Title

SubTitle

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Bachelor Project

STUDENT REPORT
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STUDENT REPORT

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Network Selection Algorithm

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Abstract:

In this bachelor's thesis an algorithm is developed, that ...

Contents

Preface

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Chapter 1

Introduction

This is about antennas [3, p. 1]

Chapter 2

Technical Analysis

2.1 Radio Wave Transmission

2.1.1 Polarization

2.1.2 Propagation

Propagation of radio vawes can be described with Maxwell's equations using the polar coordinate system (r, θ, ϕ, t) for antennas.

Multipath propagation

2.2 Radiation Characteristics

The radio waves are radiated to the near field and then far field free space. The far field is mathematically described as the distance $r > R_2$, with R_2 defined as

$$R_2 = \frac{2D^2}{\lambda} \tag{2.1}$$

with D being the largest dimension of the antenna or antenna array and λ being the wavelength of the carrier frequency [2, p. 4].

The radiation characterstics of an antenna can be described by the directivity, which doesn't depend on the distance r in the far field meaning that at the receiver the relation $r \gg R_2$ is assumed. Then the directivity is

$$D_t = 4\pi r^2 \frac{S_t\left(\theta, \phi\right)_{max}}{P_{t,r}} \tag{2.2}$$

with $S_t\left(\theta, \phi\right)_{max}$ being the maximum power density and $P_{t,r}$ being the radiated power of the antenna. The fraction $\frac{P_{t,s}}{4\pi r^2}$ is also called the power density of the isotropic radiation of the antenna. The power of the source $P_{t,s}$ to the antenna might not equal the radiated power $P_{t,r}$ due to power loss $p_{t,l}$. Power loss can happen because of reflection loss in the input medium (typically cable), conductor loss and inductor loss. The efficiency of the antenna η is described as the ratio of the radiated power and the sourced power

$$\eta = \frac{P_{t,r}}{P_{t,s}} = \frac{P_{t,r}}{P_{t,r} + P_{t,l}} \tag{2.3}$$

The gain $G(\theta, \phi)$ of the antenna is defined as the efficiency η times the directivity D and can be calculated as

$$G(\theta, \phi) = \eta D = 4\pi r^2 \frac{S_t(\theta, \phi)_{max}}{P_{t,s}} \tag{2.4}$$

or expressed in decibel with respect to the isotropic radiator

$$g_{dBi} = 10 \log_{10}(G) \tag{2.5}$$

The isotropic radiator is a theoretical antenna which radiates homogeneously in all directions, meaning that the magnitude of the power density vector $\mathbf{S}$ at a distance vector $\mathbf{r}$ is constant as

$$\left| \frac{S(r, \theta, \phi)}{S_{max}} \right| = 1 \tag{2.6}$$

It is this theoretical isotropic radiator that the gain of antennas are in respect to. The gain of a directive antenna in a certain direction is called the antenna gain G [2, pp. 10-12].

2.3 Friis Transmission Equation

The Friis transmission equation explains how the received power at a receiver antenna is related to the power of the transmitting antenna. The receiver antenna receives energy from the transmitting antenna and the effectiveness of this is described as the effective area $A_r(\theta, \phi)$ assuming that the antenna is placed in the origin of the polar coordinate system. If the antenna has the property of reciprocity, the effective area and the gain of the receiver antenna is related by

$$A_r(\theta, \phi) = \frac{\lambda^2}{4\pi} G_r(\theta, \phi) \tag{2.7}$$

If the gain of the transmitting antenna G_t is in the direction of the receiver antenna G_r then the angular dependencies of the antenna properties can be surpressed. The power of the receiving antenna is equal to the power density S_t multiplied by the effective area of the receiver antenna A_r, expressed as

$$P_r = S_t A_r \tag{2.8}$$

As previously mentioned the directivity of an antenna does not depend on the distance r from the antenna, and likewise so with the power density S_t, so the value of S_t is equal regardless of the distance from the antenna in the far field with respects to the angular dependencies. Substituting S_t and A_r in equation 2.8 for S_t equation isolated in 2.4 and equation 2.7 yields

$$\begin{aligned} P_r &= \frac{G_t P_t}{4\pi r^2} \frac{\lambda^2 G_r}{4\pi} \\ &= G_t G_r P_t \left(\frac{\lambda}{4\pi r} \right)^2 \end{aligned} \tag{2.9}$$

Also called Friis transmission equation [3, pp. 8-10].

Chapter 3

Tests

This chapter includes test descriptions and results to validate the design against the requirements. First, the two directional antennas are tested to find their gain and ensure, that the transmitter and receiver have their maximum gain at the same frequency. Finally, the full test of the beam steering and transmitter locator is tested with the transmitter fixed at a known location in the test area.

3.1 Test of Gain in Frequency Spectrum

The aim of this test is to test both directive antennas in a frequency spectrum to ensure they operate at the same frequency.

3.2 Test of Radiation Pattern

The aim of this test is to know the directiveness of the two directional antennas.

3.3 Accept Test

The aim of this test is to test the full function of the developed product. The test must show that the receiver antenna on the turntable is able to scan the test area and measure the received power at fixed angles, before selection the location with the maximum received power and focusing its beam on that location.

Equipment

To perform the test, the following equipment is needed:

- HEAD Acoustics Remote-operated Turntable, model HRT I 6498, with 24 V 60 W power supply

- D-sub 9-pin to USB-A cable
- PC with one USB-A port and XX port
- VNA ???
- VNA cable ???
- Two 50 Ω directional antennas with XX frenquecy
- power supplies to the antennas ????

Moreover, the test must be performed in a controlled environment, where the temperature is not below 0 °C or above 50 °C with a relative humidity in the range 20 % - 80 % [1].

add VNA environmental conditions

Test Execution

The following steps outline how to perform the test:

1. Do this. Refer to figure 3.1 to visualise the setup.

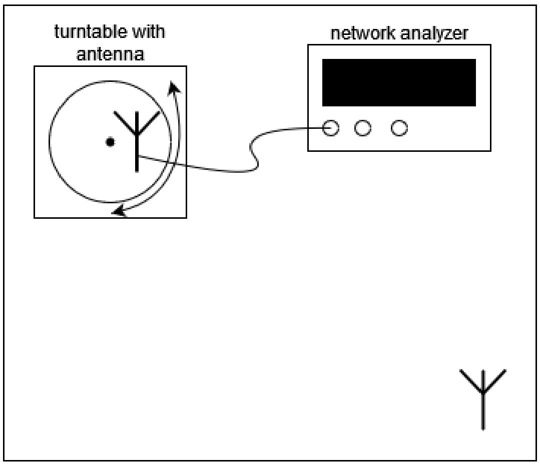

Figure 3.1: Setup for test of functionality of beam steering device.

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