

**EFFICIENT MULTIRATE
TELETRAFFIC LOSS MODELS
BEYOND ERLANG**

**EFFICIENT MULTIRATE
TELETRAFFIC LOSS MODELS
BEYOND ERLANG**

Efficient Multirate Loss Models

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LOGO

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To my parents

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Foreword

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Preface

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I. R. S.

Acronyms

ASTA	Arrivals See Time Averages
BHCA	Busy Hour Call Attempts
BR	Bandwidth Reservation
b.u.	bandwidth unit(s)
CAC	Call / Connection Admission Control
CBP	Call Blocking Probability(-ies)
CCS	Centum Call Seconds
CDTM	Connection Dependent Threshold Model
CS	Complete Sharing
DiffServ	Differentiated Services
EMLM	Erlang Multirate Loss Model
erl	The Erlang unit of traffic-load
FIFO	First in - First out

GB	Global balance
GoS	Grade of Service
ICT	Information and Communication Technology
IntServ	Integrated Services
IP	Internet Protocol
ITU-T	International Telecommunication Unit – Standardization sector
LB	Local balance
LHS	Left hand side
LIFO	Last in - First out
MMPP	Markov Modulated Poisson Process
MPLS	Multiple Protocol Labeling Switching
MRM	Multi-Retry Model
MTM	Multi-Threshold Model
PASTA	Poisson Arrivals See Time Averages
PDF	Probability Distribution Function
pdf	probability density function

PFS	Product Form Solution
QoS	Quality of Service
r.v.	random variable(s)
RED	random early detection
RHS	Right hand side
RLA	Reduced Load Approximation
SIRO	service in random order
SRM	Single-Retry Model
STM	Single-Threshold Model
TCP	Transport Control Protocol
TH	Threshold(s)
UDP	User Datagram Protocol

Introduction

The word *traffic* becomes *teletraffic* in telecommunications, as communications becomes telecommunications to indicate technology use, e.g., conversation from some distance through phones or Internet. The term teletraffic covers all kinds of computer communication traffic and telecom traffic. This book includes teletraffic loss models.

Part I

First Part

Chapter 1

This is Chapter One Title containing authors and affiliations¹

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¹I Author Organization Division Name, Organization Name, Postal Code, Part of the Country, City Name, Street Name, Country

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³II Author Organization Division Name, Organization Name, Postal Code, Part of the Country, City Name, Street Name, Country

*Corresponding Author: Author; corresauthor@gmail.com

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$$\mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (1.1)$$

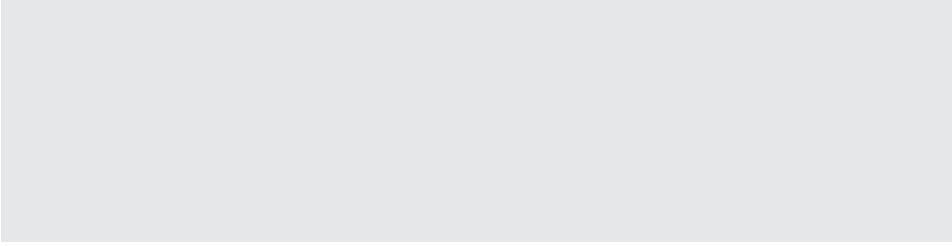


图 1.1: Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

$$\mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \tag{1.2}$$

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3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

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表 1.2: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation 1.2).

Chapter 2

This is Chapter Two Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
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2.1. This is First Level Heading

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ris.

The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

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An example for uppercase alphabet list:

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- B. Item text Item text Item text Item text Item text Item text Item text. Item text Item text.

An example for lowercase alphabet list:

- a. Lower case alpha list text. Item text Item text Item text Item text Item text Item text Item text.
- b. Item text Item text Item text Item text Item text Item text Item text. Item text Item text.
- c. Item text Item text Item text Item text Item text Item text Item text. Item text Item text.

Example for uppercase Roman List:

- I. Upper case roman list text. Item text Item text Item text Item text Item text Item text Item text.
- II. Item text Item text Item text Item text Item text Item text Item text. Item text Item text.
- III. Item text Item text Item text Item text Item text Item text

Example for lowercase roman List:

- i. Lower case roman list text. Item text Item text Item text Item text Item text Item text Item text.
- ii. Item text Item text Item text Item text Item text Item text Item text. Item text Item text.
- iii. Item text Item text Item text Item text Item text Item text

Example for custom list:

Step 1 Custom list, if the list environment not matched with above.

Step 2 Item text Item text Item text Item text Item text Item text Item text Item text Item text Item text.

Step 3 Item text Item text Item text Item text Item text Item text

Example for unnumbered list:

Unnumbered list text. Item text Item text Item text Item text Item text Item text Item text.

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For example, multiple citations from the bibliography of this article: cite: Bartelle et al. [1], Consortium [2], citep: [3, 4]. As you see in Table 2.1, the citations are to their reference in the bibliography.

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5	–15.0	17,100	–25.2

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Refer Figure 2.1 and Table 2.2 for more details.
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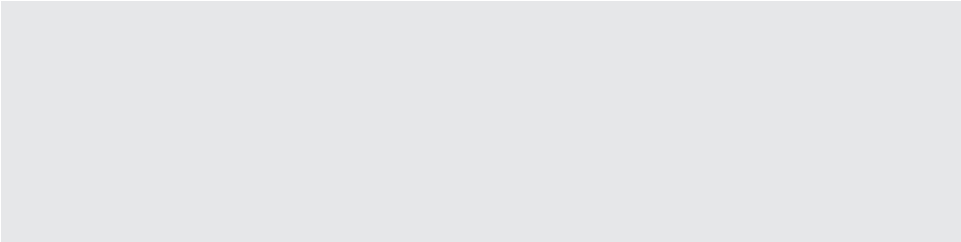


图 2.1: Figure Title.

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The manifestation of solar activity² (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation 2.1).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (2.1)$$

The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers(Equation 2.2).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \quad (2.2)$$

²This is an example for second text footnote. This is an example for second text footnote. This is an example for second text footnote.

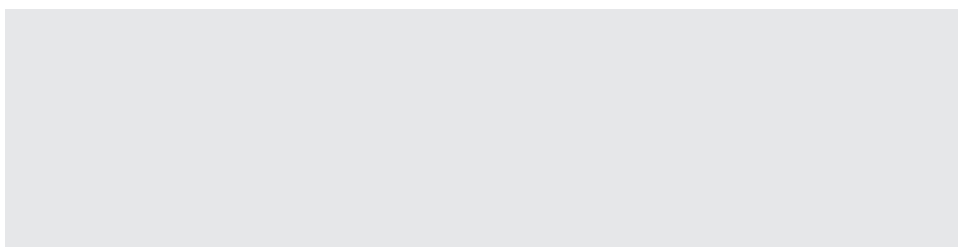


图 2.2: Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.

Part II

Second Part

Chapter 3

This is Chapter Three Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
-

3.1. This is First Level Heading

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The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for

¹This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

terrestrial observers.

Example for Quotes

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Example for Extracts

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Example for Pull quotes

Chapter 4

This is Chapter Four Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
-

4.1. This is First Level Heading

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ris.

The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth's surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

Example for Feature Fixed

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FEATURE FIXED HEAD

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Example for Boxes

Feature Title 4.3

¹This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

Feature Section

Feature Subsection

Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession.

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图 4.1: Figure Title. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. *Source: Figure Source.*

Note: For sample purpose we have used dummy eps image. Please use only the below format:

```
\begin{figure}
\includegraphics{FigName.eps}
\caption{\title{Figure Title.}Figure Caption.
Figure Caption. Figure Caption. Figure Caption.
Figure Caption. Figure Caption. Figure Caption.
\source{\textit{Source:} Figure Source.}\label{fig1}}
\end{figure}
```

Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession. Engineers uphold and advance the integrity, honor and dignity of the engineering profession.

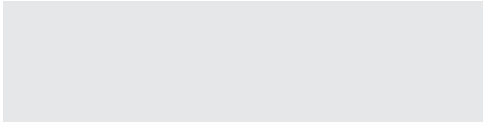
表 4.1: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

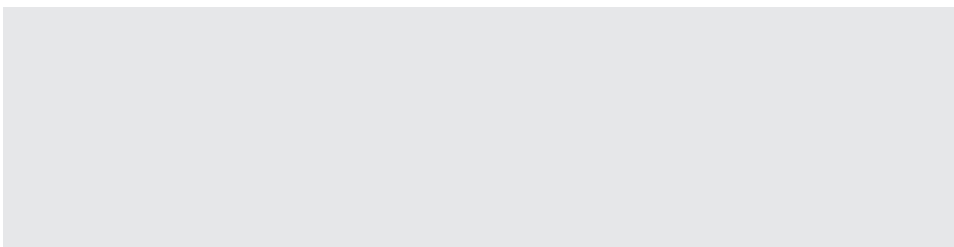
¹ Example for a first table footnote. Example for a first table footnote. Example for a first table footnote. Example for a first table footnote.

² Example for a second table footnote.



Unnumbered Figure Title. Unnumbered Figure caption. Unnumbered Figure caption. Unnumbered Figure caption. Unnumbered Figure caption. *Unnumbered Figure Source*

The sample for unnumbered Figure without caption



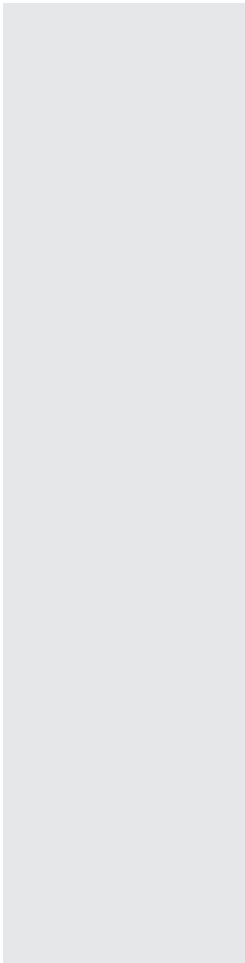


图 4.2: Figure Title

Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption. Figure Caption.

Source: Figure Source.

This is an unnumbered table

Enter unnumbered table caption here. Enter
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Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900	–12.8
4	–10.0	12,900	–10.0
5	–15.0	17,100	–25.2
6	–20.0	20,000 ¹	–16.0

¹ This is unnumbered table footnote

Source: This is unnumbered table source. This is un-
numbered table footnote

表 4.2: Enter sideways table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900	–12.8
4	–10.0	12,900	–10.0
5	–15.0	17,100 ¹	–25.2

¹ This is table footnote

For Unnumbered Table without caption and source/note:

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900	–12.8
4	–10.0	12,900	–10.0
5	–15.0	17,100	–25.2
6	–20.0	20,000	–16.0

Part III

Third Part

Chapter 5

This is Chapter Five Title

After reading this chapter you should be able to:

-
- List the main subsectors and components of the environmental and energy infrastructure
 - Explain www.google.com the function of each infrastructure sector
 - Identify components related to environmental and energy infrastructure
-

5.1. This is First Level Heading

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ris.

The manifestation of solar activity¹ (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers.

Enunciations

For bold head and italic body:

Theorem 5.1(Theorem Title): *Theorem content. Theorem content. Theorem content. Theorem content. Theorem content. Theorem content.*

Lemma 5.1: *Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content. Lemma content.*

Corollary 5.1: *Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content. Corollary content.*

For bold head and roman text:

Definition 5.1(Definition Title): Definition content. Definition content. Definition content. Definition content. Definition content. Definition content. Definition content. Definition content. Definition content. Definition content.

Remark 5.1: Remark content.

For proofs:

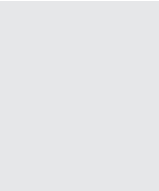
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¹This is an example for first text footnote. This is an example for first text footnote. This is an example for first text footnote.

Computer Material

```
class CEcosystem;  
struct Chromosome  
{  
    unsigned char gene[CHROMOLENGTH];  
};
```

Icons



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Following is an example for Problems section:

Problems

Related Instruction. Related Instruction. Related Instruction. Related Instruction. Related
Instruction.

1. First problem text. First problem text. First problem text.

$$f(x) = \begin{cases} kx^2(1 - x^3), & 0 < x < 1 \\ 0, & \text{otherwise} \end{cases}$$

continuation of first problem text.

Hint: Problem hint text. Problem hint text.

2. Second problem text. Second problem text. Second problem text:

- 1. $9 < X < 90$.
- 2. $X < 90$.
- 3. $X > 90$, given that $X > 9$.

3. Third problem text. Third problem text.

$$F_X(x) = \begin{cases} 0, & x < 0, \\ \frac{1}{2}\sqrt{x} + \frac{1}{2}(1 - e^{-\sqrt{x}}), & 0 \leq x \leq 1, \\ \frac{1}{2} + \frac{1}{2}(1 - e^{-\sqrt{x}}), & x > 1. \end{cases}$$

Continuation of third problem text.

4. Fourth problem text.

$$f_X(x) = \frac{k}{x}, \quad k > 0.$$

Continuation of fourth problem text

1. some text.
2. some other text.
3. more text.

附录 A

This is Appendix Title

A.1. This is First Level Heading

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A.1.1. This is Second Level Heading

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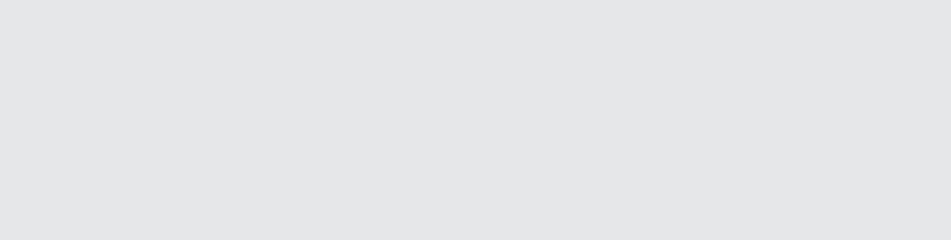


图 A.1: Figure Title

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Source: Figure Source.

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation A.1, Table A.1 and Figure A.1).

$$\mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \tag{A.1}$$

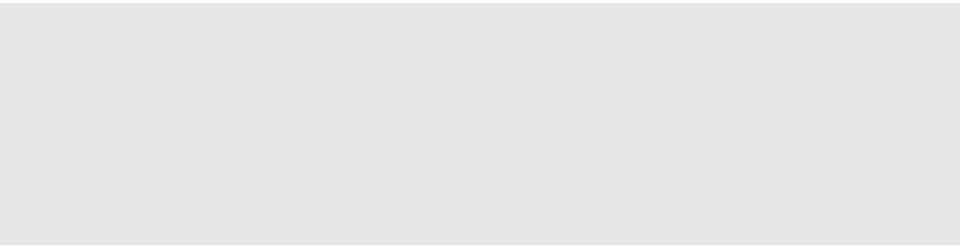


图 A.2: Figure Title

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Figure Caption.

Source: Figure Source.

表 A.1: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

¹ Example for a first table footnote. Example for a first table footnote. Example for a first table footnote. Example for a first table footnote.

² Example for a second table footnote.

表 A.2: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

¹ Example for a first table footnote. Example for a first table footnote. Example for a first table footnote. Example for a first table footnote.

² Example for a second table footnote.

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation A.2, Table A.2 and Figure A.2).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^aF^{a\mu\nu} - m\bar{\psi}\psi$$

(A.2)

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附录 B

This is Appendix Title

B.1. This is First Level Heading

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B.1.1. This is Second Level Heading

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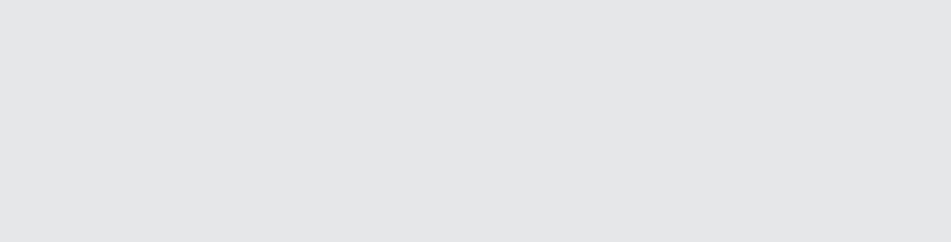


图 B.1: Figure Title.

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The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation B.1, Table B.1 and Figure B.1).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^{\mu}D_{\mu}\psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi \tag{B.1}$$

B.1.1.1. This is Third Level Heading

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表 B.1: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

¹ Example for a first table footnote. Example for a first table footnote. Example for a first table footnote. Example for a first table footnote.

² Example for a second table footnote.

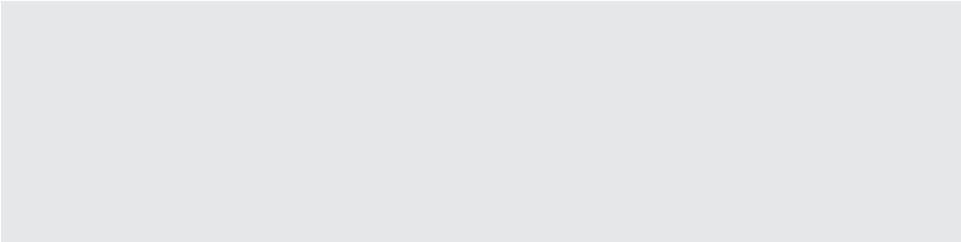


图 B.2: Figure Title.

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表 B.2: Enter table caption here.

Tap number	Relative power (dB)	Relative delay (ns)	Relative mean power (dB)
3	0–9.0	68,900 ¹	–12.8
4	–10.0	12,900 ²	–10.0
5	–15.0	17,100	–25.2

Source: Example for table source text.

¹ Example for a first table footnote. Example for a first table footnote. Example for a first table footnote. Example for a first table footnote.

² Example for a second table footnote.

The manifestation of solar activity (flares, bursts, and others) occurs over the whole Sun, and most of radio astronomy observations are made from the Earth’s surface, whereas a significant part of solar radio events (those from the far side of the Sun) is not available for terrestrial observers (Equation B.2, Table B.2 and Figure B.2).

$$\mathcal{L} \quad \mathcal{L} = i\bar{\psi}\gamma^\mu D_\mu \psi - \frac{1}{4}F_{\mu\nu}^a F^{a\mu\nu} - m\bar{\psi}\psi$$

(B.2)

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附录 C

This is Appendix Title

C.1. Import Codes From Code File

```
1  #%%
2  import numpy as np
3  import scipy.stats as st
4
5  import matplotlib.pyplot as plt
6  import seaborn as sns
7
8  sns.set_palette("Paired")
```

C.2. Write Codes In Tex File

```
1  import numpy as np
2
3  def incmatrix(genl1,genl2):
4      m = len(genl1)
5      n = len(genl2)
6      M = None #to become the incidence matrix
7      VT = np.zeros((n*m,1), int) #dummy variable
8
9      #compute the bitwise xor matrix
10     M1 = bitxormatrix(genl1)
11     M2 = np.triu(bitxormatrix(genl2),1)
12
13     for i in range(m-1):
14         for j in range(i+1, m):
15             [r,c] = np.where(M2 == M1[i,j])
16             for k in range(len(r)):
17                 VT[(i)*n + r[k]] = 1;
18                 VT[(i)*n + c[k]] = 1;
19                 VT[(j)*n + r[k]] = 1;
20                 VT[(j)*n + c[k]] = 1;
21
22             if M is None:
23                 M = np.copy(VT)
24             else:
```

```
25         M = np.concatenate((M, VT), 1)
28
29         VT = np.zeros((n*m,1), int)
30
31     return M
```

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