# Scilab Manual for Wireless Communications by Dr V. A. Sankar Ponnapalli Electronics and Telecommunication Engineering Icfai Foundation For Higher Education[1]

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November 7, 2026

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Scilab Manual and Scilab codes written in it can be downloaded from the "Migrated Labs" section at the website http://scilab.in

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# Experiment: 1

# Study of Free Space Propagation-Path Loss Model

**Scilab code Solution 1.0** Path Loss Model

```
1 // Study of Free Space Propagation-Path Loss Model (
    FSPL)
2 // OS - Windows 10
3 // Scilab 6.1.0
4 // Course Instructor Name: Dr. V. A. Sankar
    Ponnapalli
5 // Institute Name: ICFAI Foundation for Higher
    Education Hyderabad
6
7 clc;
8 clear;
9 close();
10
11 disp("Enter frequency in Hz (Recommended: 800e6 to
    2.5e9):");
12 f = input("Frequency (Hz): ");
13
```

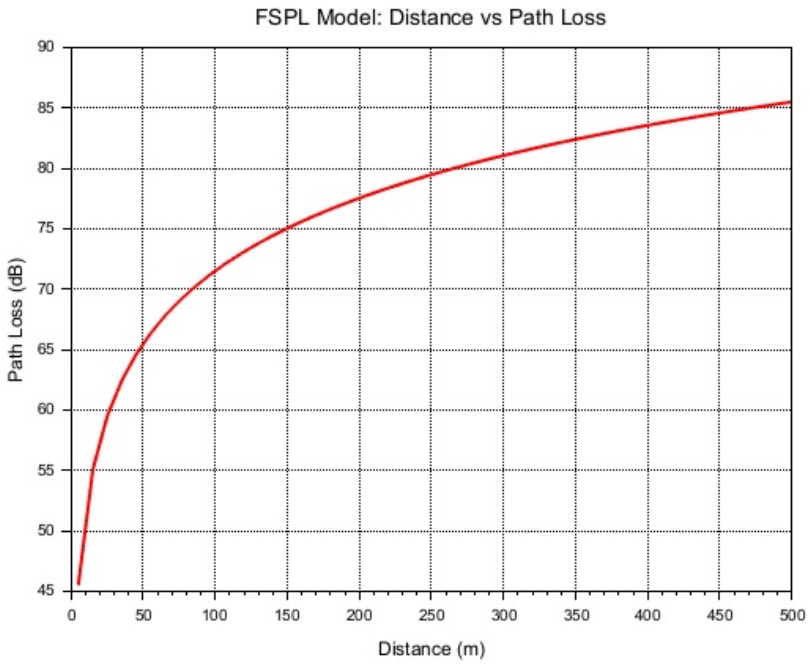



Figure 1.1: Path Loss Model

```
disp("Enter minimum distance in meters (Recommended: 1 to 10 m):");
d_min = input("Minimum distance (m): ");

disp("Enter maximum distance in meters (Recommended: 100 to 10000 m):");
d_max = input("Maximum distance (m): ");

disp("Enter number of distance samples (Recommended: 50 to 500):");
n = input("Number of points: ");

c = 3e8; // Speed of light in m/s
lambda = c / f; // Wavelength in meters
d = linspace(d_min, d_max, n);

// Compute Free Space Path Loss (FSPL)
path_loss = 20*log10(d) + 20*log10(f) + 20*log10(4 * %pi / c);

scf();
plot(d, path_loss, 'r', 'LineWidth', 2);
xlabel('Distance (m)');
ylabel('Path Loss (dB)');
title('FSPL Model: Distance vs Path Loss');
h = gca();
h.grid = [1 1]; // Turn on both axes grid

// Description of the Figure
// User Inputs:
// Enter frequency in Hz (Recommended: 800e6 to 2.5e9):
// Frequency (Hz): 900e6
// Enter minimum distance in meters (Recommended: 1 to 10 m):
// Minimum distance (m): 5
// Enter maximum distance in meters (Recommended: 100 to 10000 m):
```

```
45 // Maximum distance (m): 500
46 // Enter number of distance samples (Recommended: 50
       to 500):
47 // Number of points: 50
48
49 // The figure titled "Interactive FSPL Model:
       Distance vs Path Loss" illustrates how free space
       path loss (in dB)
50 // increases logarithmically with distance in a line
     -of-sight communication environment.
```

---

# Experiment: 2

# Study of Outdoor Propagation – Okumura Model

**Scilab code Solution 2.0** Okumura Model

```
1 // Study of Outdoor Propagation     Okumura Model
2 // OS: Windows 10
3 // Scilab Version: 6.1.0
4 // Course Instructor: Dr. V. A. Sankar Ponnapalli
5 // Institute: ICFAI Foundation for Higher Education,
      Hyderabad
6
7 clc;
8 clear;
9 close;
10
11 disp("Enter distance between T x Rx in km (Valid
      range: 1 100 km):");
12 d = input("Distance (km): ");
13
14 disp("Enter base station antenna height in meters (
      Valid range: 30 1000 m):");
```

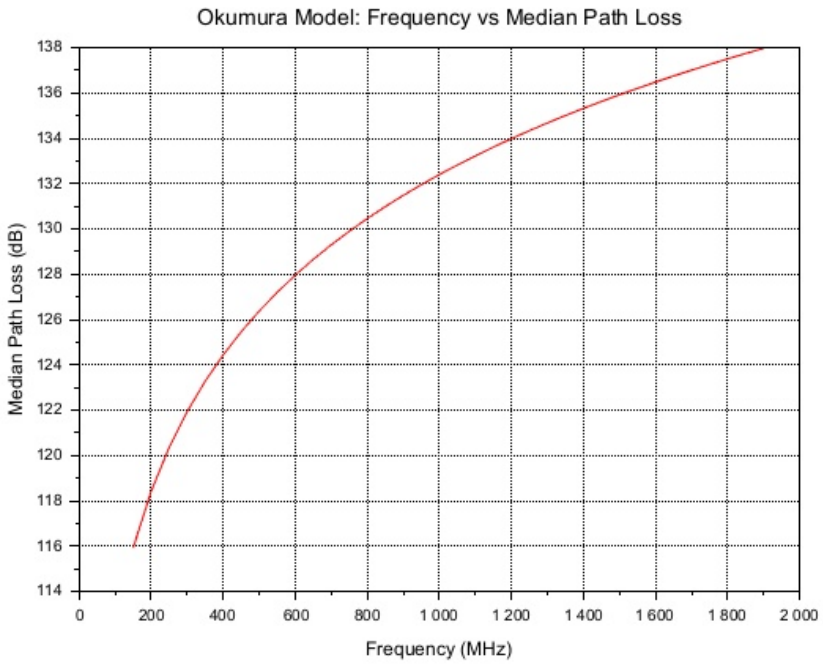



Figure 2.1: Okumura Model

```
15 ht = input("Base Station Height (m): ");
16
17 disp("Enter mobile station antenna height in meters
      (Valid range: 1  10  m):");
18 hr = input("Mobile Station Height (m): ");
19
20 disp("Choose Environment:");
21 disp("1. Urban");
22 disp("2. Suburban");
23 disp("3. Rural");
24 choice = input("Enter your choice (1  3 ): ");
25
26 select choice
27     case 1 then
28         environment = "urban";
29     case 2 then
30         environment = "suburban";
31     case 3 then
32         environment = "rural";
33     else
34         disp("Invalid choice. Defaulting to urban.")
              ;
35         environment = "urban";
36 end
37
38 f_start = 150;     // MHz
39 f_end = 1920;      // MHz
40 f_step = 50;       // MHz
41 frequencies = f_start:f_step:f_end;
42
43 medianLoss = zeros(frequencies);
44
45 // ---------------------- Path Loss Calculation
      ----------------------
46 for i = 1:length(frequencies)
47     f = frequencies(i);
48
49     // Free space path loss
```

```
50      Lf = 32.4 + 20*log10(f) + 20*log10(d);
51
52      // Antenna gains
53      Gt = 20*log10(ht / 200);
54      Gr = 10*log10(hr / 3);
55
56      // Median path loss
57      Am = Lf - Gt - Gr;
58
59      // Apply environment correction
60      select environment
61          case "suburban" then
62              Am = Am - (2 * (log10(f / 28))^2) - 5.4;
63          case "rural" then
64              Am = Am - (4.78 * (log10(f))^2) + (18.33
                    * log10(f)) - 40.94;
65      end
66
67      medianLoss(i) = Am;
68  end
69
70  scf(0);
71  plot(frequencies, medianLoss, 'r-');
72  xlabel("Frequency (MHz)");
73  ylabel("Median Path Loss (dB)");
74  title("Okumura Model: Frequency vs Median Path Loss"
      );
75  xgrid();
76
77  // Description of the Figure
78  // User Inputs:
79  //"Enter distance between Tx Rx in km (Valid range
      : 1 100 km):"
80  //Distance (km): 100
81  //"Enter base station antenna height in meters (
      Valid range: 30 1000 m):"
82  //Base Station Height (m): 200
83  //"Enter mobile station antenna height in meters (
```

```
    Valid range: 1  10  m):"
84 //Mobile Station Height (m): 3
85 //"Choose Environment:"
86 //"1. Urban"
87 //"2. Suburban"
88 //"3. Rural"
89 //Enter your choice (1  3 ): 1
90 //The figure titled "Okumura Model: Frequency vs
    Median Path Loss" illustrates how path loss
    behaves with varying frequencies in an urban
    setting and how the system parameters (distance,
    a//ntenna heights, and frequency) influence the
    signal strength.
```

---

# Experiment: 3

# Study of Outdoor Propagation – Hata Model

**Scilab code Solution 3.0** Hata Model

```
1  // Study of Outdoor Propagation     Hata Model
2  // OS: Windows 10
3  // Scilab: 6.1.0
4  // Course Instructor: Dr. V. A. Sankar Ponnapalli
5  // Institute: ICFAI Foundation for Higher Education
      Hyderabad
6
7  clc;
8  clear;
9  close;
10
11 disp("Enter Transmitter Height in meters (Valid
      range: 30  200  m):");
12 ht = input("Transmitter Height (m): ");
13
14 disp("Enter Receiver Height in meters (Valid range:
      1  10  m):");
```

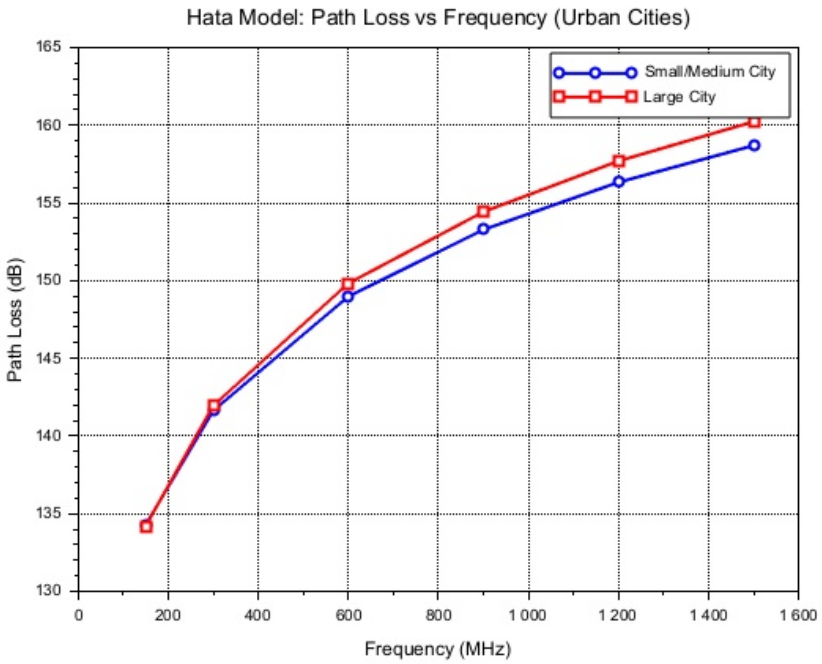



Figure 3.1: Hata Model

```
15 hr = input("Receiver Height (m): ");
16
17 disp("Enter Distance between T x Rx in km (Valid
      range: 1 20 km):");
18 d = input("Distance (km): ");
19
20 f_values = [150, 300, 600, 900, 1200, 1500]; // in
      MHz
21
22 Lp_small = zeros(1, length(f_values)); // Path loss
      for small/medium cities
23 Lp_large = zeros(1, length(f_values)); // Path loss
      for large cities
24
25 // ---------- HATA MODEL CALCULATION
      ----------
26
27 for i = 1:length(f_values)
28     f = f_values(i);
29
30     // Correction factor for small/medium cities
31     ah_small = (1.1 * log10(f) - 0.7) * hr - (1.56 *
          log10(f) - 0.8);
32
33     // Correction factor for large cities
34     if f <= 200 then
35         ah_large = 8.29 * (log10(1.54 * hr))^2 -
             1.1;
36     else
37         ah_large = 3.2 * (log10(11.75 * hr))^2 -
             4.97;
38     end
39
40     // Path Loss Calculations
41     Lp_small(i) = 69.55 + 26.16 * log10(f) - 13.82 *
          log10(ht) - ah_small + (44.9 - 6.55 * log10(
         ht)) * log10(d);
42     Lp_large(i) = 69.55 + 26.16 * log10(f) - 13.82 *
```

```
        log10(ht) - ah_large + (44.9 - 6.55 * log10(
        ht)) * log10(d);
end

scf(0);
plot(f_values, Lp_small, 'b-o', "LineWidth", 2);
plot(f_values, Lp_large, 'r-s', "LineWidth", 2);

xlabel("Frequency (MHz)");
ylabel("Path Loss (dB)");
title("Hata Model: Path Loss vs Frequency (Urban
    Cities)");
legend("Small/Medium City", "Large City", "location"
    , "upper_left");
xgrid();

// Description of the Figure
// User Inputs:
// "Enter Transmitter Height in meters (Valid range:
     30 200 m):"
// Transmitter Height (m): 50
// "Enter Receiver Height in meters (Valid range: 1
     10 m):"
// Receiver Height (m): 3
// "Enter Distance between T x Rx in km (Valid
    range: 1 20 km):"
// Distance (km): 10
// The figure titled "Hata Model: Path Loss vs
    Frequency (Urban Cities)" illustrates the
    variation of path loss with frequency for urban
    environments using the Hata propagation model.
// It compares path loss in two types of urban areas
    .
```

# Experiment: 4

# Study of Multipath Fading Channel

**Scilab code Solution 4.0** Multipath Fading Channel

```
1  //Study of Multipath Fading Channel
2  // OS-Windows 10
3  // Scilab 6.1.0
4  // Course Instructor Name: Dr. V. A. Sankar
       Ponnapalli
5  // Institute Name: ICFAI Foundation for Higher
       Education Hyderabad
6
7  clc;
8  clear;
9  close;
10
11 printf("Enter number of frequency points N (power of
       2, between 128 and 4096):\n");
12 N = input("N = ");
13 if ~((floor(log2(N)) == log2(N)) & N >= 128 & N <=
       4096) then
```

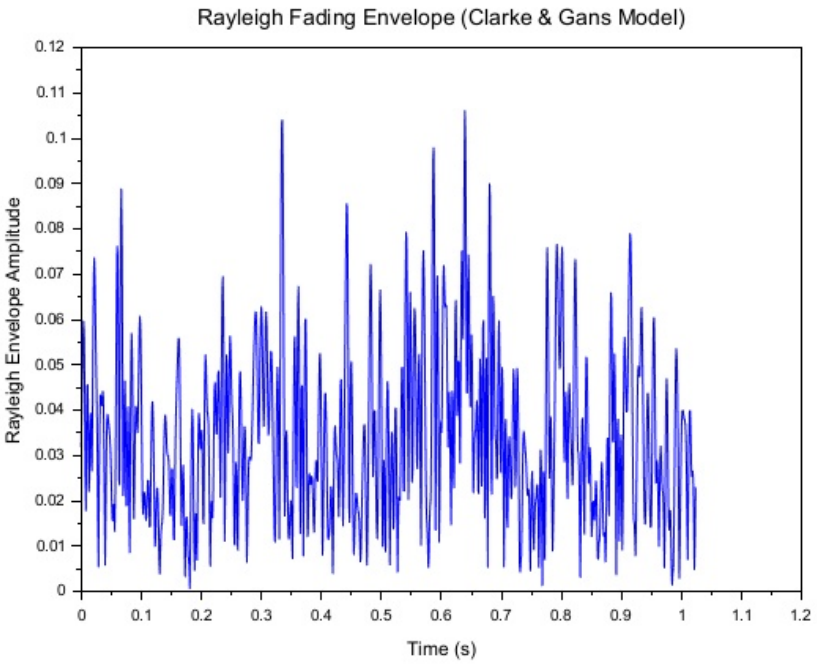



Figure 4.1: Multipath Fading Channel

```
14      error("Error: N must be a power of 2 between 128
            and 4096.");
15  end
16
17  // Input for max Doppler frequency fm
18  printf("Enter maximum Doppler frequency shift fm in
        Hz (e.g., between 10 and 500 Hz):\n");
19  fm = input("fm = ");
20  if fm <= 0 | fm > 1000 then
21      error("Error: fm must be between 10 and 1000 Hz.
            ");
22  end
23
24  // Input for sampling frequency fs
25  printf("Enter sampling frequency fs in Hz (must be >
        2*fm):\n");
26  fs = input("fs = ");
27  if fs <= 2*fm then
28      error("Error: fs must be greater than 2 * fm.");
29  end
30
31  // Derived values
32  df = fs / N;              // Frequency resolution
33  T = 1 / df;               // Duration of fading
        waveform
34  f = (-N/2:N/2-1)*df;      // Frequency axis
35
36  // --- GENERATE DOPPLER SPECTRUM S_Eg(f) ---
37  Se = zeros(1, N);
38  for i = 1:N
39      f_norm = f(i) / fm;
40      if abs(f_norm) < 1 then
41          Se(i) = 1.5 / (%pi * fm * sqrt(1 - f_norm^2)
                );
42      else
43          Se(i) = 0;
44      end
45  end
```

```
46
47 // ---- GENERATE COMPLEX GAUSSIAN NOISE ----
48 rand("normal");
49 gauss_real = rand(1, N, "normal");
50 gauss_imag = rand(1, N, "normal");
51 Gf = (gauss_real + %i * gauss_imag) / sqrt(2);
52
53 // ---- SHAPE NOISE WITH DOPPLER SPECTRUM ----
54 Sqrt_Se = sqrt(Se);
55 Hf = Gf .* Sqrt_Se;
56
57 // ---- IFFT TO TIME DOMAIN ----
58 Hf_shifted = fftshift(Hf);
59 ht = ifft(Hf_shifted);
60 ht = ht * sqrt(N);              // Normalize
61
62 // ---- COMPUTE RAYLEIGH ENVELOPE ----
63 rayleigh_envelope = sqrt(real(ht).^2 + imag(ht).^2);
64
65 t = (0:N-1)/fs;
66 scf(1);
67 plot(t, rayleigh_envelope);
68 xlabel("Time (s)");
69 ylabel("Rayleigh Envelope Amplitude");
70 title("Rayleigh Fading Envelope (Clarke & Gans Model
     )");
71
72 // Description of the Figure
73 // User Inputs:
74 //Enter number of frequency points N (power of 2,
     between 128 and 4096):
75 //N = 1024
76 //Enter maximum Doppler frequency shift fm in Hz (e.
     g., between 10 and 500 Hz):
77 //fm = 100
78 //Enter sampling frequency fs in Hz (must be > 2*fm)
     :
79 //fs = 1000
```

```
80 // The figure titled "Rayleigh Fading Envelope (
     Clarke & Gans Model)" exhibits rapid variations
     typical of Rayleigh fading with many fades per
     second, consistent with a Doppler frequency  //of
      100 Hz.
```

---

# Experiment: 5

# Modulation and Demodulation of Binary Phase Shift Keying over Additive White Gaussian Noise (AWGN) channel

**Scilab code Solution 5.0** BER OF BPSK

```
1 //Modulation and Demodulation of Binary Phase Shift
    Keying over Additive White Gaussian Noise (AWGN)
    channel
2 // OS-Windows 10
3 // Scilab 6.1.0
4 // Course Instructor Name: Dr. V. A. Sankar
    Ponnapalli
5 // Institute Name: ICFAI Foundation for Higher
    Education Hyderabad
6
7
8 clear;
9 clc;
```

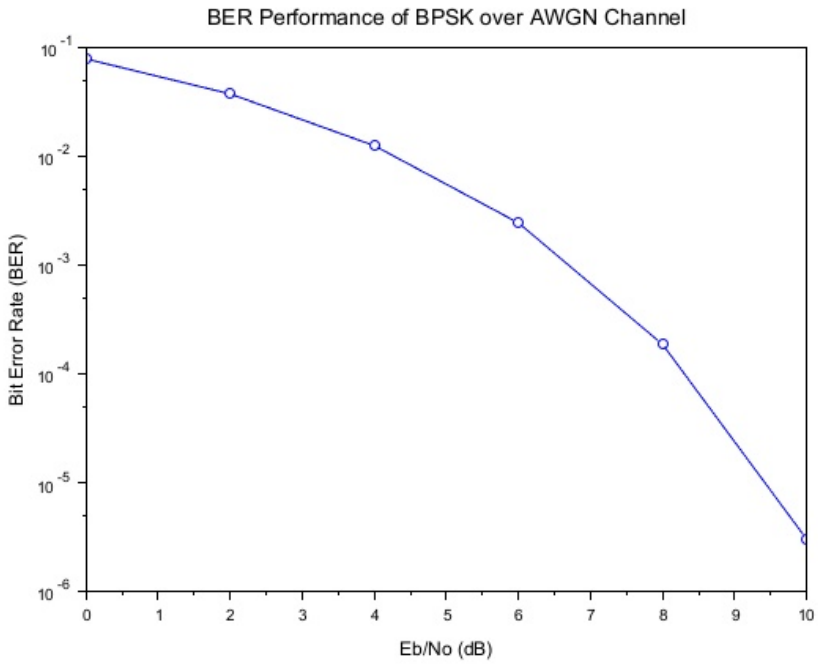



Figure 5.1: BER OF BPSK

```
close;

l = input("Enter number of bits to transmit (Choose between: 100000 to 1000000): ");
while l < 100000 | l > 1000000
    l = input("Invalid input. Enter number of bits between 100000 and 1000000: ");
end

EbNodB = 0:2:10;                % Range of Eb/No in dB
BER = zeros(1, length(EbNodB));  % Initialize BER array

// Pick example Eb/N0 for printing outputs (middle of range)
example_idx = floor(length(EbNodB)/2);
example_EbNodB = EbNodB(example_idx);

for n = 1:length(EbNodB)
    // Generate random BPSK symbols: -1 or 1
    s = 2*(round(rand(1, l))-0.5);

    // AWGN noise with variance based on Eb/N0
    noise_std = 1/sqrt(2*10^(EbNodB(n)/10));
    w = noise_std * rand(1, l, 'normal');

    // Received signal
    r = s + w;

    // Demodulation: sign detector
    s_est = sign(r);

    // BER calculation
    BER(n) = sum(s ~= s_est)/l;

    // Save example bits for display
    if n == example_idx then
```

```
43          bits_sent = (s + 1)/2;       // convert from
               -1/1 to 0/1 for clarity
44          bits_demod = (s_est + 1)/2;
45      end
46  end
47
48  // Display example output for the chosen Eb/N0
49  disp("Example Eb/N0 (dB): " + string(example_EbNodB)
       );
50  disp("First 50 generated bits (0/1):");
51  disp(bits_sent(1:50));
52  disp("First 50 demodulated bits (0/1):");
53  disp(bits_demod(1:50));
54
55  // Plot BER vs Eb/N0
56  scf();
57  semilogy(EbNodB, BER, 'o-');
58  xlabel('Eb/No (dB)');
59  ylabel('Bit Error Rate (BER)');
60  title('BER Performance of BPSK over AWGN Channel');
61
62  //// Description of the Figure
63  // User Inputs:
64  // Enter number of bits to transmit (Choose between:
       100000 to 1000000): 1e6
65  // The figure titled "BER Performance of BPSK over
       AWGN Channel" illustrates how BPSK performs over
       AWGN.
```

# Experiment: 6

# Modulation and Demodulation of Direct-Sequence Spread Spectrum

**Scilab code Solution 6.0** DSSS

```
1 // Direct-Sequence Spread Spectrum (DSSS) Modulation
      and Demodulation
2 // OS: Windows 10
3 // Scilab Version: 6.1.0
4 // Course Instructor: Dr. V. A. Sankar Ponnapalli
5 // Institute: ICFAI Foundation for Higher Education
     Hyderabad
6
7 clc;
8 clear;
9 close;
10
11 N_bits = input("Enter number of data bits (e.g., 10
     to 100): ");
12 PG = input("Enter processing gain (e.g., 5 to 20): "
```

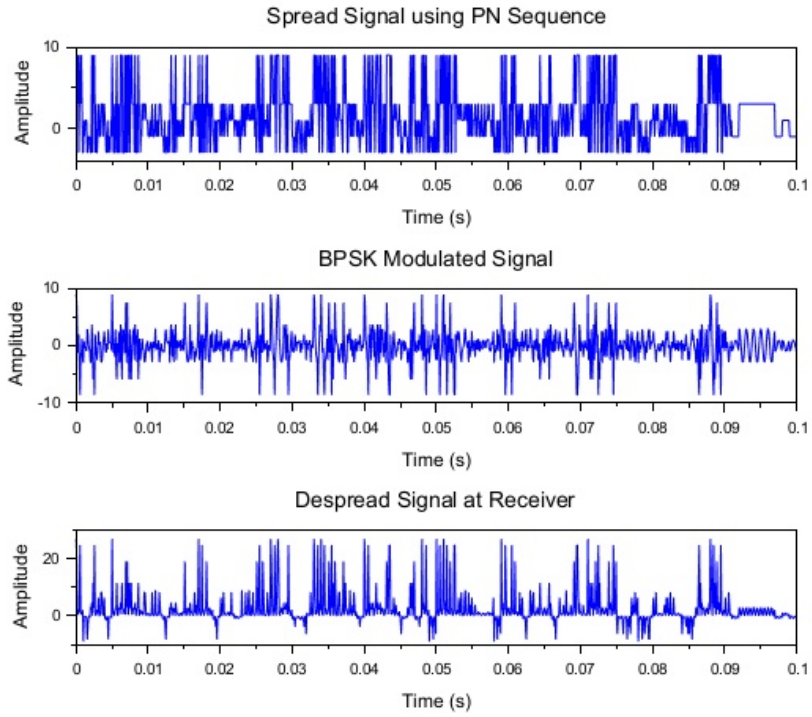



Figure 6.1: DSSS

```
    );
fc = input("Enter carrier frequency in Hz (e.g., 1000): ");
fs = input("Enter sampling frequency in Hz (must be > 10*fc): ");

// Validations
if fs <= 10 * fc then
    error("Sampling frequency must be greater than 10 times the carrier frequency.");
end

// Timing and signal parameters
Tb = 1e-3;                      // Bit duration (1 ms)
Tc = Tb / PG;                   // Chip duration
Ns = int(fs * Tb);              // Samples per bit
Nc = int(fs * Tc);              // Samples per chip
total_samples = N_bits * Ns;    // Total number of samples
t = (0:total_samples - 1) / fs;  // Time vector

// Generate random data bits (+1 or -1)
data_bits = 2 * grand(1, N_bits, "uin", 0, 2) - 1;
data_signal = matrix(ones(Ns, 1) * data_bits, 1, -1);

// Generate PN sequence long enough
num_chips = N_bits * PG;
pn_seq = 2 * grand(1, num_chips, "uin", 0, 2) - 1;
pn_signal_full = matrix(ones(Nc, 1) * pn_seq, 1, -1);

// Ensure PN signal has enough samples
if length(pn_signal_full) < total_samples then
    // Pad if too short
    extra_needed = total_samples - length(pn_signal_full);
    pn_signal_full = [pn_signal_full, ones(1,
```

```
        extra_needed)];
end
pn_signal = pn_signal_full(1:total_samples);  // Trim to exact length

// Spread signal
spread_signal = data_signal .* pn_signal;

// Carrier
carrier = cos(2 * %pi * fc * t);

// Modulate
modulated_signal = spread_signal .* carrier;

// Receiver: Demodulate
received = modulated_signal .* carrier;
despread = received .* pn_signal;

// Recover bits
recovered_bits = zeros(1, N_bits);
for i = 1:N_bits
    idx_start = (i - 1) * Ns + 1;
    idx_end = i * Ns;
    recovered_bits(i) = sign(sum(despread(idx_start:idx_end)));
end

// Plot
clf();
subplot(3,1,1);
plot(t, spread_signal);
xtitle("Spread Signal using PN Sequence");
xlabel("Time (s)");
ylabel("Amplitude");

subplot(3,1,2);
plot(t, modulated_signal);
xtitle("BPSK Modulated Signal");
```

```
78 xlabel("Time (s)");
79 ylabel("Amplitude");
80
81 subplot(3,1,3);
82 plot(t, despread);
83 xtitle("Despread Signal at Receiver");
84 xlabel("Time (s)");
85 ylabel("Amplitude");
86
87 // Display bits
88 disp("Original bits: ");
89 disp(data_bits);
90 disp("Recovered bits: ");
91 disp(recovered_bits);
92
93 // Description of the Figure
94 // User Inputs:
95 // Enter number of data bits (e.g., 10 to 100): 100
96 // Enter processing gain (e.g., 5 to 20): 10
97 // Enter carrier frequency in Hz (e.g., 1000): 1000
98 // Enter sampling frequency in Hz (must be > 10*fc):
     11000
99 //  The figure depicts Direct-Sequence Spread
    Spectrum  Modulation and Demodulation.
```

# Experiment: 7

# Simulation of TDMA Technique

**Scilab code Solution 7.0** TDMA

```
1 //Simulation of TDMA (Time Division Multiplexing and
      Demultiplexing) Technique)
2 // OS-Windows 10
3 // Scilab 6.1.0
4 // Course Instructor Name: Dr. V. A. Sankar
     Ponnapalli
5 // Institute Name: ICFAI Foundation for Higher
     Education Hyderabad
6
7 clear;
8 clc;
9 close;
10
11 disp("=== TDMA System Simulation ===");
12
13 N_r = input("Enter number of traffic bursts per
     frame (N_r) [1   100   ]: ");
```

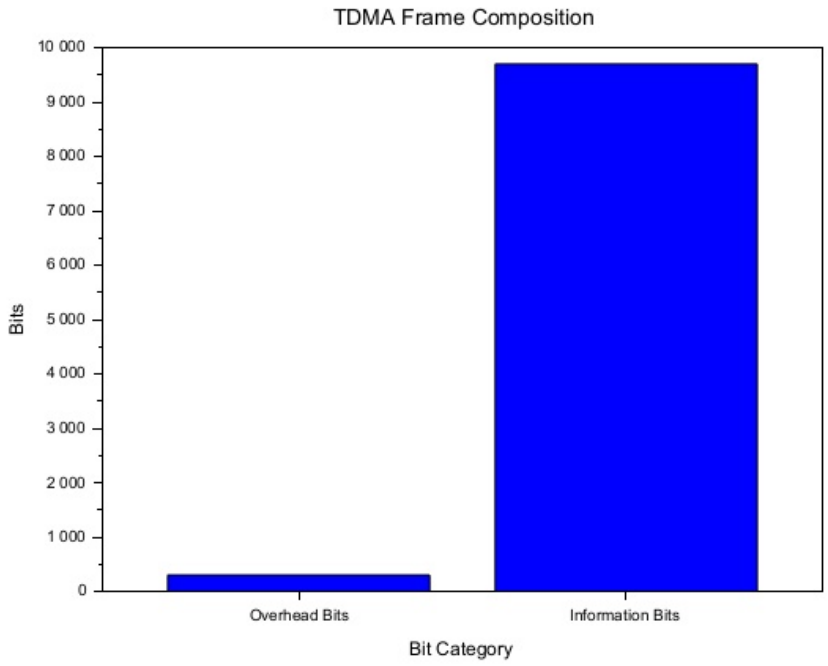



Figure 7.1: TDMA

```
14 b_r = input("Enter number of bits per traffic burst
      (b_r) [100  1000  ]: ");
15 N_p = input("Enter number of preambles per frame (
      N_p) [1  10  ]: ");
16 b_p = input("Enter bits per preamble (b_p) [10  100
      ]: ");
17 N_g = input("Enter number of guard intervals per
      frame (N_g) [1  20  ]: ");
18 b_g = input("Enter bits per guard time interval (b_g
      ) [1  50  ]: ");
19 T_f = input("Enter frame duration T_f in seconds [e.
      g., 0.01]: ");
20 R_b = input("Enter bit rate R_b in bits/sec [e.g., 1
      e6]: ");
21
22 //Overhead bits per frame
23 b_OH = N_p*b_p + N_g*b_g;
24 disp("Total overhead bits per frame (b_OH): " +
      string(b_OH));
25
26 //Total bits per frame
27 b_T = T_f * R_b;
28 disp("Total bits per frame (b_T): " + string(b_T));
29
30 //Frame Efficiency
31 eta_f = (1 - (b_OH / b_T)) * 100;
32 disp("Frame Efficiency ( _f ) in %: " + string(eta_f
      ));
33
34 // Number of TDMA Channels
35 m = input("Enter max users per channel (m) [1  100
      ]: ");
36 B_tot = input("Enter total system bandwidth B_tot in
       Hz [e.g., 200e3]: ");
37 B_guard = input("Enter guard band on one side (
      B_guard) in Hz [e.g., 10e3]: ");
38 B_c = input("Enter bandwidth per channel B_c in Hz [
      e.g., 25e3]: ");
```

```
39
40 N_channels = m * (B_tot - 2*B_guard) / B_c;
41 disp("Number of TDMA channels (N): " + string(
      N_channels));
42
43 x = [b_OH, b_T - b_OH];
44 bar(x);
45 xtitle("TDMA Frame Composition", "Bit Category", "
      Bits");
46 a = gca(); // get current axes
47 a.x_ticks = tlist(["ticks", "locations", "labels"],
      [1; 2], ["Overhead Bits"; "Information Bits"]);
48
49 // Description of the Figure
50 // User Inputs:
51
52 //Enter number of traffic bursts per frame (N_r) [1
       100  ]: 50
53 //Enter number of bits per traffic burst (b_r) [100
       1000  ]: 150
54 //Enter number of preambles per frame (N_p) [1  10
      ]: 5
55 //Enter bits per preamble (b_p) [10  100  ]: 50
56 //Enter number of guard intervals per frame (N_g) [1
       20  ]: 10
57 //Enter bits per guard time interval (b_g) [1  50  ]:
       5
58 //Enter frame duration T_f in seconds [e.g., 0.01]:
      0.01
59 //Enter bit rate R_b in bits/sec [e.g., 1e6]: 1e6
60 //Enter max users per channel (m) [1  100  ]: 50
61 //Enter total system bandwidth B_tot in Hz [e.g.,
      200e3]: 200e3
62 //Enter guard band on one side (B_guard) in Hz [e.g
      ., 10e3]: 10e3
63 //Enter bandwidth per channel B_c in Hz [e.g., 25e3
      ]: 25e3
64 //The left bar labeled   Overhead   Bits
```

```
    represents preambles and guard intervals that
    support synchronization and prevent interference.
65  //The right bar labeled    Information    Bits
    represents actual user data.
```

---

# Experiment: 8

# Simulation of FDMA Technique

**Scilab code Solution 8.0** FDMA

```
1  //Simulation of FDMA (Frequency Division
       Multiplexing and Demultiplexing) Technique
2  // OS-Windows 10
3  // Scilab 6.1.0
4  // Course Instructor Name: Dr. V. A. Sankar
       Ponnapalli
5  // Institute Name: ICFAI Foundation for Higher
       Education Hyderabad
6
7  clear;
8  clc;
9  close;
10
11 disp("==== FDMA System Capacity Simulation ====");
12
13 // Total bandwidth B_t
14 B_t = input("Enter total system bandwidth B_t in Hz
       [1e6      25e6]: ");
15 while B_t < 1e6 | B_t > 25e6
```

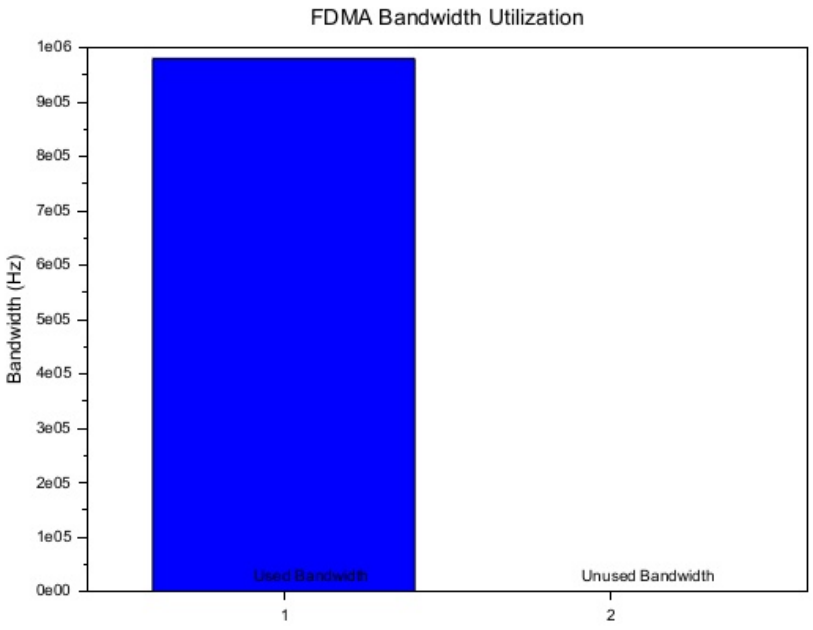



Figure 8.1: FDMA

```
16      B_t = input("Invalid! Enter B_t between 1e6 and
            25e6 Hz: ");
17  end
18
19  // Guard band per side
20  B_guard = input("Enter guard band on one side
        B_guard in Hz [1e4     5e5]: ");
21  while B_guard < 1e4 | B_guard > 5e5
22      B_guard = input("Invalid! Enter B_guard between
            1e4 and 5e5 Hz: ");
23  end
24
25  // Channel bandwidth B_c
26  B_c = input("Enter bandwidth per FDMA channel B_c in
        Hz [1e4     5e4]: ");
27  while B_c < 1e4 | B_c > 5e4
28      B_c = input("Invalid! Enter B_c between 1e4 and
            5e4 Hz: ");
29  end
30
31  //-----------------------------------
32  // Calculation
33  //-----------------------------------
34  if B_t <= 2*B_guard then
35      error("Total bandwidth must be greater than
            twice the guard band.");
36  end
37
38  B_available = B_t - 2 * B_guard;
39  N_channels = floor(B_available / B_c);
40  B_used = N_channels * B_c;
41  B_unused = B_available - B_used;
42  efficiency = (B_used / B_t) * 100;
43
44  mprintf("Total Bandwidth (B_t): %.2f Hz\n", B_t);
45  mprintf("Guard Band per side (B_guard): %.2f Hz\n",
        B_guard);
46  mprintf("Channel Bandwidth (B_c): %.2f Hz\n", B_c);
```

```
47 mprintf("Available Bandwidth after guard bands: %.2f
       Hz\n", B_available);
48 mprintf("Number of FDMA Channels (N): %d\n",
     N_channels);
49 mprintf("Total Used Bandwidth: %.2f Hz\n", B_used);
50 mprintf("Unused Bandwidth: %.2f Hz\n", B_unused);
51 mprintf("Bandwidth Utilization Efficiency: %.2f %%\n
     ", efficiency);
52
53 scf(0);
54 bar([1 2], [B_used B_unused], "stacked");
55 xt = [1, 2];
56 labels = ["Used Bandwidth", "Unused Bandwidth"];
57 for i = 1:2
58     xstring(xt(i) - 0.1, 0, labels(i));
59 end
60 ylabel("Bandwidth (Hz)");
61 title("FDMA Bandwidth Utilization");
62
63 // Description of the Figure
64 // User Inputs:
65 // Enter total system bandwidth B_t in Hz [1e6
     25e6]: 1e6
66 // Enter guard band on one side B_guard in Hz [1e4
         5e5]: 1e4
67 // Enter bandwidth per FDMA channel B_c in Hz [1e4
         5e4]: 1e4
68 // The figure titles "FDMA Bandwidth Utilization"
     shows how efficiently the bandwidth is utilized
     in an FDMA system given user-defined channel
     width and guard bands.
```

# Experiment: 9

# Simulation of CDMA Technique

**Scilab code Solution 9.0** CDMA

```
1 //Simulation of CDMA (Code Division Multiplexing and
      Demultiplexing) Technique
2 // OS-Windows 10
3 // Scilab 6.1.0
4 // Course Instructor Name: Dr. V. A. Sankar
     Ponnapalli
5 // Institute Name: ICFAI Foundation for Higher
     Education Hyderabad
6
7 clear;
8 clc;
9 close;
10
11
12 W = input("Enter total RF bandwidth W in Hz (e.g.,
     1.25e6 for 1.25 MHz): ");
13 R = input("Enter data rate R per user in Hz (e.g.,
```

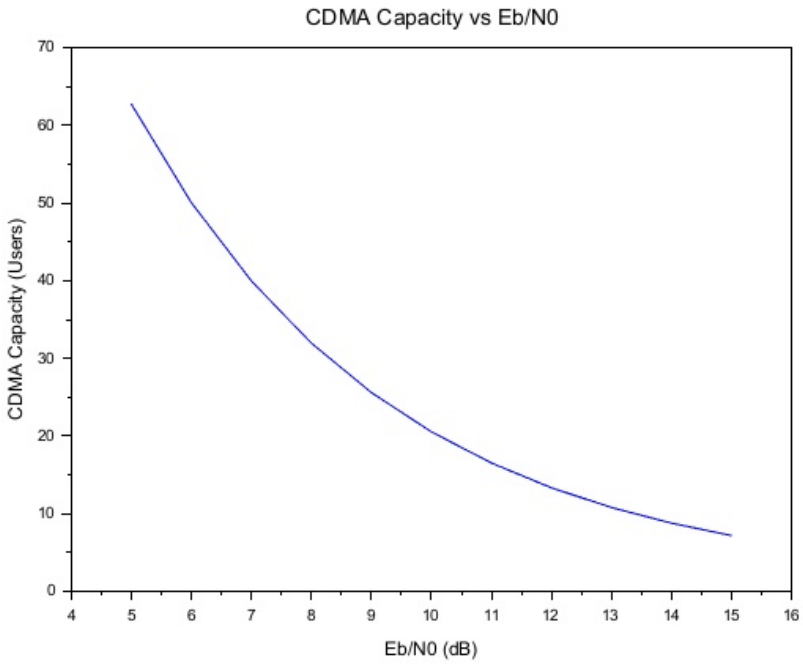



Figure 9.1: CDMA

```
    4800, 9600, 19200): ");
Eb_N0 = input("Enter Eb/N0 in dB (suggested range: 5 to 15 dB): ");
eta = input("Enter background noise fraction (suggested range: 0.5 to 1): ");
alpha = input("Enter voice activity factor (suggested range: 0.3 to 1): ");
sectorization_factor = input("Enter antenna sectorization factor (1 for omni, 3 for 120 beamwidth): ");

// Convert Eb/N0 from dB to linear
Eb_N0_linear = 10^(Eb_N0/10);

S = 1; // Assume desired signal power S = 1 unit
N_basic = 1 + (W/R) / (Eb_N0_linear * (eta/S));

// Apply sectorization and voice activity factor
N_sector = (N_basic - 1) * alpha + (eta/S);
Eb_N0_sector = (W/R) / N_sector;

// Final capacity with sectoring and voice activity
N_final = 1 + (W/R) / Eb_N0_sector;

disp("========== CDMA Capacity Results ==========");
disp("Processing Gain (W/R): " + string(W/R));
disp("Eb/N0 (linear): " + string(Eb_N0_linear));
disp("Estimated basic user capacity (no interference control): " + string(N_basic));
disp("Eb/N0 within sector with interference control: " + string(Eb_N0_sector));
disp("Estimated final user capacity (with sectorization and voice activity): " + string(N_final));

eb_range = 5:1:15;
N_plot = [];
for eb = eb_range
```

```
42      EbN0_lin = 10^(eb/10);
43      N_temp = 1 + (W/R) / (EbN0_lin * (eta/S));
44      N_plot($+1) = N_temp;
45  end
46
47  scf(0);
48  plot(eb_range, N_plot);
49  xlabel("Eb/N0 (dB)");
50  ylabel("CDMA Capacity (Users)");
51  title("Effect of Eb/N0 on CDMA Capacity");
52  xtitle("CDMA Capacity vs Eb/N0");
53
54  // Description of the Figure
55  // User Inputs:
56  // Enter total RF bandwidth W in Hz (e.g., 1.25e6
        for 1.25 MHz): 1.5e6
57  // Enter data rate R per user in Hz (e.g., 4800,
        9600, 19200): 9600
58  // Enter Eb/N0 in dB (suggested range: 5 to 15 dB):
        8
59  // Enter background noise fraction    (suggested
        range: 0.5 to 1): 0.8
60  // Enter voice activity factor    (suggested range:
        0.3 to 1): 0.5
61  // Enter antenna sectorization factor (1 for omni, 3
         for 120   beamwidth): 3
62  // The figure titled "CDMA Capacity vs Eb/N0"
        represents how the user capacity of a CDMA system
         changes with respect to the energy-per-bit to
        noise power spectral density ratio.
```