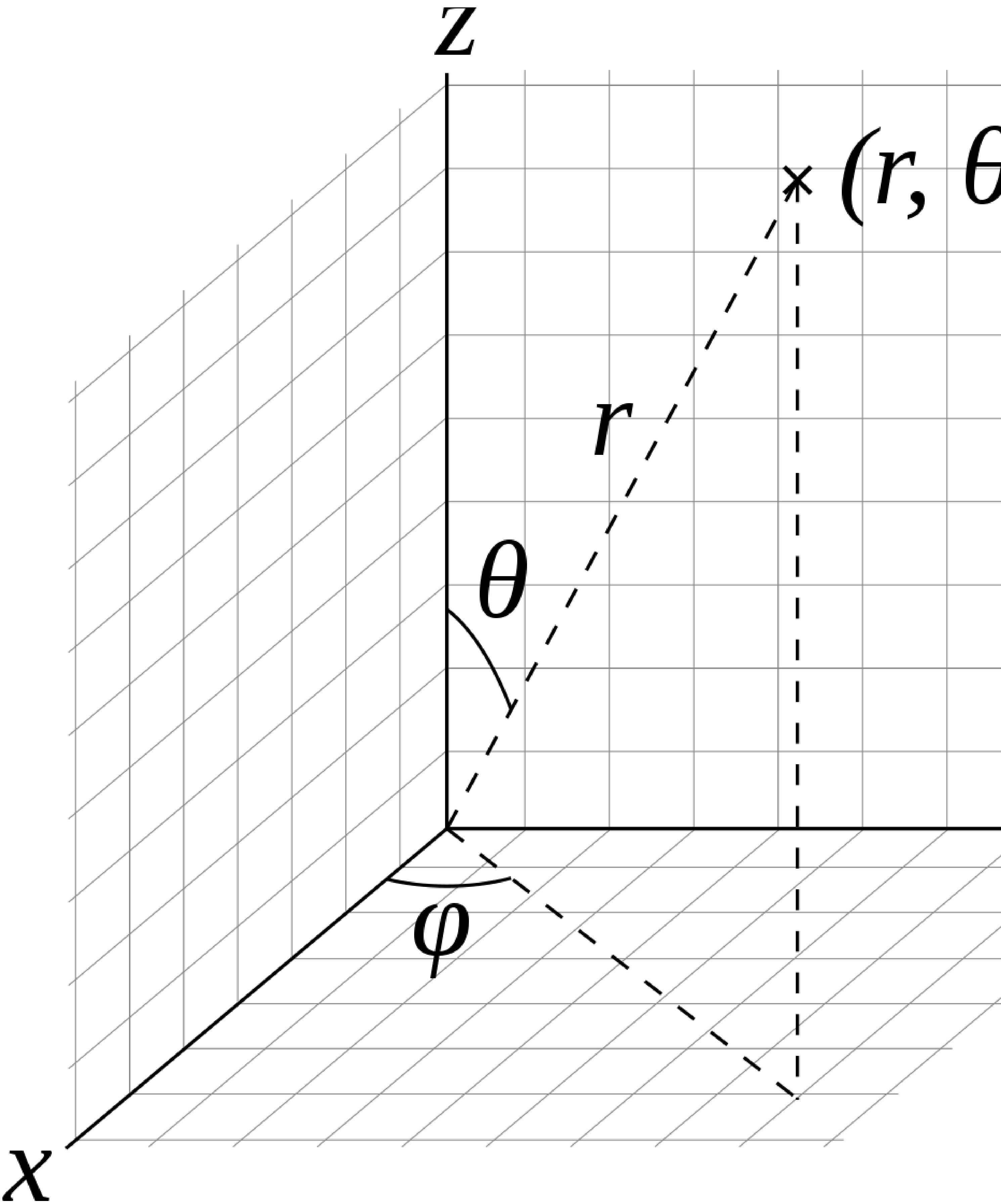

Figure 1: Antenna coordinate frame.