THIS IS MY TITLE

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NATIONAL UNIVERSITY OF SINGAPORE

2023

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(*Bachelor of Science, MIT*)

A THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF BIOLOGICAL SCIENCES

NATIONAL UNIVERSITY OF SINGAPORE

2023

DECLARATION

Iherebydeclarethatthethesisismyoriginal workandithasbeenwrittenbymeinitsentirety. Ihavedulyacknowledgedallthesourcesof informationwhichhavebeenusedinthethesis.

Thisthesishasalsonotbeensubmittedforany degreeinanyuniversitypreviously.

Ramanan Balakrishnan

18th December 2023

$$\begin{aligned}
\nabla \cdot \mathbf{E} &= \frac{\rho}{\epsilon_0} \\
\nabla \cdot \mathbf{B} &= 0 \\
\nabla \times \mathbf{E} &= -\frac{\partial B}{\partial t} \\
\nabla \times \mathbf{B} &= \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial E}{\partial t}
\end{aligned}$$

and there was light

Contents

Abstract

A section to summarize the main contributions of this thesis.

List of Tables

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ListofSymbols

λ	wavelength
ϵ_r	relative dielectric constant
k	wave number, defined as $2\pi/\lambda$

ListofAbbreviations

IEEE Institute of Electrical and Electronics Engineers

PASS Phased Array System Simulator

RF Radio Frequency

CHAPTER 1

The basics

And so it begins ...

1.1 A simple section

A citation [2]. Here is another citation [1].

1.1.1 A sub-section

Some more text here.

CHAPTER 2

Figures, sub-figures and more

A simple figure called Fig. 2.1 is shown below.

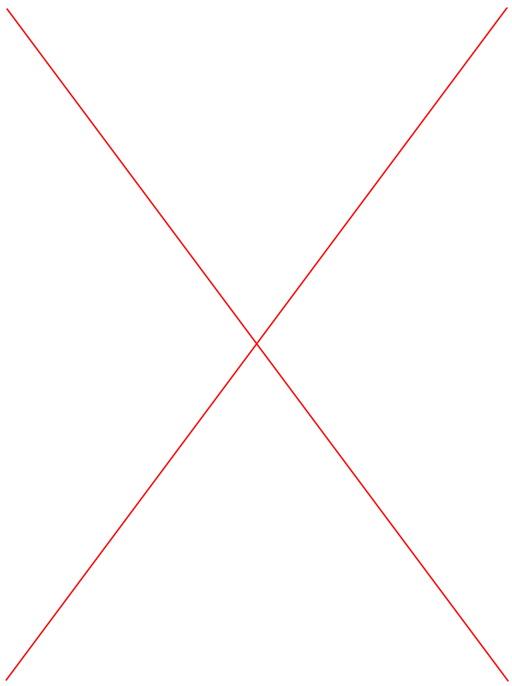


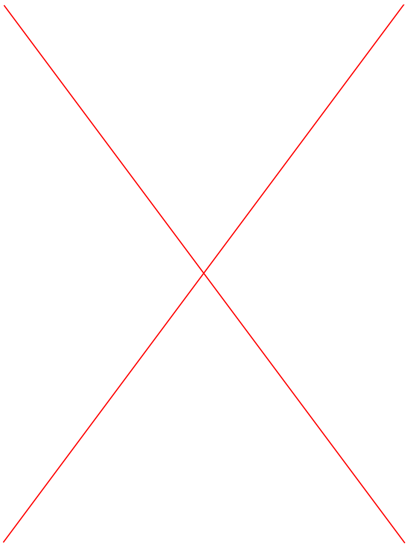
Fig. 2.1. Captions are also possible for figures.

More complicated layouts of multiple figures using `subfloat` are also possible as shown in Fig. 2.2. Reference a subfigure directly as Fig. 2.2a.

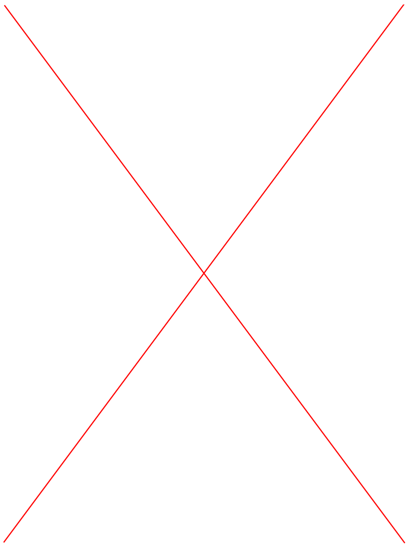
(a) (b)

Fig. 2.2. A common caption is shown for both. Use (a) and (b) to refer to the subfigures.

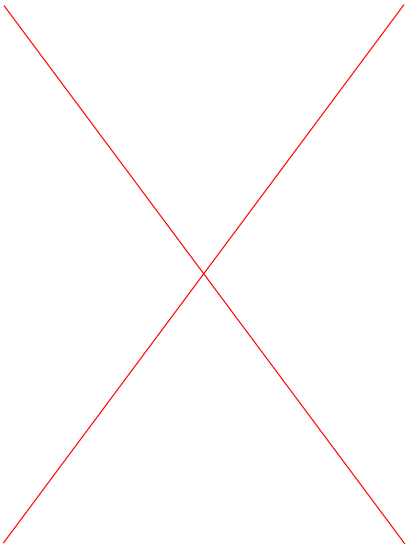
Finally, a full page of figures with a possible layout is shown in Fig. 2.3.



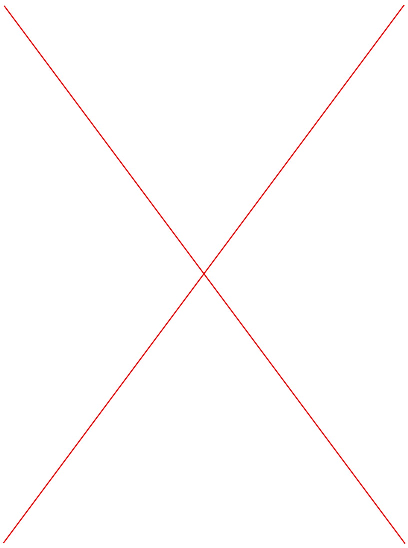
(a)



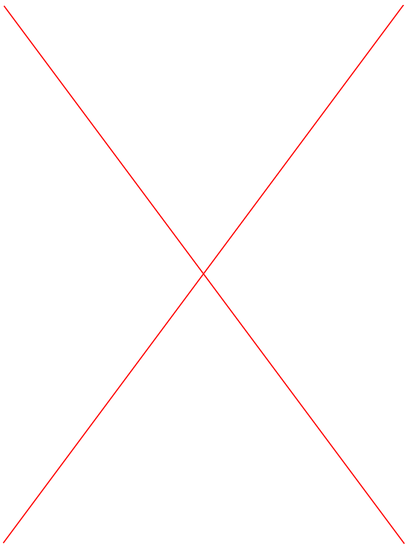
(b)



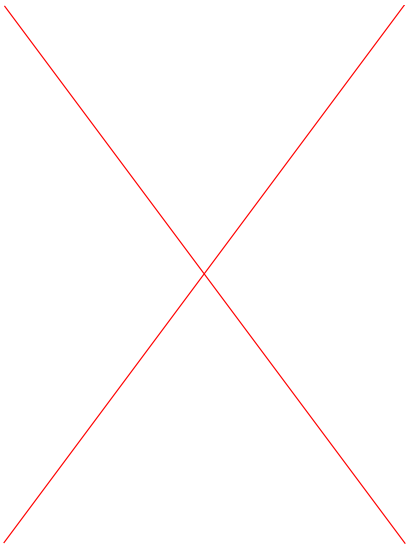
(c)



(d)



(e)



(f)

Fig. 2.3. A full page of figures!

CHAPTER 3

Let's talk tables

A simple table, with my personal tastes on borders and widths is shown below.

Table 3.1
Sequential modes in four-arm sinuous antennas.

Mode number	Port 1	Port 2	Port 3	Port 4
M_{-2}	0°	−180°	0°	−180°
M_{-1}	0°	−90°	−180°	−270°
M_{+1}	0°	90°	180°	270°
M_{+2}	0°	180°	0°	180°

All the usual features of LaTeXare possible, such as merging cells, wrapping / aligning text etc ...

Table 3.2
Role of design parameters in sinuous antennas.

<table>
<tr><th>Parameter</th><th>Denotes</th><th>Typical values</th><th>Role</th></tr>
<tr><td>N</td><td>Number of arms</td><td>4, 6, 8</td><td>Determines the number of modes obtainable.</td></tr>
<tr><td>R_1</td><td>Outer radius</td><td>$\frac{\lambda_L}{2\pi}$ to $\frac{\lambda_L}{3\pi/4}$</td><td>Sets the lower frequency limit.</td></tr>
<tr><td>τ</td><td>Growth factor</td><td>0.6 to 0.9</td><td>Controls the ratio between adjacent cells and number of cells given a fixed size.</td></tr>
<tr><td>α</td><td>Angular span</td><td>22.5° to 90°</td><td rowspan="2">These two parameters together control the angular span, interleaving and input impedance of the antenna.</td></tr>
<tr><td>δ</td><td>Angular spacing</td><td>11.25° to 45°</td></tr>
</table>

Finally, a large table, represented in landscape mode is shown in the next page.

Table 3.3
Review of performances of various broadband antennas.

Aspect	Dipole-based designs (biconical, discone, ...)	LPDA	Spiral	Sinuous
Frequency bandwidth	Typically max at around two octaves.	Comparable to dipole-based designs, extendable by increasing elements.	Ratios of up to $40:1$ are possible.	Ratios comparable to spiral designs.
Multiple Polarization	Only possible if crossed elements are added.	Only possible if crossed elements are added.	Possible with cavity-backing.	Possible with reconfigurable feed network.
Planar	Planar versions possible with maximum extents of order $\lambda/2$.	3-D array of dipole ($\lambda/2$) sized elements with maximum extent determined by required bandwidth.	Planar versions possible with extent of order of λ	Planar versions possible with extent of order of λ
Radiation pattern	Cavity required for unidirectional radiation.	Cavity not required for unidirectional radiation.	Cavity required for unidirectional radiation.	Cavity required for unidirectional radiation.

CHAPTER 4

Equations and code

The `equation` environment is the answer to all your complex greek formatting requirements.

$$\phi = (-1)^p \alpha_p \sin\left[\frac{180^\circ \log\left(r/R_p\right)}{\log \tau_p}\right], \quad R_{p+1} \leq r \leq R_p \tag{4.1}$$

I prefer to use the simple `verbatim` environment for capturing my code segments.

```
r_total = zeros(0,0);
phi_total = zeros(0,0);
for p=1:length(R)-1
    r = linspace(R(p),R(p+1)+eps,10000);
    phi = ((-1)^p) * alpha *(sin(pi*log(r/R(p))/log(tau)));
    r_total = horzcat(r_total,r);
    phi_total = horzcat(phi_total,phi);
end
```

Bibliography

[1] R. Balakrishnan, K. Mouthaan, I. Hinostroza, and R. Guinvarc'h. Dual-circular polarized planar array of connected sinuous antennas. In *Antennas and Propagation Society International Symposium (APSURSI), 2014 IEEE*, pages 941–942, July 2014.

[2] D. R. Hofstadter. *Godel, Escher, Bach: An Eternal Golden Braid.* Basic Books, Inc., New York, NY, USA, 1979.

APPENDIX A

Some additional data that might be useful

Appendices, if required, are added here.