UNIT-T

WIRELESS

CAR

Wired channels.

station
ary

weken channels

CHANNELS

+
predictable

→ Kanseria, path b/w fix
& Ry

can vary
from

simple LOS
to one
that
is severely
obstevered

*

spe

ed

by buildings, mountain

+ pliage

д

motion impacts how

rapidly the rigral

level

jades

as a mobile terrenal moves in

signal

Large-scale propagation

Models - pudicts the

strength you

an & are useful

is

Small-scale (a

%7

mean

مقسم در

arhitrary To-Ro

seperation distance

estimating

of a team

mitter

Fading

Models -

the received

the radio

Courrag

e

aria

characterize the rapid fluctuations

rignal

string tho

over

very

short travel

distances (wavelengths) a short travel

destarees time duration

=>

As a

mobile moves

ся

vag

small distances, the

instantaneous

received signal strength may fluctuate rapidly giving rise to small-scale fading. This is because the received ingral coming from

differer durctions. => In small scale fading, the received signal power may vary

is sum

byr

من

of many

contributions

much

as there

a four aiders

f magnitude

(20

20 01

40 de) when the receiver is moved only by a fraction of a

wavelength.

= As the mobile moves away from the Tx larger distances gradually decreare the local average received na meech ignal will this local average igral d it is this local level that is predicted by large-scale propagation models.

Free Spice

Propagation Model

→ Free space propagation model is used to predict received signal strength when the transmitter and receiver have clear, unobstructed LOS path between thema.

Ex: satellite communication

⇒ The microwate Los links.

free space power received by which is seperated from

from a

radiating transmitta

a

a receiver antenna

antenna

by o

a

distance d,

giver

by

the

Friis

free

space

equatio

n.

$$P_r(d) = \frac{P_t \; A_z \; A_{rd}}{\;}^{2}$$

I

(4πT) da.L

Pt -
transmitted
power

Prld) - received power
which is a
a
frenction
of
T-R seperation

GE
transmitter antenna
gain

We recover antenna
gain
Лоло

L- system low

factor

расво

я

1- wavelength in

meters

λ

⇒ The gain

of

aperture, Ac,

by

=>

an antenna is related to its

effective

Ac is related to the

physical singe

A = 4π Ae

te

⇒ The effective

aperture Ac

q

the antenna

⇒ The d is related to carrier

d

गन

⇒ Pt & Pr is expressed in

опс

coc

by

делед.

бу

same units

little are

dimensionless quantities

• → The miscellaneous losses I

are

usually due to transmission

line attenuation, filter losses & antenna

larger in the Communication system.

→ Fries free space equation shows that the received

• =>

power falls off

we received Fies

20 dB / decade.

as the square of o T-*R* seperation distance.

power decays with distance at a rate

An isotropie radiator is an ideal antenna which radiates

with unit gan cenepenly in all duections, & is used to

reference antenna gains in wireless systems.

power

* The effective isotropie radiated power (EIRP) as defined

as

EIRP = PEGE

represents the maximum radiated

рошее

& available from

a it in the direction

of

max. antenna
gain

is used instead

aɜ

* In practice, effective
radiated

power
(ERP)

the maximum

radiated

power

as compared to a

EIRP to denote the

haly

-wave

dépol
e

Antenna

⇒ The

موصل

loss represents signal attenuation

as measured in dB, & is defined

path positive

quantity

the difference blow the

effective transmetted

recaved

power.

PL (dB) = Co

- to

log

· Log P =

= -colog

Pr

povel

At hed

2.

(4T)♡ da

Amering antennas to have unit gain, ikame

=> The

λ

2

- PL (de) = co log B = =

=colog [( ) de

for

field

Pe

[+]

2

a

مه

& the

(0 Fraunhofer region,

of a teansmetting antenna is defined as

a the region

as a the region behind the

far-field

distance,

of

whoe D-

df =

λ

2

largest physical linear

dimension

Additionally, dy must

satisfy

+

of

of

?

949

40.

كندا.

the antenna

En O does not hold for d=o.

Thus large scale

propagation
models are a

close in distance, do,
known as

received

pover reference
point.

Px (do)
=

Pt Atle d2

dz dodg

(45) 2
dork

Comparing
with O

⇒ Because

$$Pr\,(d) = P2(do)\,(do),$$

dz dozdy

of laye dynamic range dynamic

range of received

power leads, often

dbm

ما

a dow cerits

vo log [Pr (do)]

+ dolog (do) ,

djsdad

[o

गत

Pr (d) dBm = 10

⇒ The distance do

fire

using

antennes in 1-2 GHz

range

is

typicall
y

chosen to be

im

in indoor environment

low

gain

f 100m

Find the

dimension

ช

a 1 km in outdoor.

W32

Fraunhofer distance you an antenna with mook.

+ operating frequency of 900 MHy. If

calculate the path loss.

Im

Antennas have unut

Sola

TO

Cuvier

find

gain,

D = Im

8 = 900MHy

of =

2D 2

λ

P2 (dB) = - 60

وما ما

de (4π)

2 d2

1 =

3×10

= 0.33

900×006

s

2(1)

3 dj so2 = 31) 2

= 6m/

P2 (dB)

=

- Co

0.33

of a transmitter

produces

transmit power in

तर

(4532d2

= 47 dB/

So w

ما

log

$(0.33)^2$

$(45)^2 =$

$(6) =$

π

2

of power,

express

the

dBm & dow. I sow is

applied to a unity gain antenna with

900Mtly carrier frequency,

find the

Reed

ay

100m

power

in dBm at *a*

free space

destance

from the antenna. What is P2 (10 km)? Arovone

unit your for receiver antenna.

Sol

mist 120

m og

Cuven : Pt=50W

fo=

900MH2

d=

d=

TO

find

100 m

· · ·D PE

(dBm) .

ii) Pz

(dBw)

dii) Pr ford = 100m

los Pe

(dBm)

v) Pr

for

d = 10km

3xrot

Я пожов

20.33

31

ASCA

;)

Pt (dBm)

=

=

to log

[Pt(mw)]

to log [00x103] =

46.93 eadem //

ii) Pt (dBw) =

co

co

Log [Pt

(w)]

= 20 (og [50] =

16.9 dow/

('

ii) Pr

Pt Gt had

=

(4π) 2 d2

L

• in) PeldBm) = to

log [la (onw)]

- v)

Consid
ering

المعاني

=

ما

co

сод

[Be

50 (1) (1)

(0.33) (49) 2

(100) = (1)

(100) = (1)

=

3.44x10-b

w

= 3.44 x 10

to log [3.44x10-2]

== 24.6dBm/

い

doz 100m + d=c0km,

Pa (d) = Pa

(de) (day

(oo)

=) Px (10 km) = Pe

(100) X100

=-24.6dBm

10x

Xx

2017

207

Px

2%

開

P2 (6) dan = to log [

P2 (de)] + as log (1)

ما

ما

co

д

（do）

0.001 W

mw

d

= Lo ley [B. (4)] +

dolog (2)

Pe *(10*

km) *dBm*

=

toto **Pe** (100) dBm + 20

log (10000

= *cotogE*–24.6 +

20 log (100) =

сод

mw

64.5dBm

И

$20\log(1) = -64.5$

dBm/

Ground Reflection (Two -

Ray). Model :))

→ The two

-ray **reflection** model is based on grometer opties & Considers both direct path + ground reflected propagation path b/w Tx & Rx

- This model is found to be accurate for puducting laye scale signal strength for mobile rades systems in caban environments over distances a several kilometers ht

Fi

As well as

LOS, micwell channels

ELOS

E_{TOT} =

=

Elos +

Eg

R

Lá

Ex = Eg

Qi

do

止

-d

K

=) The total Ě-

=> If -

ETOT

- fuld,

FTOT,, is

ETOT = ELOS +

ETOT

Eq

Fo - free space E-field at reference distance do, then for d>do, the free space propagating E-field

Eo

Cos

..

=(d,t) = Boda (es

(we (6-1))

d

مو

Where IE (d,t)) = Fado

- envelope

Eodo

d

спосворя

cy

E-fiel

d

=) Two

propag

ating

waves arrives *at* the Reng

* dieet

wave

*

reflect

ed

wave

=) The I-field due to

ELOS (d',t)

=

travels a distance d'

travels a

distance d''

205 Component at

Rx

w to do ot

d'

Cos (voc

(t-d))

دها

The E−feld for ground replented

wave

$$Eg\ (d'', t) = p\ Eod. \ Coo\ (wc\ (t-d''))$$

where

Γ

=) The tatal

-

d''

CA

lection

coeff. pe ground.

eglec

ه

مو

Electure fired FroT

(d,t) is

مشد Ry

EnoT (d,t) = Fodo los / we (t−d')) +

(−1) Eodo Cas (we (t-d''))

d'

مها

(we

d''

[Assuming perfect horizontal E-fired polarization ('=-1]

=)

=>

Using

Method

g-images

d!

ht-he

ht

ht

ht the

d"

R↑

he

The path diffrences,

between Los &

ground
reflected

paths

F

d>> hothe, wing

taylor series

is

s=d"-d' = | (ht + he)2 + d2

− |(h+pha)2=+d=

approx

s=d ″-d' = 2htha

d

=) The phose difp. Os b/w tws E–field components in

OD=

Ins

di

The time delay Ed blos arrival

c

two

Components in

td=

Os

Os

=

тогд

+c

c

coc

опре

=) As d becomes laye, the diff. blo

d ' & d" becomes

Very

small & amplitudes as

Elos +

Eg

Ove

vitually

identical of differ only in

phase. (i)

>ㅁ

22

22

Eodo

| Fode 23 |

Fade | 26

|End)

d'

d'

dir

evaluated at some time,

-feed is

evaluated

Fodo

=)

of

the

received E-field

is

say

t =

d":/c,

Епот

Eodo

d'

Eodo

LOO

Eodo

d'

d"

d

Eode

[200-1

]

Exor (d, t = 2") = Fade (en (ove ("d")) – Enda (or 0°

d"

Eodo

d"

Етот

Os

Eodo

d'

1

Ерижи

веть

lent

Eo do

d'

Exon

Eodo

d"

I

26)

Cas Os=

Si Os

D

[ENO

T)

=

x

ℵ

Eo do

d

Eodo

d

Eo do

x =

x2-

+

(Ti

de

Eodo

d

Eo do

d

todo Cas

(0 0)

d

Cool

Eo **do** Sin

(00)

de .

$$(-\ \mathrm{Eodo} + x)^2 + y^2$$

d’

Fodo Cas

d

2

2

уч

دارور

2

• Coo (02)) + (

todo si Oo) 2

Cas Os - 1)2 +

Sidl

d

s

Fodo

=

2

2-26s03

d

Cos 0−2 Cas 0+ 1+

Si2O2

"1

Fodo

d

Fodo

d

2 (1-C0000)

V. Dsix Os

Fodo 2 Si

d

when Oz

WHT,

éla

Os

<< 0.3 radians

~ 2 Eode

(00)

Етот да Eodo

0○= O2 =

2710

=

=

4п hthe

ㅠ

dd

♈

बहते

+0.3 =) O

=) $O1$ =

0.6

E

[

[to smill

values 10,

Sino ~]

(

2h+he

)

=)

d

Oo

IT hehe

dd

ها

wher

06

40.3

0.6= 455 hehe

477h4h

=>

$d =$

21

0.61

eld

20he he λ

=>

ETOT (d) ≈

~

2 Fodo

d

add

−K v/m

$d2$

ШКТ,

Pr=

Pt Gr Gq d2

(4)이자

PiGi Ca

(20

hehe)

2

(4π) 2=

d2

2 2

Pt GE Ge ho

he

d

d4

40dB / decade. The

Aκ

large distances, the

recoeved

power falls off

distance raised to the fourth power,

or at a

with

path

воль

lors for the two

–

лау

rate

model car

of

be expressed in dB as,

PL (dB) = 40logd – (10 loght

+ ologba + 20 loght + dolog ha

a

BS + uses a

255 dB to

A mobile is located 5 km away from vertical 1/4 monopole antenna with a receiver cellular radio rignals. The E field at 1 km from

gain

of

is measured to be co-3 v/m. The carrier

the Tx

for

the system is 900M

HY

of K

used

Hy.

a) Find the length of effective aperture

frequen
cy

the

of

Rei
ng

antenna

the

b) Find the received power at the mobile wing the two-

ray ground reflection model

assuming the height of Tixing

antenna is som & Being antenna

som & Reing antenna in 1.5m

above

groun

d.

soln

(ato

Cuver T-R seperation, d=5 km

E-fiel

d

field at a

distance

of

961

-3 vlm

1 km = 10

Freg. of operation,
f=200M Hay

do=1

3X108

8=

λ = = = f

900X106

=1km

= 0.33 м

Alu

a) Length
of

the antenna, &= 1/4 =
0-38/4

8.21.Can.

apertive of
antenna

Expection

apective

3

Words (0.13)'

Ae

a

Ad2

435 (0 (033) "

0-016 m2

EAT (d) =

6) The total clester

fild,

2 Fodo Thehe

d

ad

22x10-3

5×103

3

(50)

= 2x10 2x1 x

102 [21/10)

(10)]

0.333(5×103)

118.3 ×

10-6

x

10-6

V/m.

The receind

powa

at

a

distanc

e

Pr (d) = 1212 Ae

=

12055

(112-1x10-

6)2 (0.016)

-5.4 X10

13

ل

W.

1-62

रु

122.68 dBwCon -92.68dBm

12.5

Lerke Budget

Design

→ by wring path loss models to catinate

the received ingral

level as

a

pencion

destance, it becomes

possible to predict

the SNR for mobile

communication system.

Log alistance Path Loss Model

=) Both theoretical & measurement based

inderate that

with distance.

=) The

measurement based

propagation model

received signal power

decreases logazichriely

average

average large
mole

path

low for an arbiterry
T-R

seperation is,

PL (d) &

^

n
-path

do

PL (dB) = PL

(do) + Lon Log (1)

CO

n

los component which indicates the rate at which the

path loes Increased

4300

with distance, do

do – close in

distance

Slab laman

reference

d- T-R seperation distance

Eindhon ment

Free

2

space

Ueban Qua

2.7-3.5

In building

LOS

shadowed webar

obsturched by
building

3-5

16-1.8

4-6

→ in large
coverage
Commonly

Are

smaller

cellular

sys

tems,

1 km rejerice
distances

R

100 m aim) are used.

used, whereas in microcellular systems, much
distances (such as

Log - normal

shadowing

distanc
e

path

loes model does not comider the

be

=) The

Log

fact that the

surrounding

environmental

clutter

vastly different at two

diffrent locations having

T-R

seperation.

may

the same

=) Ar

ary

value

cy

d,

the

peeth

Lois PL (d) at a

particula

r

location is random & destributed log-normally about the mean distance dependent value. (i)

PL(d) [dB] = PL (d) +

Xo

4

PL (do) +

Lon log (d)

+ Xo

do

Px (*d*) [dBm] = Pt [dBm] - PL

(d) [dB]

Xo - Zew-mear Gaursion distributed

random raciable (in dB)

with standard deviation J.

سته

A

=) The log- normal distibution

describes the random shadowing

over

a

large

number

measurement

effect which occur

of mean

locations which have the same T-R

seperation, but have
different
level

clutter on

The propagation
path. This

phenomenon is referred
to as

normal
shadowing.

log-n
e

that measured
rignal

=>

Lo
g

namel shadowing
implies
leuds at a
specific T-R seperation
have
a
Caurrian
=> The close iůs
reperenc
e
distribution about the distance
dependent
mean
distanc
e do,
do, the
path
воло
exponent n,
las model T-R

seperation.

for an

f the standard deviation & statiscally

describe the path

a specifi

arbitrary

location having

=) In

practice

the values

nd l are

g

completed

from

measured data

usin

g

linear regression such
that the diff.
losses is
minimized
b/w the measured & estimated
of
path
in a
mean
squerre
sense
over a
vide
range
of
measwement

be used to
locations & T-R
seperations.

∞

penction (egy) may the received rignal

lead will particular

level.

مه

S exp (-2 =)dx =

1/2 [1-cy (2)]

=> The

The &- penction

а елая

determine the

peob. that

that

exceed for

fall

kelow)

a

The &-penction is defined

R(2)=

शा

z

where

$Q(z) =) -2(-2)$

The pestability that the receased

density function

as

Pr [Pa (*d*)

yue]

(1

V- Pe *(d)*

=

&

rignal.

leal well

excee

d

a certain value I can be calculated from the curulative

Ally

the **peob**. that the received rignal level will he

below I is

giver

by

Px [*Pald)*]=

Q (Pald) -*20*)

دمة سامحيا

Jad

Lowe own

The d

414

3 / 4

LH RELESS
CRANDONEES

of

the
amplitudes,
phases

оя

jui

Fading @ raped fluctuations

multipath delays of a radio signal & Caused by interference the two

blu

Ne o

short period of time

de more versions.

the transmitted signal which arrive at the receive at slightly different times.

Small Scale Multipath Propagation

→

Multipath in radio channd creates small scale fading

Effects.

The

*

effec
t

Are

Rapid
changes

* Random

диа
д

Doppler shifts

in

signal strength swed

nodulation due to varying

by meelipath propagation

* Time Dispersion (ccher) caused delays.

→ Que to relative motion between mobile & BS, each multipath experiences an apparent shit is frequency.

the mobile

This is called Doppler shift & is directly proportional

to the

velocity of

of

w.rt direction

Factors

exfluences

=> Factors

direction

of

→ Multipath

Propagation

motion

az

arrival of multipath

Small Scale
Fading

* The presence of reflecting objects
& scatterers

is the channel creates a cons
in

Constantly
changing
environment

Feed

igral

the disipates the signal energy in amplitude phase +

time. Thus, the multiple

versions

respect

displaced

with

spatial

Overtation

Speed

of

the mobile

g

али

to

one another is

time 7

&

The relative motion blw is + mobile results is

random

on each

be tue

movi
ng

freq

.

g

or

towar
d

modulation due to different

doppler shifts

the multipath component. Doppler shift will

-ve

dependi
ng

a

on whether the mobile :

away
from

→ Sped of surrounding objects

the BS.

mabras

If objects in the radio channel are in nation, they endure time varying doppler shift

of

the

the

surrounding

objects

the mobile, then this

7

of

moves

On

at a

me

effects domerates small side

surrounding objects

in

Itepeeth

components.

greater rate

than

jade

y.

ects can be

igne

nd..

y

multipath
channel

→ Transmission Bandwidth
of the signal

g

úgnal bandwidth >
bandwidth

Otherwire, mention

*

Ff

Gixed
rignal

of liked
amplitude

ay

signal will be distorted in time but will not

fade much

over a

local area .

Д

signal bandwidth &

bandwidth

of multipath chann the rignal

will change rapidly but

signal will not be distand in time

M

Paramet

ers

of

Mobile Multipath

channels

=>

=> Many meiltepath

channel parameters

derived

are

pawce delay

people. They

relative

to a

powe

r

Are

requeren

ted

the

from as

plots of

as

a

frenctio

n of

excers

delay with

respeck

fixed time delay

reference.

=> Time Dispersion

Parameters

TM

* The time dispersive properties of wideband

multipath

are most commonly

quantified by

channels

mean excers

del

ay

* The

mear

excess

delay

propele

-- =

(e) at

rons

delay

their ex

delay

spread

(se).

is the

first

moment

of

power

$\underline{\acute{Z}} Ax^2 Zx$

Ep (ex)

Ik

K

Ɂ

E Ax

Ep (ex)

k

k

the central

g

*

where P (z) - multipath

powce delay propile.

The hors

moment

When

delay spread is the

square Rook

the power delay

peopile

of

ર

G2 = =22- (E) 2

2

R 2

Elite EP (en) to

Eau

k

{P (ek)

K

2

리

Typical values

of

д

что

delay

spread

Ale

on

the order

us is outdoor mobile radio channels & on the order

мо

ůr indoor radio channels.

مو

д

नै

* The cons

delay spread &

mear

+ mear excers

delay the tempeal

are

defin

ed

a

from

Average of

+

average

d

single

PDP which is

or spatial

consecutive impulse response

measurement collected

over

a

local

ама

* The maximum excers

del

ay

(x dB)

g

the PDP is the

time delay during which multipath

energy falls to XdB below the maximum.

In other words, it is defined

as

Ex

d

Ex- to where to is first

arriving signal & #

delay at

which a

-max. EXEEED

is within

signal

(does

полтавізо

в Со

Rxed power

-60

x *dB*

cy

multipath
component

the strangest
arriving multipath

(does not
necessarily

necessarily arive at

to)

KRMS

delay

Ries delay
spied.

246. чого

Max. Excers delay

<[dB = 84 Ad

-20

-10

fe Mear Excels delay = 45.05 m

← Threshold level=-2013

+ + +

O to по BO 200

200 3200 300 400

Excers-delay (Mrs)

* ir practice, values for Z, ZZ & Je depend

cy

on the

choice

nome threshold used to pexers P(c).

The nove hearhold is used to differentiate multipath components & Thermal

if

ти

noire threshold is too low, the noire will be

4306

as multipath, giving rise to values

nove

processe
d

ce

Je that

Are

artegically

high.

Compute

the

ять

ہیں

ਲ

Z, et

delay spread for the following power

delay

people.

P(e)

0 μs

صدق میرا

2/62473

delay

spread

Calculate &ms

Sol

E p(za)

Ta

==

к

روح

11

-

EP(4)

EP (za)

Ta2

2

[(0) (0) +

(1) (1) +

(1) ()]

1+1

31.5 us

(1) (0) 2 + (1)

(1) 2 +(1) (2+)

انی

=

=

{p(eu)

ما

2

1+1

25-(1.5)2 = 0.5 us !

لرحمة

=25 us

→ Coherence Bandwidth

* Coherence Bandwidth is derived

is the statistical

spread. It

is

of

frequencies

flat $(\tilde{a}o)$

a

fro
m

the

rens

dela
y

the

g

lange

statistical measure

over which the channel can be considered

channel which paises all spectral Components with approx equal gain & linear phase).

+ Two

*

Bc

Two sinusoids with freq. seperation greater than Be are

are

affected quite differently

If coherence bandwidth is defined

as the bandwidth

over which the jeeg. Corelation perction is above 0.9,

Be ≈ 50 TE

Bc

JE

of the firg- correlation is chosen to be above 0.5,

Bc

Bc ~

1

se

Ther

Calculate the mean

excess

dela

y

rons

delay

spread +

the maximum excers

giver

delay (10 dB) for the multipath people

below: Estimate the joy.

coherence

bandwidth

the channel, klould this channel be suitable for Aveps

AMPS

or CSM

revize without the use of

ar

equaling er?

ОСВЗЯ

-codo

-2010

-30do

Pa(c)

2.

(مسد)

73

Soh

=> The

ぞ
とこ

200

ear

excers

delay is beads

mear

-Rods

-lods

(1)'(s) + (0.1)(2) + (0-1)

(1) + 0.01(0)

-0.01 + 01+0-1+!

o da

+0,01

0.1 0.1

4.38 us

=) The second

moment

احد

== (0.01) (0) 2 + (0-1) (1) 2 + (0-1).

(2)2 + (1) (5)2

Ions delay

spread

0-01 +0-1 +0.1+1

Coherence Bandered

th

=)

Bc

5 бe

1

Je =

ك

אן

N

= 21.07 us?

Trods bask

!

1.37 us

=

146 KH2

backwar alf

5(1.37.us)

wolle wethout.

aT

are

equalizer

: : Bc > 30k Hy, AMPS will

ASH requires 200KHy bandwidth which

However

Exceeds Bc, thus

channel.

an

equalizer would be needed for this

NA

استما

=> **Doppler** Spread ±

Coherence? Tiême

eте

*

Delay spread & coherence bandwidth do not offer information about the time

native

of

the

varyi

ng

channel caused by either

relation motion between

the mobile & base station, o

1

f

by

movement object in the channel.

Doppler spread & coherence

time

Are

nature

of

parameters which describe

the time varying

the channel û a small-scale

small-scale region.

* Doppler spread BD is a measure of spectral broadening caused by the time rate of change of the mobile radio channel & is defined as the range of frequencies Nee which the received Doppler spectrum is essentially

пол гело

* when a

рше

serusoidal tone

за *of* frequency fe is Toud, the received signal specteun, called the Doppler specterem, will have components in the range feafed to fitfd, where

fd

is

* The

which is

the Doppler shift.

The amount

a

of spectial broadening

depends function of

relative velocity of

the angle ○ b/w the duection

ϴ

& duection

g

arreial

g

of

notion

on fd

The mobile,

and

of

scattered waves.

the mobile

If

the bareband signal bandwidth is much

greater than

Bo, the effets of Doppler spread

Are

neglegible at The Rx.

This is a

slow

jadi ng

channel

Dopp ler

+ Coherence time Pe is the time domain dual

spread of is used to characterge the time varying

of frequeing

dispersiviners of

nature

the channel is time

domain. The doppler spread &

cohuence time

inversely

proportional to

be

122

fm

one

one

another

* Coherence time is a statistical measure

اوت

aи

the time duration

g

over which the channel impulse response is invavant of quantifies the scorelarity of at different times.

*

of the reciprocal bandwidth

essentia lly

the channel

response

the baseband ugnal is
t

greater than the coherence time of the channel, then the channel will change during the tansmissio Causing distortion at the receiver.

barebar
d

message,

hus

f

the coherence time is defined

as the time ova

which

the time correlation

function

q

Jc = Tc

16 π

for

is above 0.5, then,

Wheee

•

for

^ так .

dopple shift & mm =

old.

* Another popular

theems sule i

^c=

√

935

baleant 0.423

16πT

Zu

foo

Thus two signals

arriving with

than Tc

ale

Determine

make

that

a

time seperation

greater

affected differently by

the channel.

the proper spacial sampling central required
to small scale propagation measurements
which assume Consecutive samples
highly correlated in time.
How

a

many samples will

2

1900

Meting

мну

таке

these

&

are

be

required

và

ove

com travel distance

1=50 mls . How long would it take

measurements, acsiering they
could be made moving vehicle? what
is the Doppler

is real time from

if fe=

to

ů

sprea
d

Sob

една
в

Bo

for

Joe correlation

to Pic/2.

Pic =

167

7

16 при

=

ac

=

a

the channel ?

let time between samples is

ad

[:

fm=v/d]

16 пе

16πToge

[-id=c/fe]

паза

9x3×108

16xп X 50 X 1900x106

=

565us

laking time samples at has then Ate half the sampling enterral is

П

sx =

50x565 us

=

=

1.41 cm.

B

.: Mo.

of

su

a

com travel distance

is

Nx

منا

=

samples required

10

DX

141×10

-२

= Jos samples.

Time taker for their measurement

com

somlo

and

equal to

0.20.

The

Doppler

spread, BD =

for

ҕ

Typ
es

Small Scale
Fading

c

=

6
sox (900 Xcь

3x cot

=

316,66
Hay
Hy

Fading Effect due to multipath
Time Delay **Spread**

* Had

Fading

of the mobile radio

channel has

linear phase

response over a

than the bandwidth

g

a

Constant

gan

व्

дай

bandwidth which is

greater

the food signal, then the

received

signed will undergo flat

fading.

Tixed rignal is preserved.

The spectral chay of → The shergth of the received ignel charges wis time, due to fluctuations in the gair of the channel caused by multiparh.

s (t)

s(t).

x(t)

thi(te).

h16,2)

ясы)

t

t

Exx Is

1ste

k

1s

+ The recipeoral

F

-5-

fe

bandwidth

Z

the transmitted ignal is

much larger than the multipath time delay spread of he channel + holz, c)

can

excess

be

approxima
ted

مع

have
ry

no

delay (few a ringle detta
puction with 2=0) .

→ Hat
fading

channels

channels (os) Narrowband
channels.

are also known

as

amplitude
varying

Hlad fadin g channels cause deep fades, & tees may require 20 a 30 di more transmitter power to achieve low het error rates.

→ The distortica distibution of instantaneous gan of flat fading channels is he Rayleigh destebution.

Thus

a rignal undergoes flat

fading if

Bs de Be

क्

As >> Je

Bw

Pin-

Reciprocal Bu

Bandwidth

Bs

бе

ims

delay spread

Bc. Coherence Bandwidth

* Frequency

Selective Fading

phase

response

F

the channel

possesses a

constant

gain

4 linear

ove

a

bandwidth that is smaller than

frequen

cy

fadin

g

transmitted **signal**, then the

channel creates

the received

ungral.

the bandwidth

selective

on

→ The channel impube response has multipath delay spread which is greater than the reciprocal handwond the of the transmitted

Thus the

merrage.

Road ugnal includes multiple versions

the transmitted wavessem

which are

по

attenuated &

delayed in time of herce he loved signal is distracted. Theis & channel induces ISI, due to time dispersion of the Txed nymedo

wither he channel.

→

Frequ
ency

Zara

selective fading channels are much more difficult to model than flat fading channels since each meeltipath signal must be modeled & the channel must be considered to be

a

linear felter.

_s(t)

h(t,e)

\hite)

0 1

t

t

حراء

f

ЯCH

ЯCH

To+e

The channel becomes

frequ

ency

is different for different frequency components.

→→ Frequery selective fading

delays which
appesach the
transmitted

selection, where
he gain

multipa
th

is caused

by or exceed the
symbol period

путв
о!

are also known as wideband
channels.

+Th

ey

Thus, a

rignal undergoes

frequency

Bs y Bc

TS & TE

A rule

thumb:

Ў трусоте

selective

Jading *of*

→

• flat

jading

Ts & 10 TE - freg. selective
Jading

⇒ Fading Effects due
to Doppler Spread

* Fast
Fading

وفل

→ In a fast Jading channel, the channel impulse Response changes rapidly wither the symes) duration.

(e) the coherence
the channel is smaller than

the symbol period of

time

f

the transmitted

rignal.

→ This causes frequency

despiñas (also called time

selection jadiny) due to

Doppler spreading

→ Thus a

signal undayses

jait Jading i

Ts > T

वे

Bs X BD

→ A flat fading, fast fading chamel is

a channel in which

the

amplitude

late

the delta

pencion

function

varies

%

faster than

the of change of transmitted

baseband signal.

→ In prequency selective, fast

fading channel, the

phases, & time

delays of any

one

ад

amplitu
des,

the multipath

8

Components vary faster than the rate of change of the Red synel.

* Slow
Fading

fadin
g

In slow

channel, the channel impulse response

علم

changes at a rate much slower than

the transmitted

bandband rignal

s(t).

→ The aloppler spread of the

channel is much less than

the bandwidth

Thuis a

of

the baseband

rignal.

upral undergoes slow

jading of rignal

lis xx

Pic

q

Bs >> *BD*

12

Pransmitted
symol period

wad regnel
Всю

Br
бе

Hat dow

Flat Fast

Fading

Fadin
g

Fung. Selective Treg.
selective

slow Fading Fast
Fadey

(

BC

Fy selective 1 Frey.

Selective

slow

Fading

Fixed symol

opened

Fast

Fading

Bc

Far Foot

Fat slow

Fadey

Fadin

g

Bs

Bd

Txed signal Bow

Small Scale

Fading

(Band

on

multipath time
delay spread)

CUCAL

Har Fadiy

Bw

Br

→ Bu of repnel LOW
& chanel

g
(Bs)

8
(Bc)

» Delay spead I symbol
peñad

(As)

(se)

Freq. selective
Feeding

=). Bo y черпав y воз
channel

حمه جعبه لا
(Bs)

својy

=) Dday spread > symbol
perial

(TS)

Small – Scale
Fading

Doppler
Spread)

(Based on

Fast Fadiny

(ITC)
-) coherence time <
Symsol perad

(a)

(se)

slov Jaday

2) Coherence teme >

Symso peñar

(c)

(Ts)