Scilab Textbook Companion for Satellite Communications by D. C. Agarwal[1]

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August 10, 2013

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

Book Description

Title: Satellite Communications

Author: D. C. Agarwal

Publisher: Khanna Publishers, New Delhi

Edition: 6

Year: 2006

ISBN: 81-7409-213-7

Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 29

Solved Problems

Scilab code Exa 29.1 Calculate the radius of geostationary satellite

```
//Ex:1
clc;
clear;
close;
u=3.986*10^5;//kepler's const in km^3sec^(-2)
T_P=86164.09;// time period of earth in sec
a=(T_P^2*(u/(4*%pi*%pi)))^(1/3);
printf("Radius of geostationary satellite = %d
    kilometer",a);
```

Scilab code Exa 29.2 The space shuttle a LEO satellite often orbits at an altitude of 250km What happens if the altitude of the shuttle becomes less than 250km

```
//Ex:2
clc;
clear;
close;
```

```
r_e=6378.14;//in km
h=250;//in km
a=r_e+h;//Radius of space shuttle orbit at 250km
   altitude in km
u=3.986*10^5;//kepler's const inkm^3/sec^2
t_p=(4*%pi^2*a^3/u)^(1/2);//in sec
printf("Time period ofthe orbit=%f sec",t_p);
printf("\nThe shuttle will slow down due to friction
    with earth atmosphere. Thus , the spacecraft
   will be in stable if its orbit period is more
   than 5370.30 sec");
```

Scilab code Exa 29.3 Determine the linear velocity of the shuttle along its orbit

```
//Ex:3
clc;
clear;
close;
a=6628.14;//Radius of space shuttle in km
T=5370.30//Time period in sec
v_s=2*%pi*a/T;//Velocity in km per sec
printf("Velocity of the shuttle =%f km per sec", v_s
   );
```

Scilab code Exa 29.4 A satellite is rotating in an elliptical orbit Calculate its orbital period

```
//Ex:4
clc;
clear;
close;
h_p=1000;//perigee height in km
```

```
h_a=4000;//apogee height in km
R_E=6378.14;// radius of earth in km
a=(2*R_E+h_p+h_a)/2;//Semi major axis in km
u=3.986*10^5//km^3 per sec^2
T_P=(4*%pi^2*a^3/u)^(1/2);//Orbit period in sec
printf("Orbital period =%f sec",T_P);
```

Scilab code Exa 29.5 Calculate the radius of the orbit

```
//Ex:5
clc;
clear;
close;
T=86400;//Orbital period in sec
u=3.986*10^5;//Kepler's const in km^3 per sec^2
a=(T^2*u/(4*%pi^2))^(1/3);//Radius of orbital in km
printf("Radius of orbital =%d km",a);
```

Scilab code Exa 29.6 Estimate the rate of drift around the equator of the sub satellite in degree per day Is the satellite moving towards east or west

```
//Ex:6
clc;
clear;
close;
t_p=235.9;//Orbital period which is longer than a
    sidereal day in sec
d_r=360*t_p/86400;//Drift rate per day
printf("Drift rate =%f degree per day",d_r);
printf("\n Since the earth moves towards east ");
```

Scilab code Exa 29.7 Calculate the velocity of the satellite in orbit

```
//Ex:7
clc;
clear;
close;
h=1000;//Altitude in km
R_e=6378;//Radius of the earth in km
a=R_e+h;//Height of satellite from centre of the earth in km
u=3.986*10^5;//Kepler's const in km^3 per sec^2
T=(4*%pi*%pi*a^3/u)^(1/2);//Time period in km
v_s=((2*%pi*a)/T);
printf("Velovity of satellite = %f km/s",v_s);
```

Scilab code Exa 29.8 calculate the component of velocity towards an observer at an earth station

```
//Ex:8
clc;
clear;
close;
r_e=6378;//radius of earth in km
h=1000;//altitude in km
cosx=r_e/(r_e+h);
v_s=7.35;//Velocity of satellite in km
v_tr=v_s*cosx;//component of satellite velocity towardsthe observer
printf("Component of the satellite velocity=%f km/sec",v_tr);
```

Scilab code Exa 29.9 Determine the doppler shift of the received signal at the earth station Discuss the impact of this shift on signal bandwidth

```
//Ex:9
clc;
clear;
close;
v_tr=6.354;//Velocity component of satellite
y=0.015// wavelength for Ka band tx with frequency 20 gega hertz in meter
d_s=v_tr/y;//Doppler shift in khz
printf("Doppler shift =%f kHz",d_s);
```

Scilab code Exa 29.10 calculate the dimension of a reflector antenna

```
//Ex:10
clc;
clear;
close;
y=0.0272;//Wavelength in meter
db_x=6-2;//Bandwidth of an aperture antenna in degree
d=75*y/db_x;//dimension in m
printf("Dimension of an antenna=%f meter",d);
```

Scilab code Exa 29.11 Determine the receive power

```
//Ex:11
clc;
clear;
close;
eirp=21;//Eirp in db
g_r=50.5;//Receiving antenna gain in db
y=2.727*10^(-2);//Wavelength in m
h=4*10^7;//Height in m
p_l=20*log(4*%pi*h/y)/log(10);//Path loss in db
```

```
p_r=eirp+g_r-p_l;//received power in db
printf("Received power =%f db",p_r);
```

Scilab code Exa 29.12 Calculate the received power at earth station

```
//Ex:12
clc;
clear;
close;
p_t=13;//Tranponder output power in db w
b_t=1;//Transponder output backoff in db
g_t=30;//satellite antenna gain in db
g_r=59.2;//Earth station antenna gain in db
l_fs=195;//Free space loss in db
l_a=-2;//Edge of beam loss in db
l_air=0.2;//Air atmospheric loss in db
l_o=0.4;//Other losses in db
p_r=p_t+g_t+g_r-b_t-l_fs-l_a-l_air-l_o;//Received
    power in db w
printf("received power=%f db watt",p_r);
```

Scilab code Exa 29.13 Find the downlink noise power budget

```
//Ex:13
clc;
clear;
close;
k=-228.6;//Boltzman;s const in dbW/k/Hz
t_s=18.8;//System temp noise in db
b_n=74.3;//Noise bandwidth in db
n_r=k+b_n+t_s;//Receiver noise power in db watt
printf("Receiver noise power=%f db watt",n_r);
```

Scilab code Exa 29.14 Find CN ratio in the receiver in clear air

```
//Ex:14
clc;
clear;
close;
p_r=-96.4;//Received power in db watt
n_r=-135.5;//Receiver noise power in db watt
cn_r=p_r-n_r;//C/N ratio in db watt
printf("C/N ratio=%f db watt",cn_r);
```

Scilab code Exa 29.15 Find the earth station GT ratio

```
//Ex:15
clc;
clear;
close;
n_a=0.68;//Overall eficiency
d=30;//Diameter in m
f=4150*10^6;//Frequency in Hz
c=3*10^8;//Speed of light in m
y=c/f;//Wavelength in m
G_a=n_a*%pi^2*d^2/y^2;
G=10*log(G_a)/log(10);
t=19;// in db
printf("G/T ratio =%f db/k",G-t);
```

Scilab code Exa 29.16 Calculate the new GT ratio

```
//Ex:16
clc;
clear;
close;
t_s=10*log(88)/log(10);// in dbk
G=60.6;// in db
printf("G/T ratio =%f dbk",G-t_s);
```

Scilab code Exa 29.17 Bandwidth of satellite transponder is 36MHz Earth station use RRC filter Calculate the max bit rate

```
//Ex:17
clc;
clear;
close;
a=0.4;// roll_off factor
m=1;// for BPSK
B=36*m;
r_s=B/(1+a);// max bit rate in Mbps
printf("The max bit rate=%f Mbit/sec",r_s);
```

Scilab code Exa 29.18 calculate the max bit rate that can be sent through this transponder with QPSK

```
//Ex:18
clc;
clear;
close;
a=0.4;// roll_off factor
m=2;// for QPSK
B=36*m;
r_s=B/(1+a);// max bit rate in Mbps
printf("The max bit rate=%f Mbit/sec",r_s);
```

Scilab code Exa 29.19 Find the value of overall CN at the earth station

```
//Ex:19
clc;
clear;
close;
c_nu=316.22;//25;//c/n ratio for earth station
c_nd=100;//20;//c/n ratio from a transponder
c_n=1/((c_nu)^(-1)+(c_nd^(-1)));//overall c/n ratio
printf("The overall c/n ratio=%f db ",c_n);
c_ndb=10*log(c_n)/log(10);//overall c/n ratio in db
printf("\n The overall c/n ratio=%f db", c_ndb);
```

Scilab code Exa 29.20 Calculate the power output of an uplink transmitter

```
//Ex:20
clc;
clear;
close;
g_t=26;//gain of satellite in db
l_s=207;//Path losses in db
l_ss=l_s+1.5+0.5+1.2;// all losses
g_r=50;// in db
p_o=10*log(1)/log(10);// output of the transponder
    in dbW
g_n=127;// linear gain in dbW
p_r=p_o-g_n;//received power in dbW
p_t=p_r-g_r-g_t+l_ss;//in dbW
printf(" Power output of an uplink tarnsmitter=%f
    dbW ", p_t);
```

```
p_tW=10^(p_t/10);
printf("\n Power output of an uplink tarnsmitter=%f
   W",p_tW);
```

Scilab code Exa 29.21 find output power rating required for the transmitter

```
//Ex:21
clc;
clear;
close;
p_tr=7.2+7;//transmitted power when rain attenuation
    of 7db
printf("Transmitted power=%f dbW", p_tr);
```

Scilab code Exa 29.22 Calculate the uplink transmitter power required

```
//Ex:22
clc;
clear;
close;
k=-228.6;//Boltzmann's const in dbW/K/Hz
t_s=10*log(500)/log(10);//in db
B=10*log(43.2*10^6)/log(10);//in dbHz
n_tr=k+t_s+B;//Transponder noise power in dbW
p_r=n_tr+30;//received power at the transponder
   input must be 30 db greater than noise power in
   db
g_st=16.2;//Satellite antenna gain in db
g_est=25;//Earth statiion antenna gain in db
p_rs=95.2;// in db
l_ss=207+3;//Losses in db
p_t=p_rs+g_st+g_est-l_ss;
```

```
printf("Required transmitted power=%f dbW", p_t);
```

Scilab code Exa 29.23 Calculate the symbol rate

```
//Ex:23
clc;
clear;
close;
B_s=10^6;//B.W. in Hz
a=0.5;// Roll_off of a filter
r_sym=B_s/(1+a);//Symbol rate in bps
printf("Symbol rate =%f bit/sec", r_sym);
printf("\n Symbol rate =%f Kbit/sec", r_sym/1000);
```

Scilab code Exa 29.24 Estimate the BW occupied by the RF signal and the frequency range of transmitted signal

```
//Ex:24
clc;
clear;
close;
a=0.25;// Roll_off
r_s=16*10^3;//Symbol rate in Hz
B_s=r_s*(1+a);//signal BW in Hz
f_c=14.125*10^6;// in Hz
f_min=f_c-(B_s)/2;//min frequency in Hz
f_max=f_c+(B_s)/2;//max frequency in Hz
//printf("min frequency=%f MHz",B_s);
printf("min frequency=%f MHz", f_min/10^6);
printf("\n max frequency=%f MHz",f_max/10^6);
//Hence frequency range of transmitted signal is
   from 14.115 MHz to 14.135 MHz
```

Scilab code Exa 29.25 Calculate the required carrier to noise ratio

```
//Ex:25
clc;
clear;
close;
r_b=10*log(60*10^6)/log(10);//in db Hz
Eb_n=8;//Energy per bit to noise power density in db
c_n=Eb_n+r_b;//in db
printf("The C/N ratio=%f db",c_n);
```

Scilab code Exa 29.26 Calculate the earth station transmitter power needed for transmission of a baseband signal

```
//Ex:26
clc;
clear;
close;
r_b=10*log(1.544*10^6)/log(10);//bit rate in db bit/
    s
Eb_n=9;//Eb/No in db
c_n=Eb_n+r_b;//C/N ratio in db
c_ns=71;//in db
g_t=-8;//G/T ratio in db
l_s=210;//Losses in db
k=228.6;//in db
e_rp=c_ns+g_t+l_s-k
G_upa=42;//uplink antenna gain in db
p_t=e_rp-G_upa;// in dbW
p_t1=10^(p_t);// in Watt
printf("required power =%f dbW",p_t);
printf("\n required power =%f Watt",p_t1);
```

Scilab code Exa 29.27 Calculate the uplink power increase required for TDMA operation

```
//Ex:27
clc;
clear;
close;
r_b=62;//bit rate in db bits/s
r_bu=71-62;//uplink bit rate increase
p_up=2.4+r_bu;//Earth station transmitted power in
   dbW
printf("The earth station transmitted power =%f dbw"
   ,p_up);
```

Scilab code Exa 29.28 Calculate the EIRP of a satellite downlink

```
//Ex:28
clc;
clear;
close;
p_s=10*log(6)/log(10);//transmit power in db
g_a=50.2;// Antenna gain in db
e_rp=p_s+g_a;//EIRP in dbW
printf("The EIRP=%f dbW", e_rp);
```

Scilab code Exa 29.29 Calculate the gain of 3 m paraboidal antenna

```
//Ex:29
clc;
```

```
clear;
close;
u=0.55;//aperture efficiency
f=12;// in GHz
d=3;// diameter in m
G_i=u*(10.472*f*d)^2;
g=ceil(G_i);
g_i=10*log(g)/log(10);//in db
printf("Gain=%f ",g_i);
```

Scilab code Exa 29.30 Calculate the overall noise temperature of the system

```
//Ex:30
clc;
clear;
close;
t_a=35;//antenna noise temp in K
f=12;//receiver noise figure in db
F=10^(12/10);//receiver noise figure
l_c=10^(5/10);//cable loss
g_lna=10^5;//LNA gain
t_lna=150;//noise temp in K
t_o=290;// in K
t_s=t_a+t_lna+(l_c-1)*t_o/g_lna+l_c*(F-1)*t_o/g_lna;
printf("Gain=%d K",t_s);
```

Scilab code Exa 29.31 Calculate the carrier to noise spectral density ratio

```
//Ex:31
clc;
clear;
close;
```

```
k=-228.6;// in db
e_irp=50;// EIRP in dbW
g_t=19.5;//G/T ratio in db/k
l_fs=210;//free space loss in db
l_ab=2;//atmospheric absorption loss in db
l_ap=2;//antenna pointing loss in db
l_rf=1;//receiver feedback loss in db
l_s=l_fs+l_ab+l_ap+l_rf;//losses in db
c_n=e_irp+g_t-l_s-k;// C/N spectral density ratio in
    db
printf("carrier to noise spectral density ratio=%d
    dbW",c_n);
```

Scilab code Exa 29.32 Calculate the earth station EIRP required for saturation assuming clear sky conditions

```
//Ex:32
clc;
clear;
close;
f=14;//frequency
A_o=-(21.45+20*log(f)/log(10));//effective area in
    db
y_str=-100;//flux density required to saturate the
    transponder in db
l_s=200;//free space losses in db
e_irp=y_str+A_o+l_s;//the earth station EIRP
    required for saturation in dbw
printf("the earth station EIRP required for
    saturation=%f dbW",e_irp);
```

Scilab code Exa 29.33 Calculate the effective isotropic radiated power in watts as seen by the antenna

```
//Ex:33
clc;
clear;
close;
e_irp=52;//EIRP  in dbW
p_s=10^(e_irp/10);//effective isotropic radiated
   power in W
printf("effective isotropic radiated power=%f KW",
   p_s/1000);
```

Scilab code Exa 29.34 Calculate the noise power for a BW of 36 MHz

```
//Ex:34
clc;
clear;
close;
t_a=40;// noise temp in K
t_r=100;//receiver noise temp in K
t_n=t_a+t_r;//total noise temp in K
B_n=36*10^6;//BW in Hz
k=1.38*10^(-23);// Boltzmann's const in J/K
p_n=k*t_n*B_n;//noise power in W
printf("noise power=%f pW",p_n/(10^(-12)));
```

Scilab code Exa 29.35 Calculate the total link loss

```
//Ex:35
clc;
clear;
close;
l_fs=202;//free space loss in db
l_ab=0.5;//atmospheric absorption loss in db
l_ap=1;//antenna pointing loss in db
```

```
l_rf=2;//receiver feedback loss in db
l_s=l_fs+l_ab+l_ap+l_rf;//losses in db
printf("the total link loss=%f db",l_s);
```

Scilab code Exa 29.36 Calculate the clear sky carrier to noise ratio for a satellite TV system having worst case EIRP of 51 dbw

```
//Ex:36
clc;
clear;
close;
e_irp=51;// EIRP in dbW
g_t=13.12;//G/T ratio in db/k
l_fs=205.34;//free space loss in db
l_ab=0.17;//atmospheric absorption loss in db
df=16;// in MHz
f_v=5;// in MHz
B=df+2*f_v;// in MHz
k=1.38*10^(-23);// Boltzmann's const in J/K
k_b=k*B*10^6;
kB=10*log(k_b)/log(10);
c_n=e_irp-l_fs+g_t-l_ab-kB;
printf("carrier to noise ratio=%f dbw",c_n);
```

Scilab code Exa 29.37 Calculate the transmission bit rate for stop and wait system

```
//Ex:37
clc;
clear;
close;
d_r=24;//Data rate in Kbits/s
t_b=1/(d_r*10^3);//bit time in sec
```

```
t_bi=.0005;// in sec
p_d=2*0.240;//path delay in sec
printf("Waiting of ack takes place %f sec", t_bi+p_d
   );
t_ack=p_d+t_bi;//Acknowledgement time in sec
n_b=79;// number of blocks
t_tr=n_b/2;//Time taken for transmission in sec
r_b=(n_b*127)/t_tr;//bit transmission rate in bits/s
printf("\n bit transmission rate =%f bits/s",r_b);
```

Scilab code Exa 29.38 what should be the capacity of the transmit buffer

```
//Ex:38
clc;
clear;
close;
t_r=(79*127)/(24*10^3);//Time required to transmit
   79 blocks in sec
t_pb=t_r/79;//Transmission time per block
n_b=0.48/t_pb;//no. of blocks which arrive at the
   receiver
n_B=ceil(n_b);
c_r=n_B*127;//the required capacity in bits
printf("The required capacity=%d bits",c_r);
```

Scilab code Exa 29.39 Calculate the transmission bit rate for Selective Repeat ARQ system

```
//Ex:39
clc;
clear;
close;
n_b=79-1;//no. of blocks in this system
```

```
r_eff=n_b/79;//rate efficiency
r_b=24*r_eff;//bit tkbits/sransmission rate in
printf("Bit transmission rate =%f Kbits/s",r_b);
```

Scilab code Exa 29.40 Calculate the noise power in transponder1 or in the inbound SCPC FDMA channels

```
//Ex:40
clc;
clear;
close;
k=-228.6;//dbW/K/Hz
b_n=10*log(128*(10^3))/log(10);// in dbHz
t_s=10*log(500)/log(10);//in dbk
t_S=ceil(t_s);
n_tr=k+t_S+b_n;// in dbW
printf("noise power=%f dbW",n_tr);
```

Scilab code Exa 29.41 Calculate the noise power in the hub station receiver or in inbound SCPC FDMA channel

```
//Ex:41
clc;
clear;
close;
k=-228.6;// in db
t_s=10*log(150)/log(10);// in dbK
b_n=51.1;// in dbHz
n_h=k+t_s+b_n;//the noise power in the hub station
   receiver in dbw
printf("noise power=%f dbW",n_h);
```

Scilab code Exa 29.42 Calculate the noise power in transponder2

```
//Ex:42
clc;
clear;
close;
b_n=10*log(10^6)/log(10);// in dbHz
t_s=10*log(500)/log(10);//temp in dbK
T_s=ceil(t_s);
k=-228.6;// in db
n_rt=k+b_n+T_s;//the noise power in transponder-2 in
    dbW
printf("the noise power in transponder-2=%f dbW",
    n_rt);
```

Scilab code Exa 29.43 Calculate the noise power in the VSAT receivers

```
//Ex:43
clc;
clear;
close;
k=-228.6;// in db
t_s=10*log(150)/log(10);// temp in dbK
b_n=10*log(10^6)/log(10);// in dbHz
n_h=k+t_s+b_n;//the noise power in the VSAT in dbW
printf("the noise power in the VSAT=%f dbW",n_h);
```

Scilab code Exa 29.44 Calculate the power received at the satellite transmitted from the VSAT uplink

```
//Ex:44
clc;
clear;
close;
p_t=10*log(2)/log(10);// transmit power in dbW
g_t=42;// Gain of the VSAT transmit antenna in db
g_r=30;//Gain of the satellite receive antenna in db
l_p=207;//Free space path loss at 14HGz
l_b=2;//Beam loss in db
l_a=0.5;//atmospheric loss in db
l_l=0.5;//miscellaneous loss in db
l_o=l_b+l_a+l_l;// other losses in db
p_r=p_t+g_t+g_r-l_p-l_o;//the power received in dbW
P_r=floor(p_r);
printf("The power received=%f dbW",P_r);
```

Scilab code Exa 29.45 Calculate the uplink inbound CN ratio in transponder1

```
//Ex:45
clc;
clear;
close;
p_tr1=-135;//power received in transponder-1 in dbW
n_tr1=-150.5;//noise power in transponder-1 in dbw
c_n=p_tr1-n_tr1;//C/N ratio in db
printf("The C/N ratio=%f db",c_n);
```

Scilab code Exa 29.46 Calculate the max number of VSAT channels that can be handled by the system

```
//Ex:46
clc;
```

```
clear;
close;
p_ts=10*log(20)/log(10);//saturated transponder
   power in dbw
b=2;//back_off in db
p_b=p_ts-b;//power becomes with back_off in db
p_B=floor(p_b);
P_b=10^(p_B/10);//Power becomes with back_off
n_c=P_b/1;//no. of channels
n_cs=floor(n_c);
printf("The max no. of VSAT channels=%f",n_cs);
```

Scilab code Exa 29.47 Calculate the centrifugal force for a satellite of mass 100 kg orbitting with a velocity of 8 km per s at a height of 200 km

```
//Ex:47
clc;
clear;
close;
m=100;//mass in kg
v=8000;//velocity in m/s
r=6370*10^3;//radius of earth in m
h=200*10^3;//height above the earth surface in m
c_f=(m*v^2)/(r+h);//centrifugal force in newtons
printf("The centrifugal force=%d newtons",c_f);
```

Scilab code Exa 29.48 Determine the orbital velocity of a satellite moving in a circular orbit at a height of 150 km

```
//Ex:48
clc;
clear;
close;
```

```
G=6.67*10^(-11);//Gravitation const in N—m^2/kg^2
r_e=6370*10^3;//radius of earth in m
h=150*10^3;// height in m
m=5.98*10^24;//mass of earth in kg
u=G*m;
v=sqrt(u/(r_e+h))/1000;// velocity in km/s
printf("The orbital velocity of a satellite=%f km/s"
    ,v);
```

Scilab code Exa 29.49 Determine the semi major axis of elliptical orbit

```
//Ex:49
clc;
clear;
close;
r_a=30000;//apogee in km
r_p=1000;//perigee in km
a=(r_a+r_p)/2;//Semi_major axis in km
printf("The semi_major axis=%f km",a);
```

Scilab code Exa 29.50 Determine the orbital eccentricity

```
//Ex:50
clc;
clear;
close;
a_p=30000;// the difference b/w apogee and perigee
    in km
a=16000;//Semi_major axis in km
e=a_p/(2*a);//orbital eccentricity
printf("The orbital eccentricity=%f",e);
```

Scilab code Exa 29.51 Determine the apogee the perigee and eccentricity

```
//Ex:51
clc;
clear;
close;
r_a=30000+6370;//apogee in km
r_p=200+6370;//perigee in km
e=(r_a-r_p)/(r_a+r_p);// eccentricity
printf("The apogee=%f km",r_a);
printf("\n The perigee=%f km",r_p);
printf("\n The orbital eccentricity=%f",e);
```

Scilab code Exa 29.52 Determine the apogee and perigee distance

```
//Ex:52
clc;
clear;
close;
e=0.5;//orbital eccentricity
a_e=14000;//dis b/w center of ellipse to the center of earth in km
a=a_e/e;//semi major axis in km
r_a=a*(1+e);//apogee in km
r_p=a*(1-e);//perigee in km
printf("The apogee=%d km",r_a);
printf("\n The perigee=%d km",r_p);
```

Scilab code Exa 29.53 Determine the relationship between their orbital periods

```
//Ex:53
clc;
clear;
close;
G=6.67*10^(-11);//Gravitation const in N-m^2/kg^2
a_1=18000;//semi major axis for satellite-1
a_2=24000;//semi major axis for satellite-2
t2_t1=(a_2/a_1)^(3/2);//The ratio of orbital periods
    of given two satellite
printf("Orbital periods ratio of two satellite =%f",
    t2_t1);
printf("\n thus orbital period of satellite_2 is
    1.54 times that of satellite_1");
```

Scilab code Exa 29.54 Determine the escape velocity for an object to be launched from surface of earth

```
//Ex:54
clc;
clear;
close;
G=6.67*10^(-11);//Gravitation const in N-m^2/kg^2
r_e=6370*10^3;//radius of earth in m
m=5.98*10^24;//mass of earth in kg
u=G*m;
v_e=sqrt((2*u)/r_e);//escape velocity in km/s
printf("The escape velocity=%f km/s",v_e/1000);
```

Scilab code Exa 29.55 Calculate the period of a satellite in an eccentric elliptical orbit

```
//Ex:55
clc;
```

```
clear;
close;
a=50000*1000/2;//semi major axis in km
G=6.67*10^(-11);//Gravitation const in N-m^2/kg^2
m=5.98*10^24;//mass of earth in kg
u=G*m;
st=sqrt((a^3)/u);
s_t=6.25*10^3;
t=2*(3.14)*s_t;
printf("The period of a satellite=%f s",t);
printf("\n The period of a satellite is 10 hours 54
    minutes");
```

Scilab code Exa 29.56 Determine the orbital time period and the velocity at the apogee and perigee point

```
//Ex:56
clc;
clear;
close;
r_a=35000+6360;//apogee in km
r_p=500+6360;//perigee in km
A=(r_a+r_p)/2;//Semi_major axis in km
a=A*1000;//Semi_major axis in m
G=6.67*10^(-11);//Gravitation const in N-m^2/kg^2
m=5.98*10^24;//mass of earth in kg
u=G*m;
t=2*(3.14)*sqrt((a^3)/u);
printf("The orbital time period=%d s",t);
printf("\n The orbital time period is 10 hours 20
    minutes");
x=2/(r_a*1000);
y=1/a;
v_a=sqrt(u*(x-y));// velocity at apogee in m/s
c=2/(r_p*1000);
```

```
v_p=sqrt(u*(c-y));// velocity at perigee in m/s
printf("\n The velocity at apogee=%d m/s",v_a);
printf("\n The velocity at perigee=%f km/s",v_p
    /1000);
```

Scilab code Exa 29.57 Determine the target eccentricity

```
//Ex:57
clc;
clear;
close;
d_ap=30000;//Difference of apogee and perigee dis in
    km
s_ap=50000;//sum of apogee and perigee dis in km
e=d_ap/s_ap;
printf("The orbital eccentricity=%f",e);
```

Scilab code Exa 29.58 Determine the apogee the perigee and eccentricity

```
//Ex:58
clc;
clear;
close;
a=20000;//apogee in km
b=16000;//perigee in km
x=2*a;//sum of apogee and perigee
B=-40000;
A=1
C=256000000;
r_a1=(-B+sqrt(B^2-(4*A*C)))/2;
printf("The apogee distance=%d km",r_a1);
r_p1=x-r_a1;
printf("\n The perigee distance=%d km",r_p1);
```

Scilab code Exa 29.59 Determine the orbital period

```
//Ex:59
clc;
clear;
close;
G=6.67*10^(-11);//Gravitation const in N-m^2/kg^2
r_e=6360*10^3;//radius of earth in m
h=640*10^3;// height in m
m=5.98*10^24;//mass of earth in kg
u=G*m;
v=sqrt(u/(r_e+h));// velocity in km/s
V=7.54;// km/s
t=(2*3.14*(r_e+h)/1000)/V;
printf("The orbital period=%d s",t);
printf("\n The orbital period is 1 hour 37 minutes")
    ;
```

Scilab code Exa 29.60 What will be the time taken by the satellite to move from A to B in the direction shown in figure

```
//Ex:60
clc;
clear;
close;
t_s=3+(10/60);// in hours
//Area B to A=Area of half of ellipse-Area of
    triangle(AOB);
// =(pi*a*b)/2-(b*OC)                from given figure
    ;
// =(pi*a*b)/2-(b*a*e);
```

```
//  =0.97*a*b;
//Area A to B=(pi*a*b)/2+0.6*a*b=2.2*a*b;
//The ratio of two areas is=2.2;
t=2.2*t_s;// time taken in hours
T=ceil(t);
printf("The time taken=%d hours", T);
```

Scilab code Exa 29.61 Determine the semi major axis and semi minor axis and the orbit eccentricity

```
//Ex:61
clc;
clear;
close;
r_a=50000;//apogee in km
r_p=8000;//perigee in km
a=(r_a+r_p)/2;//Semi_major axis in km
b=sqrt(r_a*r_p);//semi minor axis in km
e=(r_a-r_p)/(r_a+r_p);//eccentricity
printf("The semi_major axis=%f km",a);
printf("\n The semi_minor axis=%f km",b);
printf("\n The eccentricity=%f km",e);
```

Scilab code Exa 29.62 Determine the orbital period of satellite2

```
//Ex:62
clc;
clear;
close;
G=6.67*10^(-11);//Gravitation const in N-m^2/kg^2
a_1=16000;//semi major axis for satellite-1
a_2=24000;//semi major axis for satellite-2
t1=10;//the orbital period of satellite-1 in hours
```

```
t2=t1*(a_2/a_1)^(3/2);//The ratio of orbital periods
    of given two satellite
printf("Orbital periods of satellite-2=%f hours",t2)
   ;
```

Scilab code Exa 29.63 Calculate the max deviation in latitude and also determine the max displacement in kms

```
//Ex:63
clc;
clear;
close;
h=35800;//height in km
r=6364;//earth's radius in km
r_o=r+h;//orbital radius in km
i=2;//angle of inclination in degree
w_m=0.0175;
y_m=i;//max latitude deviation
d_m=r_o*i*(3.14/180);//max displacement due to
   latitude deviation in km
D_m=d_m*(w_m/y_m);//max displacement due to
   longitude deviation in km
printf("max displacement due to latitude deviation=
   %d km",d_m);
printf("\n max displacement due to longitude
   deviation=%f km",D_m);
```

Scilab code Exa 29.64 Determine the magnitude of velocity impulse needed to correct the inclination of 2 degree

```
//Ex:64
clc;
clear;
```

```
close;
u=39.8*10^13;
r=42164*10^3;
i=2*(3.14/180);//angle of inclination in degree
a=(sqrt(u/r))*tan(i);//the magnitude of velocity
    impulse in m/s
printf("The magnitude of velocity impulse=%d m/s",a)
    ;
```

Scilab code Exa 29.65 Determine the angle of inclination between the new orbital plane and the equatorial

```
//Ex:65
clc;
clear;
close;
r=42164;// in km
d_m=500;// in km
i=d_m/r;// the angle of inclination in rad
printf("The angle of inclination=%f rad",i);
printf("\n The angle of inclination=%f degree",i
    *(180/3.14));
```

Scilab code Exa 29.66 Determine the theoretical max coverage angle also determine the max slant range

```
//Ex:66
clc;
clear;
close;
r=6378;//radius of earth in km
h=35786;// in km
r_h=r+h;//height in km
```

```
E_min=0;// in degree
P=cos(E_min*3.14/180);
Q=(r/(r_h)*P);
a_mx=(asin(Q))*(180/3.14);//the theoretical max coverage angle in degree
D=(r^2)+(r_h^2)-2*r*r_h*sin(a_mx*3.14/180);
d=sqrt(D);// in km
d1=ceil(d);//max slant range in km
printf("The theoretical max coverage angle=%f degree",a_mx);
printf("\n The max slant range=%d km",d1);
```

Scilab code Exa 29.67 What would be the new max coverage angle and the slant range

```
//Ex:67
clc;
clear;
close;
R_e=6378;// in km
H=35786;// in km
E_min=5;// min elevation angle in degree
x=cos(E_min*3.14/180);
R=R_e/(R_e+H);
P=2*asin(R*x);// in radian
a_max=(P)*180/3.14;// in degree
printf("The max coverage angle=%f degree", a_max);
```

Scilab code Exa 29.68 Calculate the angle subtended by the arc of the satellite footprint at the center of the earth

```
//Ex:68
clc;
```

```
clear;
close;
R_e=6378;// in km
H=35786;// in km
E1=5;// min elevation angle in degree
E2=0;// min elevation angle in degree
x1=cos(E1*3.14/180);
x2=cos(E2*3.14/180);
R=R_e/(R_e+H);
P1=asin(R*x1);// in radian
P2=asin(R*x2);// in radian
a1=(P1)*180/3.14;// in degree
a2=(P2)*180/3.14;// in degree
y=175-(a1+a2);
printf("The angle subtended=%f degree", y);
```

Scilab code Exa 29.69 Determine the round trip delay for an earth station

```
 //Ex:69
clc;
clear;
close;
r=6378;//radius of earth in km
h=35786;// in km
r_h=r+h;//height in km
E_min=5;// in degree
P=cos(E_min*3.14/180);
Q=(r/(r_h)*P);
a_mx=(asin(Q))*(180/3.14);//the theoretical max
   coverage angle in degree
a_mx1=E_min+a_mx;
D=(r^2)+(r_h^2)-2*r*r_h*sin(a_mx1*3.14/180);
d=sqrt(D);// in km
d1=ceil(d);//max slant range in km
c=3*10^5;// in m/s
```

```
t=2*d1/c;
printf("The round trip delay=%f millisec",t*1000);
```

Scilab code Exa 29.70 Determine the max shadow angle that occurs at equinoxes for a satellite orbitting in a circular equatorial orbit at a height of 13622 km above the surface of earth also determine the max daily eclipse duration

```
//Ex:70
clc;
clear;
close;
r=6378;//radius of earth in km
r_o=r+13622;// radius of orbit in km
s_mx=180-2*(acos(r/r_o))*(180/%pi);//the max shadow
    angle in degree
t_e=(s_mx/360)*24;// max daily eclipse duration in
    hours
printf("The max shadow angle=%f degree",s_mx);
printf("\n The max daily eclipse duration=%f hours",
    t_e);
```

Scilab code Exa 29.71 Determine the total time from the first day of eclipse to the last day also determine the same for geostationary orbit at a height of 35786 km

```
//Ex:71
clc;
clear;
close;
r=6378;//radius of earth in km
h=35786;// height in km
r_o=2000;// in km
```

```
x=37.4;// in degree
i_e=x/2;// in degree
y=asin(i_e/23.4);
y1=y*180/%pi;// in degree
y2=floor(y1);
t=(365*y2*%pi)/(2*%pi*180);// in days
A=acos(r/(r+h));
B=A*180/%pi;// in degree
y_mx=180-2*B;
C=(asin((y_mx/2)/23.4))*(180/%pi);// in degree
t2=(365*C*%pi)/(2*%pi*180);// in days
printf("The total time of eclipse=%f days",t);
printf("\n The total time for geostationary orbit=%f
    hours",t2);
```

Scilab code Exa 29.72 Calculate the incremental velocity to be given to the satellite at the apogee point by the apogee kick motor to circularize the orbit

```
//Ex:72
clc;
clear;
close;
R=6378;//radius of earth in km
h=35786;// height in km
r=R+h;//in km
a=(2*R+35786+300)/2;//semi major axis in km
u=39.8*10^13;//N-sq.m/kg
v_a=sqrt(u*((2/r*1000)-(1/a*1000)));//m/s
V_a=v_a/1000000;//km/s
v_c=sqrt(u/r*1000);
dv=v_c/1000000-V_a;//icremental velocity
printf("The incremental velocity=%f km/s",dv);
```

Scilab code Exa 29.73 Determine the velocity change required to circularize the orbit

```
//Ex:73
clc;
clear;
close;
i=28;// in degree
v_a=1.61;// in km/s
v_c=3.07;// in km/s
x=cos(i*3.14/180);
dv=sqrt(v_a^2+v_c^2-2*v_a*v_c*x);
printf("The velocity change=%f km/s",dv);
```

Scilab code Exa 29.74 Determine the max line of sight distance between two communication satellites

```
//Ex:74
clc;
clear;
close;
printf("OA=AC.sinx=(R+H)sinx");
printf("\n x=acos(R/(R+H))");
printf("\n Therefore");
printf("\n OA=(R+H)sin(acos(R/(R+H)))");
printf("\n Max line of sight=2.OA");
printf("\n Max line of sight=2(R+H)sin(acos(R/(R+H))
   )");
```

Scilab code Exa 29.75 Determine the max line of sight distance and also for geostationary satellites

```
//Ex:75
clc;
clear;
close;
R=6370;// Radius of earth in km
x=(R/(R+R));
y=(acos(x))*(180/%pi);
d_mx=2*2*R*sin(y*%pi/180);
R_H=42164;// in km
x1=(R/(R_H));
y1=(acos(x1))*(180/%pi);
d_mx1=2*R_H*sin(y1*%pi/180);
printf("The max line of sight distance=%d km", d_mx)
    ;
printf("\n The max line of sight distance for
    geostationary satellites=%f km", d_mx1);
```

Scilab code Exa 29.76 Find the round trip propagation delay

```
//Ex:76
clc;
clear;
close;
a_d=130-70;//angular difference in degree
printf("The line of sight distance(AB) b/w the two
    satellites in given figure");
printf("\n sq(AB)=sq(AC)+sq(BC)-2AC*BC*cos(60)");
printf("\n AC=BC=R...........(orbital radius)");
printf("\n sq(AB)=sq(R)+sq(R)-2*sq(R)*(0.5)");
printf("\n AB=R");
printf("\n Round trip time=(2R/(3*10^8))");
```

Scilab code Exa 29.77 Determine the round trip propagation delay

```
//Ex:77
clc;
clear;
close;
a_d=30+15;//angular difference in degree
R=10000;//orbital radius in km
l_s=sqrt((R^2)+(R^2)-2*(R^2)*cos(45*3.14/180));
R_tp=(2*l_s)/(3*10^5);
printf("The round trip propagation delay=%f sec",
   R_tp);
printf("\n The round trip propagation delay=%f
   millisec", ceil(R_tp*1000));
```

Scilab code Exa 29.78 Determine the earth station azimuth and elevation angles

```
//Ex:78
clc;
clear;
close;
R=6378;// Radius of earth in km
R_o=42164;//orbital radius in km
A1=(atan(tan(20*%pi/180)/(sin(60*%pi/180))))*(180/
   %pi);// in degree
A=180-A1;//Azimuth angle in degree
x_sl=20*%pi/180;//Diff b/t satellite longitude &
   earth station longitude in radians
x_l=60*%pi/180;;//earth station latitude in radian
B=cos(x_sl)*cos(x_l);
s=(acos(B))*(180/%pi);
```

```
s1=R*sin(s*%pi/180);
s2=R_o-R*B;
E=(atan(s2/s1))*(180/%pi)-s;
printf("The Azimuth angle=%f degree", A);
printf("\n The elevation angle=%f degree", E);
```

Scilab code Exa 29.79 Determine the max eclipse time in a day during the full eclipse period

```
//Ex:79
clc;
clear;
close;
R=6378;// Radius of earth in km
H=10000;// in km
A=(R/(R+H));
A1=(acos(A))*(180/%pi);
y_m=180-2*A1;
y_m1=ceil(y_m);
u=39.8*10^13;// in N sq.m/kg
a=(R+H)*1000;// in m
p_o=2*%pi*sqrt((a)^3/(u));// orbital period in sec
p_o1=p_o/3600;//  orbital period in hours
t_e=(y_m1/360)*p_o1;// eclipse duration in hours
t_e1=t_e*60;// eclipse duration in min
printf("The eclipse duration=%f hours", t_e);
printf("\n The eclipse duration=%f minutes", t_e1);
```

Scilab code Exa 29.80 Determine the incremental velocity required to correct the orbit inclination

```
//Ex:80
clc;
```

```
clear;
close;
i=5.3;// in degree
v_a=1.61;// in km/s
v_c=3.07;// in km/s
x=cos(i*3.14/180);
dv=sqrt(v_a^2+v_c^2-2*v_a*v_c*x);
printf("The incremental velocity=%f km/s",dv);
```

Scilab code Exa 29.81 Determine the earth station azimuth and elevation angles

```
//Ex:81
clc;
clear;
close;
R=6378;// Radius of earth in km
R_o=42164;//orbital radius in km
x_sl=(105-60)*%pi/180;//Diff b/t satellite longitude
    & earth station longitude in radians
x_l=30*%pi/180;//earth station latitude in radian
B=cos(x_sl)*cos(x_l);
s=(acos(B))*(180/%pi);
s1=R*sin(s*%pi/180);
s2=R_o-R*B;
E_a=(atan(s2/s1))*(180/%pi)-s;
x_sl1=(105-90)*%pi/180;//Diff b/t satellite
    longitude & earth station longitude in radians
x_l1=45*%pi/180;//earth station latitude in radian
B1=cos(x_sl1)*cos(x_l1);
so=(acos(B1))*(180/%pi);
s3=R*sin(so*%pi/180);
s4=R_o-R*B1;
E_B=(atan(s4/s3))*(180/%pi)-so;
E_b=floor(E_B);
```

```
E_a1=E_a*%pi/180;// Ea in rad
E_b2=E_b*%pi/180;// Eb in rad
L1=(R/R_o)*cos(E_a1);// in rad
M1=(asin(L1))*(180/3.14);// in rad
N1=(E_a+M1)*(%pi/180);
nm1=sin(N1);
d1=(R_o^2)+(R^2)-2*R*R_o*nm1;
d_a=sqrt(d1);
L2=(R/R_o)*cos(E_b2);// in rad
M2=(asin(L2))*(180/%pi);// in rad
N2=(E_b+M2)*(3.14/180);
nm2=sin(N2);
d2=(R_o^2)+(R^2)-2*R*R_o*nm2;
d_a2=sqrt(d2);
r_c=d_a+d_a2;
p_d=r_c/(3*10^5);
p_d1=p_d*1000;
s_tr=500000/10000;// in millisec
T_pd=p_d1+s_tr;// Total propagation delay in
    millisec
printf("The Total propagation delay=%f millisec",
    T_pd);
```

Scilab code Exa 29.82 Calculate the power gain of a paraboloid reflector antenna with a mouth dia of 10 m at 6 GHz

```
//Ex:82
clc;
clear;
close;
d=10;//in m
f=6*10^9;//in Hz
u=0.8;//Aperture efficiency
A=(%pi*d^2)/4;
c=3*10^8;//velocity of light in m/s
```

```
y=c/f;//wavelength in m
G=(u*4*3.14*A)/(y^2);
printf("Gain=%f db",10*log(G)/log(10));
```

Scilab code Exa 29.83 Determine the width in degree in the elevation direction

```
//Ex:83
clc;
clear;
close;
dx=1*(%pi/180);//azimuth beamwidth in rad
G=315507;
dy=(4*%pi*180)/(G*dx*%pi);//the width in degree
printf("The width=%f degree",dy);
```

Scilab code Exa 29.84 Determine the antenna power gain in db and also the operational frequency

```
//Ex:84
clc;
clear;
close;
x=3*10^(-4);//solid angle of antenna beam in sterad
G=(4*%pi)/x;//Power gain
g=10*log(G)/log(10);// power gain in db
u=0.90;//aperture efficiency
A=20;//crasection area
y=sqrt((u*4*%pi*%pi*A*A)/(4*G));//operational
    wavelength in m
c=3*10^8;//velocity of light in m/s
f=c/y;//operational frequency in Hz
printf("The antenna power gain=%f db",g);
```

```
printf("\n The operational frequency=%f MHz",f
    /1000000);
```

Scilab code Exa 29.85 Determine the antenna power gain

```
//Ex:85
clc;
clear;
close;
d=20;//dia in m
A=(%pi*d*d)/4;// Aperture raea
c=3*10^8;//velocity of light in m/s
f1=11.95*10^9;//in Hz
f2=14.25*10^9;// in Hz
y1=c/f1;//wavelength in m for f1
y2=c/f2;//wavelength in m for f2
u1=0.98*0.99*0.97*0.85*0.90*0.92;//aperture eff for
    11.95 GHz
u2=0.96*0.99*0.97*0.85*0.90*0.92;//aperture eff for
    14.25 GHz
G1=(u1*4*%pi*A)/(y1*y1);
G2=(u2*4*%pi*A)/(y2*y2);
g2=10*log(G2)/log(10);// in db
g1=10*log(G1)/log(10);// in db
printf("The antenna power gain=%f db",g1);
printf("\n The antenna power gain=%f db",g2);
```

Scilab code Exa 29.86 Determine the earth station EIRP

```
//Ex:86
clc;
clear;
close;
```

```
p_o=10*log(10000)/log(10);// power at output in dbW
g_a=60;//antenna gain in dbW
l_s=2;// losses in dbw
e_irp=p_o+g_a-l_s;// EIRP in dbw
printf("The earth station EIRP=%d dbW",e_irp);
```

Scilab code Exa 29.87 Determine the equivalent noise temp of the cascaded arrangement

```
//Ex:87
clc;
clear;
close;
t_e1=100;// in K
t_e2=60;// in K
t_e3=20;// in K
G1=10^6;
G2=10^4;
t_e=t_e1+(t_e2/G1)+(t_e3/G1*G2);
printf("The equivalent noise temperature=%d K",t_e);
```

Scilab code Exa 29.88 Determine the noise figure of the cascaded arrangement

```
//Ex:88
clc;
clear;
close;
F1=2;
F2=10;
F3=15;
F4=20;
G1=100;
```

```
G2=10;
G3=10;
F=F1+(F2-1)/G1+(F3-1)/(G1*G2)+(F4-1)/(G1*G2*G3);
f=10*log(F)/log(10);//noise figure in db
printf("The noise figure=%f db",f);
```

Scilab code Exa 29.89 Determine the earth station system noise temp and GT ratio referred to the input of the low noise amplifier

```
//Ex:89
clc;
clear;
close;
t_a=60;// antenna noise temp in k
l1=1.075;//loss in waveguide in K
t_o=290;// in K
t_e2=160;// in K;
t_e3=10000;// in k
G2=10^6;// low noise ampr gain
t_s=(t_a/l1)+(l1-1)*(t_o)/l1;// noise temp in k
t_e=t_e2+(t_e3/G2);// Equivalent noise temp in K
t=t_s+t_e;// system noise temp in k
T=10*log(t)/log(10);//system noise temp in db
G=66-0.3;// in db
g_t=G-T;//G/T ratio in db/K
printf("The system noise temperature=%f K", t);
printf("\n The G/T ratio=%f db/K", g_t);
```

Scilab code Exa 29.90 Determine the earth station system noise temp and GT ratio referred to the input of waveguide and input of down converter

```
//Ex:90
```

```
clc;
clear;
close;
t_a=60;// antenna noise temp in k
l1=1.075;//loss in waveguide in K
t_o=290;// in K
t_e2=160;// in K;
t_e3=10000;// in k
G2=10^6;// low noise ampr gain
t_eq=(l1-1)*t_o+(t_e2*l1)+(t_e3*l1)/G2;// in K
t_s1=t_a+t_eq;// in k
T_s1=10*log(t_s1)/log(10);// in db
G=66;// in db
g_t1=G-T_s1;//G/T ratio in db/K
t_s2=(t_a*G2)/l1+(l1-1)*(t_o*G2)/l1+(t_e2*G2)+t_e3;
T_s2=10*log(t_s2)/log(10);// in db
G_2=66-0.3+60;// in db
g_t2=G_2-T_s2;//G/T ratio in db/K
printf("The G/T ratio=%f db/K", g_t1);
printf("\n The G/T ratio=%f db/K", g_t2);
printf("\n Both the G/T ratio are same");
```

Scilab code Exa 29.91 Determine the first local oscillator frequency range of second oscillator frequency and frequency spectrum

```
//Ex:91
clc;
clear;
close;
b_c=36;//carrier BW in MHz
f_c=1000;//Center freq in MHz
f_i=70;// first intermediate freq in MHz
f_smx=6400;//max uplink freq spectrum in MHz
f_smn=5900;//min uplink freq spectrum in MHz
f_l1=f_c-f_i;// in MHz
```

```
f_l2mx=f_smx-f_c;// in MHz
f_l2mn=f_smn-f_c;// in MHz
f_s1=f_smx-2*(f_l1+f_i);
f_s2=f_smn-2*(f_l1+f_i);
printf("The first local oscillator frequency=%f MHz"
    , f_l1);
printf("\n The max second oscillator frequency =%f
    GHz", f_l2mx/1000);
printf("\n The min second oscillator frequency =%f
    GHz", f_l2mn/1000);
printf("\n The max frequency spectrum =%f GHz", f_s1
    /1000);
printf("\n The min frequency spectrum =%f GHz", f_s2
    /1000);
```

Scilab code Exa 29.92 Determine the first local oscillator frequency and range of second oscillator frequency and frequency spectrum and BW of BPF1 and BPF2

```
//Ex:92
clc;
clear;
close;
b_c=72;//carrier BW in MHz
f_c=1190;//Center freq in MHz
f_i=140;// first intermediate freq in MHz
f_smx=14500;//max uplink freq spectrum in MHz
f_smn=14000;//min uplink freq spectrum in MHz
f_l1=f_c-f_i;// in MHz;
f_l1=f_c-f_i;// in MHz
f_l2mx=f_smx-f_c;// in MHz
f_l2mn=f_smn-f_c;// in MHz
f_s1=f_smx-2*(f_l1+f_i);
f_s2=f_smn-2*(f_l1+f_i);
b_pf1=140;// in MHz
```

```
b_pf2=500;// in MHz
printf("The first local oscillator frequency=%f MHz"
    , f_l1);
printf("\n The max second oscillator frequency =%f
    GHz", f_l2mx/1000);
printf("\n The min second oscillator frequency =%f
    GHz", f_l2mn/1000);
printf("\n The max frequency spectrum =%f GHz", f_s1
    /1000);
printf("\n The min frequency spectrum =%f GHz", f_s2
    /1000);
printf("\n The BW of BPF-1=%f MHz", b_pf1);
printf("\n The BW of BPF-1=%f MHz", b_pf2);
```

Scilab code Exa 29.93 Determine the first local oscillator frequency range of second oscillator frequency and frequency spectrum

```
//Ex:93
clc;
clear;
close;
b_c=36;//carrier BW in MHz
f_d=4000;//Dowm link freq in MHz
f_i=70;// first intermediate freq in MHz
f_smx=4200;//max uplink freq spectrum in MHz
f_smn=3700;//min uplink freq spectrum in MHz
f_dl2=1000;// in MHz
f_l2=f_d-f_dl2;// in MHz
f_l1=f_d-f_i-f_l2;// in MHz
printf("The max second oscillator frequency =%f GHz"
    , f_l2/1000);
printf("\n The min second oscillator frequency =%f
    MHz", f_l1);
printf("\n The center frequency of BPF-1 =%f GHz",
    f_dl2/1000);
```

```
printf("\n The BW=%f MHz", b_c);
```

Scilab code Exa 29.94 Determine the center frequency BW of BPF1 and range of second oscillator frequency

```
//Ex:94
clc;
clear;
close;
b_c=72;//carrier BW in MHz
f_l1=2100;//first local oscillator frequency in MHz
f_i=140;// first intermediate freq in MHz
f_smx=11700;//max downlink freq spectrum in MHz
f_smn=10700;//min downlink freq spectrum in MHz
f_c=f_l1+f_i;//in MHZ
f_l2mx=f_smx-f_c;// in MHz
f_l2mn=f_smn-f_c;// in MHz
printf("The center frequency of BPF_1=%f GHz", f_c
    /1000);
printf("\n The BW=%f MHz", f_i);
printf("\n The max second oscillator frequency =%f
    GHz", f_l2mx/1000);
printf("\n The min second oscillator frequency =%f
    GHz", f_l2mn/1000);
```

Scilab code Exa 29.95 Find the system noise temperature and GT as referred to the input of low noise amplifier

```
//Ex:95
clc;
clear;
close;
g_a=55;// antenna gain in db
```

```
l_w=0.1;//waveguide loss in db
L=10^(0.01);//waveguide loss
t_o=300;// in k
t_a=25+3.3+1+10+15;//antenna noise temperature in k
t_e=(L-1)*t_o;//equivalent noise temp in k
t_s=t_a+(L-1)*t_o/L;// in k
g_ln=10^(55/10);
t_eq=45+(315000/g_ln);// in K
t=t_s+t_eq;// in K
G=g_a-l_w;// in db
g_t=G-10*log(t)/log(10);// in db/K
printf("The system noise temperature =%d k", t);
printf("\n The G/T ratio=%f db/K", g_t);
```

Scilab code Exa 29.96 Determine the equivalent noise temperature of the low noise amplifier

```
//Ex:96
clc;
clear;
close;
t_o=300;// in K
g_a=65;// antenna gain in db
n_c=60;//in K
l_w=0.5;//waveguide loss in db
g_s=g_a-l_w;//system gain in db
L=10^(.5/10);
t_s=(n_c/L)+(L-1)*t_o/L;
g_t=40;// in db/K
t=10^((g_s-g_t)/10);//in k
t_e=t-t_s;//in k
printf("The equivalent noise temperature=%f K", t_e);
```

Scilab code Exa 29.97 Determine the output powers of the three carriers

```
//Ex:97
clc;
clear;
close;
p_i1=50;// i/p power at f1 in db
p_i2=40;// i/p power at f2 in db
p_i3=25;// i/p power at f2 in db
p_c1=47;// carrier power at (f1) at i/p of second 3
    db coupler
p_c2=37;// carrier power at (f2) at i/p of second 3
    db coupler
p_c3=25;// carrier power at (f3) at i/p of second 3
    db coupler
pc1=p_c1-3;//carrier power at (f1) at output in db
pc2=p_c2-3;//carrier power at (f2) at output in db
pc3=p_c3-3;//carrier power at (f3) at output in db
printf("The carrier power at (f1) at output=%f db",
    pc1);
printf("\n The carrier power at (f2) at output=%f db
    ", pc2);
printf("\n The carrier power at (f3) at output=%f db
    ", pc3);
```

Scilab code Exa 29.98 Determine the power loss suffered by each one of the five carriers after all have combined and appeared at the output

```
//Ex:98
clc;
clear;
close;
```

```
f_d1=3;// in db
A=10^(-f_d1/10);
B=1-A;
l_s=-10*log(B)/log(10);
f_d2=4.76;// in db
A2=10^(-f_d2/10);
B2=1-A2;
l_s2=-10*log(B2)/log(10);
f_d3=6;// in db
A3=10^(-f_d3/10);
B3=1-A3;
l_s3=-10*log(B3)/log(10);
f_d4=6.97;// in db
A4=10^(-f_d4/10);
B4=1-A4;
l_s4=-10*log(B4)/log(10);
l_o=f_d3+l_s4;//in db
printf("The power loss suffered of the five carriers
    after all have combined=%f db",l_o);
```

Scilab code Exa 29.99 Find the link carrier to noise ratio

```
//Ex:99
clc;
clear;
close;
c_nu=10^(25/10);// The uplink carrier to noise ratio
c_nd=10^(20/10);// The uplink carrier to noise ratio
c_n1=(1/c_nu)+(1/c_nd);
c_n=1/c_n1;// carrier to noise ratio
printf("The carrier to noise ratio=%f db", 10*log(
   c_n)/log(10));
```

Scilab code Exa 29.100 determine CNu and CNd and CN

```
//Ex:100
clc;
clear;
close;
p_c=10*log(200)/log(10);// carrier power in db
g_t=57.6;// transmit gain in db
B_oi=0;// in db
e_s=p_c+g_t+B_oi;//satellite saturation EIRP in dbW
k=10*(log(1.38)/log(10)-23*log(10)/log(10));//
    Boltzmann's const in db
B=10*log(36000000)/log(10);// in db
L=1.5;// in db
s=20*log((4*3.14*14*(10^9)*37000*(10^3))/(3*(10^8)))
    /log(10);
g_t=1.6;// in db
c_nu=e_s-s+g_t-k-B-B_oi-L;
G=56.3;// in db
g_td=G-10*log(160)/log(10);
L1=1;// in db
e_s1=44;// in db
s1=20*log((4*3.14*12*(10^9)*37000*(10^3))/(3*(10^8))
    )/log(10);
c_nd=e_s1-s1+g_td-k-B-B_oi-L1;
c_u=10^(27/10);
c_d=10^(24.9/10);
c_n=(c_u*c_d)/(c_u+c_d);
printf("The uplink carrier to noise ratio=%f db",
    c_nu);
printf("\n The downlink carrier to noise ratio=%f db
    ", c_nd);
printf("\n The carrier to noise ratio=%f db", 10*log
    (c_n)/log(10));
```

Scilab code Exa 29.101 Determine the carrier EIRP required to saturate the satellite TWTA

```
//Ex:101
clc;
clear;
close;
p_t=10*log(500)/log(10);// in dbW
g_t=60;// in dbW
e_irp=p_t+g_t;
e_p=ceil(e_irp);
B_oi=1;//  input back_off in db
e_s=e_p+B_oi;//saturation EIRP in dbW
printf("The saturation EIRP=%d dbW", e_s);
```

Scilab code Exa 29.102 Determine the satellite EIRP for the retransmitted carrier

```
 //Ex:102
clc;
clear;
close;
B_o=10*log(2)/log(10);// in db
b_o=floor(B_o);
e_ps=50;// in db
e_irps=e_ps-b_o;// satellite EIRP in db
printf("The satellite EIRP for the retransmitted
   carrier=%d dbW", e_irps);
```

Scilab code Exa 29.103 Determine the angular separation of the two satellites as viewed by the earth tation also determine the separation distance betwwwn the two satellites in the orbit

```
//Ex:103
clc;
clear;
close;
b=85-25;// in degree
r=42164;//orbit radius in km
d_a=38000;// in km
d_b=36000;// in km
x=1-cos(b*3.14/180);
y=acos((d_a^2+d_b^2-2*r*r*x)/(2*d_a*d_b))// in
    radian
z=y*180/3.14;// in degree
d=1.4149*r*sqrt(x);
printf("The angular separation of the two satellites
    =%f degree", z);
printf("\n The separation distance of the two
    satellites=%f km", d);
```

Scilab code Exa 29.104 Determine the angular separation and separation distance

```
//Ex:104
clc;
clear;
close;
b=30-25;// in degree
r=42164;//orbit radius in km
d_a=38000;// in km
d_b=36000;// in km
x=1-cos(b*3.14/180);
y=acos((d_a^2+d_b^2-2*r*r*x)/(2*d_a*d_b))// in
    radian
z=y*180/3.14;// in degree
d=1.414*r*sqrt(1-0.996);
D=1.414*r*0.063;
```

```
printf("The angular separation of the two satellites
    =%f degree", z);
printf("\n The separation distance of the two
    satellites=%f km", D);
```

Scilab code Exa 29.105 Calculate the power flux density at the satellite for an earth station located at 90 degree W longitude and 40 degree N latitude

```
//Ex:105
clc;
clear;
close;
u=0.55;//efficiency
f=14*10^9;// in hz
D=5;// in m
c=3*10^8;// speed of light in m/s
g=(u*(%pi*f*D)^2)/(c*c);//antenna gain
G=10*log(g)/log(10);//antenna gain in db
p_amp=26.98;// in db
b_o=3;// in db
p_op=p_amp-b_o;// in db
l_w=0.5;// in db
p_f=p_op-l_w;// in db
e_irp=p_op+G;// in db
e=23.48+54.7;// in db
e_p=10^(e/10);
R=42164;// in km
r=6378;// in km
E=41;// in degree
q=E+asin((r*(cos(E*3.14/180))/R)*180/3.14);
q1=47.55;
d=(R*R)+(r*r)-2*R*r*sin(q1*3.14/180);
d1=sqrt(d);
d_f=(e_p)/(4*%pi*d);
printf("Power flux density=%e W/sq.m", d_f/1000000);
```

Scilab code Exa 29.106 Determine the theoritical max area of the earth surface

```
//Ex:106
clc;
clear;
close;
R_e=6378;//in km
H=35786;// in km
l=R_e/(R_e+H);
m=asin(l);// in rad
a=m*180/3.14;// in degree
x=90-8.7;// in degree
o_c=R_e*sin(a*3.14/180);// dis OC in the given
   triangle AOC IN KM
h=R_e-o_c;//in km
E=10;// in degree
y=90-a-E;// in degree
O_C=R_e*sin(18.56*3.14/180);
O_C1=ceil(O_C);// the newvalue of OC in km
h1=R_e-O_C1;// The new value of H in km
a_r=2*3.14*R_e*h1;//in sq.km
printf("The covered area=%d sq.km", a_r);
```

Scilab code Exa 29.107 Determine the percentage of the earth area covered for the two cases of angle of elevation

```
//Ex:107
clc;
clear;
close;
```

```
R_e=6378;//in km
h1=5413.26;// in km when E=0 degree
h2=4348;// in km when E=10 degree
a_r1=h1*100/(2*R_e);// percentage of area covered
a_r2=h2*100/(2*R_e);//percentage of area covered
printf("The percentage of area covered when E=0
    degree=%f %%", a_r1);
printf("\n The percentage of area covered when E=0
    degree=%f %%", a_r2);
```

Scilab code Exa 29.108 Determine the gain of spot beam antenna if the glowal coverage antenna has a gain of 50 db

```
//Ex:108
clc;
clear;
close;
g_gc=10^(50/10);
a_c=4.5;// coverage angle in degree
a_b=17.34;// beam angle in degree
g_sb=g_gc*(a_b/a_c)^2;
printf("The gain of spot beam antenna=%f db", 10*log
    (g_sb)/log(10));
```