

Scilab Manual for
Wireless Communications
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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
    Ponnappalli
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
    2.5 e9):");
12 f = input("Frequency (Hz): ");
13
```

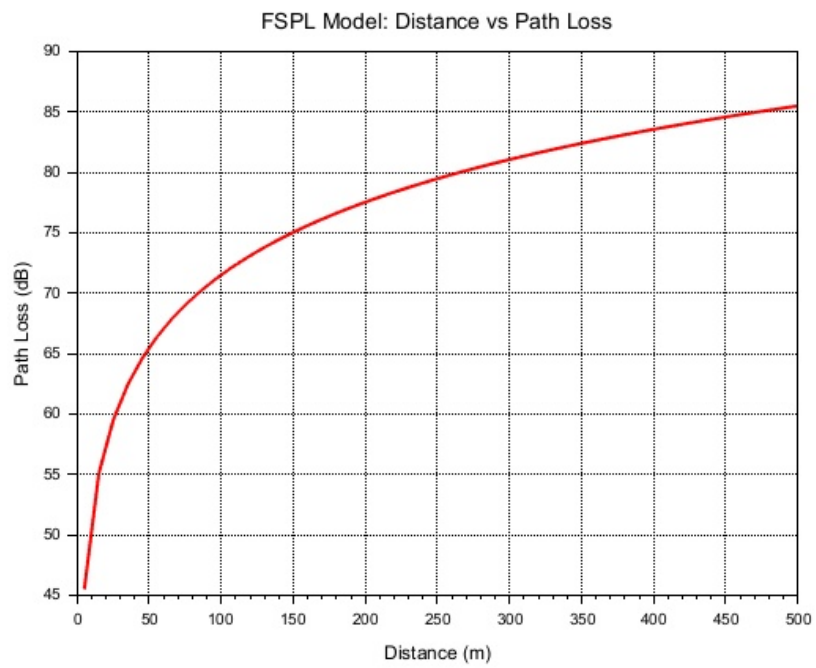


Figure 1.1: Path Loss Model

```

14 disp("Enter minimum distance in meters (Recommended:
      1 to 10 m):");
15 d_min = input("Minimum distance (m): ");
16
17 disp("Enter maximum distance in meters (Recommended:
      100 to 10000 m):");
18 d_max = input("Maximum distance (m): ");
19
20 disp("Enter number of distance samples (Recommended:
      50 to 500):");
21 n = input("Number of points: ");
22
23 c = 3e8; // Speed of light in m/s
24 lambda = c / f; // Wavelength in meters
25 d = linspace(d_min, d_max, n);
26
27 // Compute Free Space Path Loss (FSPL)
28 path_loss = 20*log10(d) + 20*log10(f) + 20*log10(4 *
      %pi / c);
29
30 scf();
31 plot(d, path_loss, 'r', 'LineWidth', 2);
32 xlabel('Distance (m)');
33 ylabel('Path Loss (dB)');
34 title('FSPL Model: Distance vs Path Loss');
35 h = gca();
36 h.grid = [1 1]; // Turn on both axes grid
37
38 // Description of the Figure
39 // User Inputs:
40 // Enter frequency in Hz (Recommended: 800e6 to 2.5
      e9):
41 // Frequency (Hz): 900e6
42 // Enter minimum distance in meters (Recommended: 1
      to 10 m):
43 // Minimum distance (m): 5
44 // 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 Ponnappalli
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):");
```

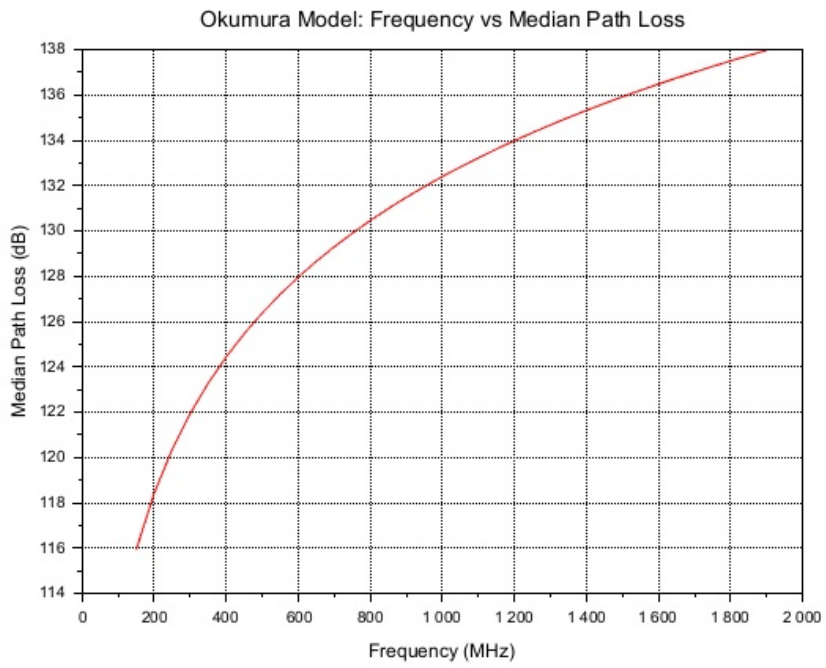


Figure 2.1: Okumura Model

```

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         ;
36         environment = "urban";
37 end
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
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
65                 * log10(f)) - 40.94;
66
67     end
68     medianLoss(i) = Am;
69 end
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     );
76 xgrid();
77 // Description of the Figure
78 // User Inputs:
79 // "Enter distance between Tx Rx in km (Valid range
80 // : 1 100 km):"
81 // Distance (km): 100
82 // "Enter base station antenna height in meters (
83 // Valid range: 30 1000 m):"
84 // Base Station Height (m): 200
85 // "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 Ponnappalli
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):");
```

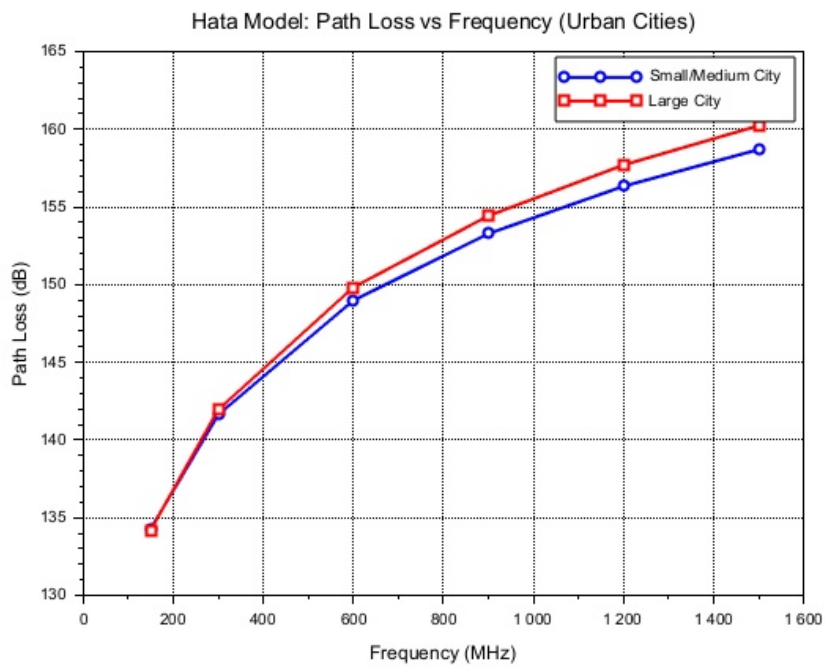


Figure 3.1: Hata Model

```

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);
43 end
44
45 scf(0);
46 plot(f_values, Lp_small, 'b-o', "LineWidth", 2);
47 plot(f_values, Lp_large, 'r-s', "LineWidth", 2);
48
49 xlabel("Frequency (MHz)");
50 ylabel("Path Loss (dB)");
51 title("Hata Model: Path Loss vs Frequency (Urban
        Cities)");
52 legend("Small/Medium City", "Large City", "location"
        , "upper_left");
53 xgrid();
54
55 // Description of the Figure
56 // User Inputs:
57 // "Enter Transmitter Height in meters (Valid range:
        30 200 m):"
58 // Transmitter Height (m): 50
59 // "Enter Receiver Height in meters (Valid range: 1
        10 m):"
60 // Receiver Height (m): 3
61 // "Enter Distance between T x Rx in km (Valid
        range: 1 20 km):"
62 // Distance (km): 10
63 // 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.
64 // 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
```

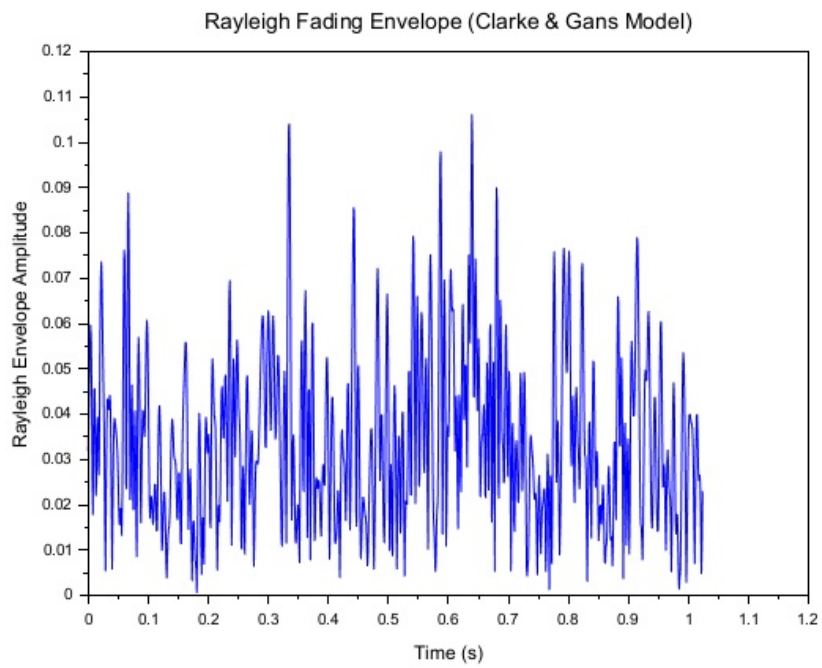


Figure 4.1: Multipath Fading Channel

```

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
   Ponnappalli
5 // Institute Name: ICFAI Foundation for Higher
   Education Hyderabad
6
7
8 clear;
9 clc;
```

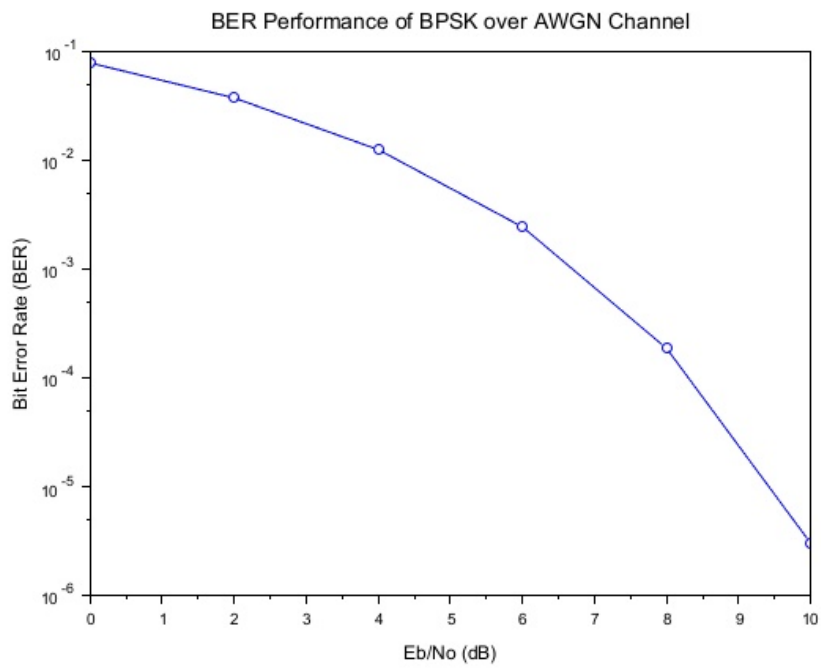


Figure 5.1: BER OF BPSK

```

10 close;
11
12 l = input("Enter number of bits to transmit (Choose
           between: 100000 to 1000000): ");
13 while l < 100000 | l > 1000000
14     l = input("Invalid input. Enter number of bits
           between 100000 and 1000000: ");
15 end
16
17 EbNodB = 0:2:10;           // Range of Eb/No in
           dB
18 BER = zeros(1, length(EbNodB)); // Initialize BER
           array
19
20 // Pick example Eb/N0 for printing outputs (middle
           of range)
21 example_idx = floor(length(EbNodB)/2);
22 example_EbNodB = EbNodB(example_idx);
23
24 for n = 1:length(EbNodB)
25     // Generate random BPSK symbols: -1 or 1
26     s = 2*(round(rand(1, 1))-0.5);
27
28     // AWGN noise with variance based on Eb/N0
29     noise_std = 1/sqrt(2*10^(EbNodB(n)/10));
30     w = noise_std * rand(1, 1, 'normal');
31
32     // Received signal
33     r = s + w;
34
35     // Demodulation: sign detector
36     s_est = sign(r);
37
38     // BER calculation
39     BER(n) = sum(s ~= s_est)/l;
40
41     // Save example bits for display
42     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 Ponnappalli
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): ")
```

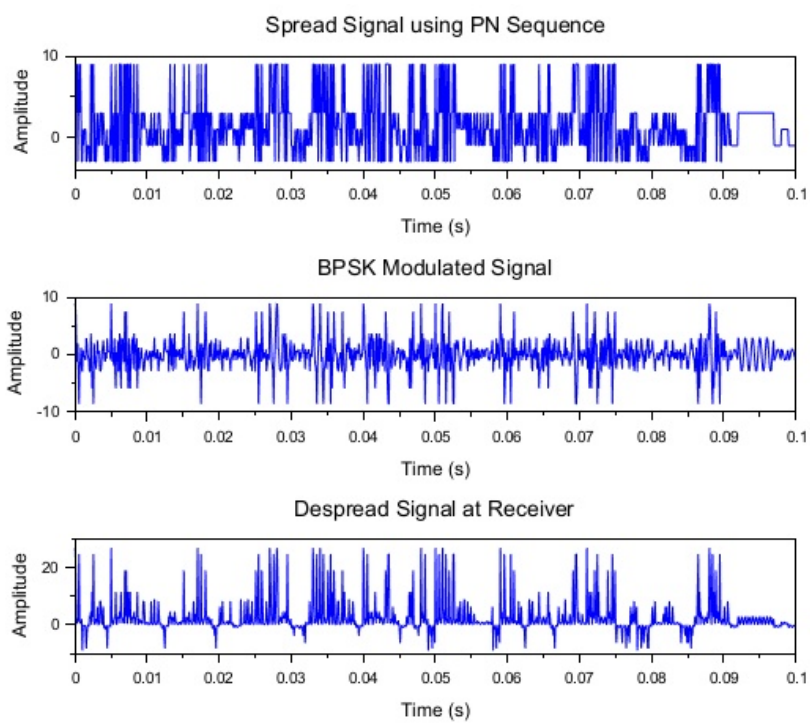


Figure 6.1: DSSS

```

    );
13 fc = input("Enter carrier frequency in Hz (e.g.,
    1000): ");
14 fs = input("Enter sampling frequency in Hz (must be
    > 10*fc): ");
15
16 // Validations
17 if fs <= 10 * fc then
18     error("Sampling frequency must be greater than
    10 times the carrier frequency.");
19 end
20
21 // Timing and signal parameters
22 Tb = 1e-3; // Bit duration (1 ms)
23 Tc = Tb / PG; // Chip duration
24 Ns = int(fs * Tb); // Samples per bit
25 Nc = int(fs * Tc); // Samples per chip
26 total_samples = N_bits * Ns; // Total number of
    samples
27 t = (0:total_samples - 1) / fs; // Time vector
28
29 // Generate random data bits (+1 or -1)
30 data_bits = 2 * grand(1, N_bits, "uin", 0, 2) - 1;
31 data_signal = matrix(ones(Ns, 1) * data_bits, 1, -1)
    ;
32
33 // Generate PN sequence long enough
34 num_chips = N_bits * PG;
35 pn_seq = 2 * grand(1, num_chips, "uin", 0, 2) - 1;
36 pn_signal_full = matrix(ones(Nc, 1) * pn_seq, 1, -1)
    ;
37
38 // Ensure PN signal has enough samples
39 if length(pn_signal_full) < total_samples then
40     // Pad if too short
41     extra_needed = total_samples - length(
        pn_signal_full);
42     pn_signal_full = [pn_signal_full, ones(1,

```

```

        extra_needed)];
43 end
44 pn_signal = pn_signal_full(1:total_samples); //
    Trim to exact length
45
46 // Spread signal
47 spread_signal = data_signal .* pn_signal;
48
49 // Carrier
50 carrier = cos(2 * %pi * fc * t);
51
52 // Modulate
53 modulated_signal = spread_signal .* carrier;
54
55 // Receiver: Demodulate
56 received = modulated_signal .* carrier;
57 despread = received .* pn_signal;
58
59 // Recover bits
60 recovered_bits = zeros(1, N_bits);
61 for i = 1:N_bits
62     idx_start = (i - 1) * Ns + 1;
63     idx_end = i * Ns;
64     recovered_bits(i) = sign(sum(despread(idx_start:
        idx_end))));
65 end
66
67 // Plot
68 clf();
69 subplot(3,1,1);
70 plot(t, spread_signal);
71 xtitle("Spread Signal using PN Sequence");
72 xlabel("Time (s)");
73 ylabel("Amplitude");
74
75 subplot(3,1,2);
76 plot(t, modulated_signal);
77 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
    Ponnappalli
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 ]: ");
```

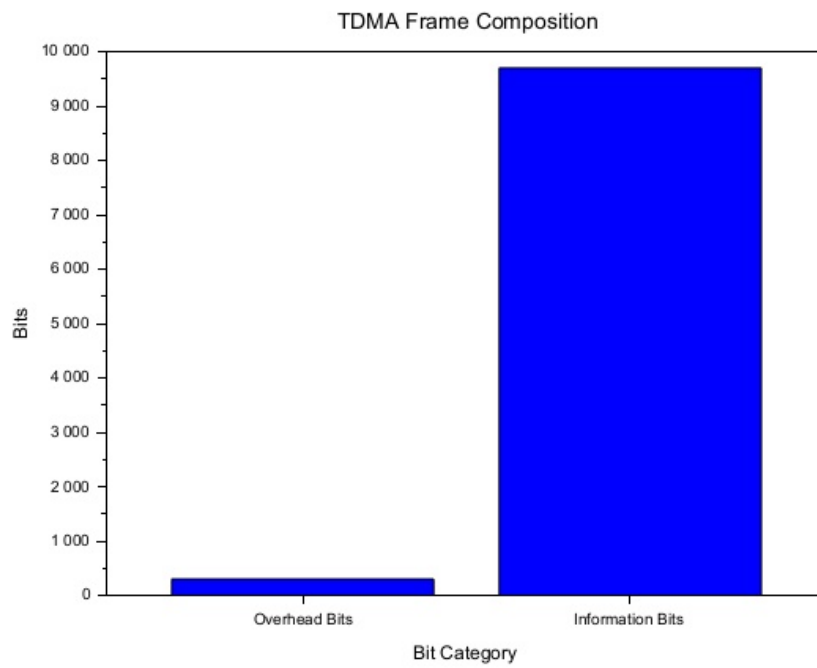


Figure 7.1: TDMA

```

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 ( eta_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
  Ponnappalli
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
```

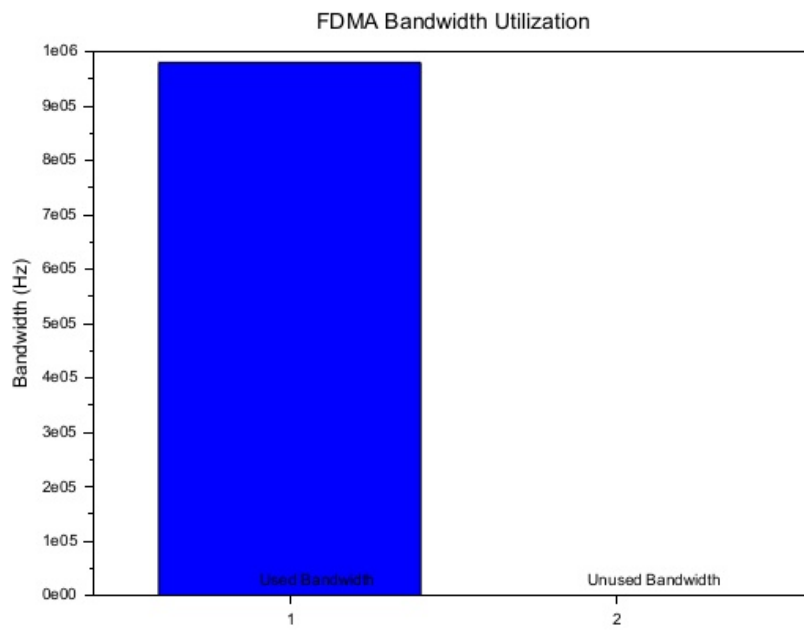


Figure 8.1: FDMA

```

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: %.2 f
      Hz\n", B_available);
48 mprintf(" Number of FDMA Channels (N): %d\n",
      N_channels);
49 mprintf(" Total Used Bandwidth: %.2 f Hz\n", B_used);
50 mprintf(" Unused Bandwidth: %.2 f Hz\n", B_unused);
51 mprintf(" Bandwidth Utilization Efficiency: %.2 f %%\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
    Ponnappalli
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.,
```

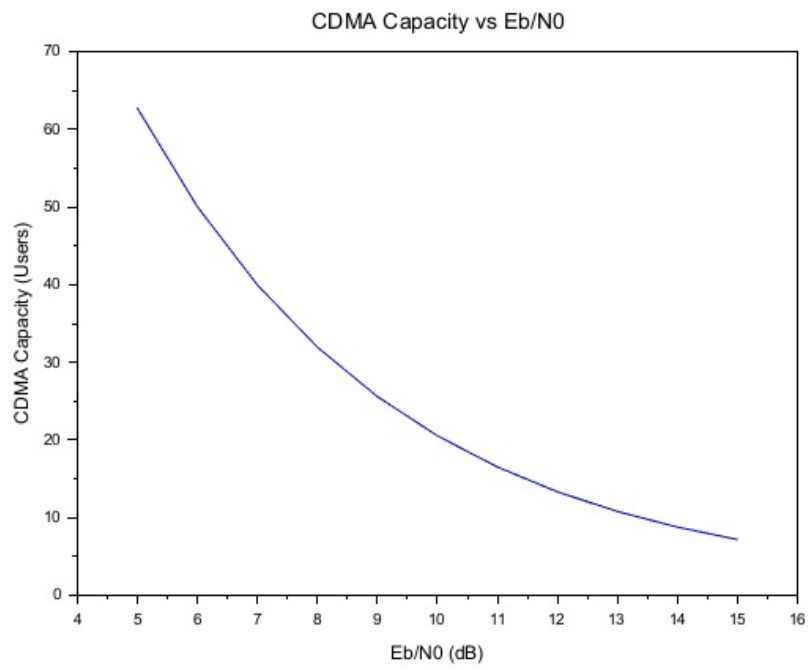


Figure 9.1: CDMA

```

    4800, 9600, 19200): ");
14 Eb_N0 = input("Enter Eb/N0 in dB (suggested range: 5
    to 15 dB): ");
15 eta = input("Enter background noise fraction    (
    suggested range: 0.5 to 1): ");
16 alpha = input("Enter voice activity factor    (
    suggested range: 0.3 to 1): ");
17 sectorization_factor = input("Enter antenna
    sectorization factor (1 for omni, 3 for 120
    beamwidth): ");
18
19 // Convert Eb/N0 from dB to linear
20 Eb_N0_linear = 10^(Eb_N0/10);
21
22 S = 1; // Assume desired signal power S = 1 unit
23 N_basic = 1 + (W/R) / (Eb_N0_linear * (eta/S));
24
25 // Apply sectorization and voice activity factor
26 N_sector = (N_basic - 1) * alpha + (eta/S);
27 Eb_N0_sector = (W/R) / N_sector;
28
29 // Final capacity with sectoring and voice activity
30 N_final = 1 + (W/R) / Eb_N0_sector;
31
32 disp("===== CDMA Capacity Results =====");
33 disp("Processing Gain (W/R): " + string(W/R));
34 disp("Eb/N0 (linear): " + string(Eb_N0_linear));
35 disp("Estimated basic user capacity (no interference
    control): " + string(N_basic));
36 disp("Eb/N0 within sector with interference control:
    " + string(Eb_N0_sector));
37 disp("Estimated final user capacity (with
    sectorization and voice activity): " + string(
    N_final));
38
39 eb_range = 5:1:15;
40 N_plot = [];
41 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.

```
