Lampiran 1. Perhitungan *Bit Error Rate* Sistem

```
%Mencari Bit Rate
Nfft=1024
Nused=841
B=10000000                                  %bandwidth 10 MHz
fsampling=28/25                             %frekuensi sampling
Ts=Nfft/B/fsampling                         %periode sampling
br_bpsk12=Nused*1*0.5/Ts                    %bitrate modulasi BPSK 1/2
br_qpsk12=Nused*2*0.5/Ts                    %bitrate modulasi QPSK 1/2
br_qpsk34=Nused*2*0.75/Ts                   %bitrate modulasi QPSK 3/4
br_16qam12=Nused*4*0.5/Ts                    %bitrate modulasi 16QAM 1/2
br_16qam34=Nused*4*0.75/Ts                  %bitrate modulasi 16QAM 3/4
br_64qam23=Nused*6*0.67/Ts                  %bitrate modulasi 64QAM 2/3
br_64qam34=Nused*6*0.75/Ts                  %bitrate modulasi 64QAM 3/4
%Mencari Eb/N0
SNR_bpsk12=6.4                              %signal to noise ratio BPSK 1/2
SNR_qpsk12=9.4                              %signal to noise ratio QPSK 1/2
SNR_qpsk34=11.2                             %signal to noise ratio QPSK 3/4
SNR_16qam12=16.4                            %signal to noise ratio 16QAM 1/2
SNR_16qam34=18.2                            %signal to noise ratio 16QAM 3/4
SNR_64qam23=22.7                            %signal to noise ratio 64QAM 2/3
SNR_64qam34=24.4                            %signal to noise ratio 64QAM 3/4
Ebno_bpsk12=SNR_bpsk12-(10*log10(B/br_bpsk12))     %energy bit per
noise ratio BPSK 1/2
Ebno_qpsk12=SNR_qpsk12-(10*log10(B/br_qpsk12))     %energy bit per
noise ratio QPSK 1/2
Ebno_qpsk34=SNR_qpsk34-(10*log10(B/br_qpsk34))     %energy bit per
noise ratio QPSK 3/4
Ebno_16qam12=SNR_16qam12-(10*log10(B/br_16qam12))   %energy bit per
noise ratio 16QAM 1/2
Ebno_16qam34=SNR_16qam34-(10*log10(B/br_16qam34))   %energy bit per
noise ratio 16QAM 3/4
Ebno_64qam23=SNR_64qam23-(10*log10(B/br_64qam23))   %energy bit per
noise ratio 64QAM 2/3
Ebno_64qam34=SNR_64qam34-(10*log10(B/br_64qam34))   %energy bit per
noise ratio 64QAM 3/4
%Mencari BER
BER_bpsk12=0.5*erfc(sqrt(Ebno_bpsk12))
BER_qpsk12=0.5*erfc(sqrt(Ebno_qpsk12))
BER_qpsk34=0.5*erfc(sqrt(Ebno_qpsk34))
BER_16qam12=(4*(sqrt(16)-
1))/(sqrt(16)*log2(16))*erfc(sqrt((3*log2(16))/(4*(16-
1))*Ebno_16qam12))BER_16qam34=(4*(sqrt(16)-
1))/(sqrt(16)*log2(16))*erfc(sqrt((3*log2(16))/(4*(16-
```

```
1))*Ebno_16qam34))BER_64qam23=(4*(sqrt(64)-
1))/(sqrt(64)*log2(64))*erfc(sqrt((3*log2(64))/(4*(64-
1))*Ebno_64qam23))BER_64qam34=(4*(sqrt(64)-
1))/(sqrt(64)*log2(64))*erfc(sqrt((3*log2(64))/(4*(64-1))*Ebno_64qam34))
EbN0=[3.0268 9.0371 12.5981 19.0474 22.6084 28.3794 30.5693];
BIT=[0.0069 1.0623e-005 2.5893e-007 0.0043 0.0020 0.0257 0.0214];
plot(EbN0,BIT);
grid on
xlabel('Eb/NO');
ylabel('Bit Error Rate (BER)');
title('Grafik Pengaruh EB/N0 terhadap BER');
```

Lampiran 2. Perhitungan *Delay end to end* Sistem

```
%Menghitung payload
B_codeca=64000                  %bandwidth audio
B_codecv=384000                 %bandwidth video
framerate=0.033                 %frame rate
Pla_max=160                     %payload audio maksimal
Plv_max=254                     %payload video maksimal
NALU=8                          %header NALU
Hrtpv=96                        %header RTP video conference
Hudpv=64                        %header UDP video conference
Hipv=320                        %header IP video conference
Pla=B_codeca*framerate          %payload audio
Plv=B_codecv*framerate          %payload video
Pa=Pla/Pla_max                  %paket audio
Pv=Plv/Plv_max                  %paket video
P_dataa=Pla+(Pa*(NALU+Hrtpv+Hudpv+Hipv))    %paket data audio
P_datav=Plv+(Pv*(NALU+Hrtpv+Hudpv+Hipv))    %paket data video
Wdata=(P_dataa+P_datav)/8  %panjang paket data video conference
%Menghitung Delay Codec
ta=0.00075                      %delay audio
tv=0.15                         %delay video
tcodec=2*(ta+tv)                %delay codec video conference
%Menghitung delay proses
Hrtp=12                         %header RTP
Hudp=8                          %header UDP
Hip=20                          %header IP
Hethernet=18                    %header ethernet
Hmac=6                          %header MAC
MSS1=1460                       %maximum segmen size
Nframe=4                        %banyak frame
Wmessage=Wdata+Hrtp             %panjang messaga
Nsegmen=Wmessage/MSS1    %banyak segmen
Wsegmen=Wmessage+(Nframe*Hudp)  %panjang segmen
Wdatagram=Wsegmen+Hip    %panjang datagram
Wframe_eth=Wdatagram+Hethernet  %panjang frame ethernet
Wframetot=Wframe_eth+Hmac  %panjang frame total
%Kapasitas kanal
B=10000000                      %bandwidth kanal 10 MHz
SNR_bpsk12=6.4                  %signal to noise ratio BPSK 1/2 (dB)
SNR_qpsk12=9.4                  %signal to noise ratio QPSK 1/2 (dB)
SNR_qpsk34=11.2                 %signal to noise ratio QPSK 3/4 (dB)
SNR_16qam12=16.4                %signal to noise ratio 16QAM 1/2 (dB)
SNR_16qam34=18.2                %signal to noise ratio 16QAM 3/4 (dB)
SNR_64qam23=22.7                %signal to noise ratio 64QAM 2/3 (dB)
```

```
SNR_64qam34=24.4          %signal to noise ratio 64QAM 3/4 (dB)
SNRw_bpsk12=10^(SNR_bpsk12/10)  %signal to noise ratio BPSK 1/2 (watt)
SNRw_qpsk12=10^(SNR_qpsk12/10)  %signal to noise ratio QPSK 1/2 (watt)
SNRw_qpsk34=10^(SNR_qpsk34/10)  %signal to noise ratio QPSK 3/4 (watt)
SNRw_16qam12=10^(SNR_16qam12/10)%signal to noise ratio 16QAM 1/2
(watt)
SNRw_16qam34=10^(SNR_16qam34/10)%signal to noise ratio 16QAM 3/4
(watt)
SNRw_64qam23=10^(SNR_64qam23/10)%signal to noise ratio 64QAM 2/3
(watt)
SNRw_64qam34=10^(SNR_64qam34/10)%signal to noise ratio 64QAM 3/4
(watt)
C_bpsk12=B*log2(1+SNRw_bpsk12)  %kapasitas kanal BPSK 1/2
C_qpsk12=B*log2(1+SNRw_qpsk12)  %kapasitas kanal QPSK 1/2
C_qpsk34=B*log2(1+SNRw_qpsk34)  %kapasitas kanal QPSK 3/4
C_16qam12=B*log2(1+SNRw_16qam12)%kapasitas kanal 16QAM 1/2
C_16qam34=B*log2(1+SNRw_16qam34)%kapasitas kanal 16QAM 3/4
C_64qam23=B*log2(1+SNRw_64qam23)%kapasitas kanal 64QAM 2/3
C_64qam34=B*log2(1+SNRw_64qam34)%kapasitas kanal 64QAM 3/4
%Delay enkapsulasi dan dekapsulasi
Cethernet=100000000                %laju data ethernet
tenc1=((Wframetot-Wdata)/Cethernet)*8          %delay enkapsulasi
ethernet
tenc2_bpsk12=((Wframetot-Wdata)/C_bpsk12)*8     %delay enkapsulasi BPSK
1/2
tenc2_qpsk12=((Wframetot-Wdata)/C_qpsk12)*8     %delay enkapsulasi QPSK
1/2
tenc2_qpsk34=((Wframetot-Wdata)/C_qpsk34)*8     %delay enkapsulasi QPSK
3/4
tenc2_16qam12=((Wframetot-Wdata)/C_16qam12)*8   %delay enkapsulasi
16QAM 1/2
tenc2_16qam34=((Wframetot-Wdata)/C_16qam34)*8   %delay enkapsulasi
16QAM 3/4
tenc2_64qam23=((Wframetot-Wdata)/C_64qam23)*8   %delay enkapsulasi
64QAM 2/3
tenc2_64qam34=((Wframetot-Wdata)/C_64qam34)*8   %delay enkapsulasi
64QAM 3/4
tdec1_bpsk12=((Wframetot-Wdata)/C_bpsk12)*8     %delay dekapsulasi BPSK
1/2
tdec1_qpsk12=((Wframetot-Wdata)/C_qpsk12)*8     %delay dekapsulasi QPSK
1/2
tdec1_qpsk34=((Wframetot-Wdata)/C_qpsk34)*8     %delay dekapsulasi QPSK
3/4
tdec1_16qam12=((Wframetot-Wdata)/C_16qam12)*8   %delay dekapsulasi
16QAM 1/2
```

```
tdec1_16qam34=((Wframetot-Wdata)/C_16qam34)*8   %delay dekapsulasi
16QAM 3/4
tdec1_64qam23=((Wframetot-Wdata)/C_64qam23)*8   %delay dekapsulasi
64QAM 2/3
tdec1_64qam34=((Wframetot-Wdata)/C_64qam34)*8   %delay dekapsulasi
64QAM 3/4
tdec2=((Wframetot-Wdata)/Cethernet)*8          %delay dekapsulasi ethernet
%Delay proses
tproc_bpsk12=tenc1+tenc2_bpsk12+tdec1_bpsk12+tdec2  %delay proses
BPSK 1/2
tproc_qpsk12=tenc1+tenc2_qpsk12+tdec1_qpsk12+tdec2  %delay proses
QPSK 1/2
tproc_qpsk34=tenc1+tenc2_qpsk34+tdec1_qpsk34+tdec2  %delay proses
QPSK 3/4
tproc_16qam12=tenc1+tenc2_16qam12+tdec1_16qam12+tdec2 %delay proses
16QAM 1/2
tproc_16qam34=tenc1+tenc2_16qam34+tdec1_16qam34+tdec2 %delay proses
16QAM 3/4
tproc_64qam23=tenc1+tenc2_64qam23+tdec1_64qam23+tdec2 %delay proses
64QAM 2/3
tproc_64qam34=tenc1+tenc2_64qam34+tdec1_64qam34+tdec2 %delay proses
64QAM 3/4
%Delay Propagasi Urban
v=300000000              %cepat rambat udara
tprop_bpsk12u=2176.66/v     %delay propagasi BPSK 1/2 urban
tprop_qpsk12u=1879.15/v     %delay propagasi QPSK 1/2 urban
tprop_qpsk34u=1720.54/v     %delay propagasi QPSK 3/4 urban
tprop_16qam12u=1333.6/v     %delay propagasi 16QAM 1/2 urban
tprop_16qam34u=1221.03/v    %delay propagasi 16QAM 3/4 urban
tprop_64qam23u=979.45/v     %delay propagasi 64QAM 2/3 urban
tprop_64qam34u=901.18/v     %delay propagasi 64QAM 3/4 urban
%Delay Propagasi Suburban
tprop_bpsk12s=2839.96/v %delay propagasi BPSK 1/2 suburban
tprop_qpsk12s=2420.88/v %delay propagasi QPSK 1/2 suburban
tprop_qpsk34s=2199.72/v %delay propagasi QPSK 3/4 suburban
tprop_16qam12s=1667.92/v %delay propagasi 16QAM 1/2 suburban
tprop_16qam34s=1515.55/v %delay propagasi 16QAM 3/4 suburban
tprop_64qam23s=1192.77/v %delay propagasi 64QAM 2/3 suburban
tprop_64qam34s=1089.59/v %delay propagasi 64QAM 3/4 suburban
%Delay Propagasi Rural
tprop_bpsk12r=13346.97/v %delay propagasi BPSK 1/2 rural
tprop_qpsk12r=11261.13/v %delay propagasi QPSK 1/2 rural
tprop_qpsk34r=10169.54/v %delay propagasi QPSK 3/4 rural
tprop_16qam12r=7574.96/v %delay propagasi 16QAM 1/2 rural
tprop_16qam34r=6840.69/v %delay propagasi 16QAM 3/4 rural
```

```
tprop_64qam23r=5301.5/v  %delay propagasi 64QAM 2/3 rural
tprop_64qam34r=4814.8/v  %delay propagasi 64QAM 3/4 rural
%Delay transmisi
ttrans_bpsk12=Wframetot/C_bpsk12*8 %delay transmisi BPSK 1/2
ttrans_qpsk12=Wframetot/C_qpsk12*8 %delay transmisi QPSK 1/2
ttrans_qpsk34=Wframetot/C_qpsk34*8 %delay transmisi QPSK 3/4
ttrans_16qam12=Wframetot/C_16qam12*8 %delay transmisi 16QAM 1/2
ttrans_16qam34=Wframetot/C_16qam34*8 %delay transmisi 16QAM 3/4
ttrans_64qam23=Wframetot/C_64qam23*8 %delay transmisi 64QAM 2/3
ttrans_64qam34=Wframetot/C_64qam34*8 %delay transmisi 64QAM 3/4
%Delay antrian
miu_bpsk12=C_bpsk12/Wframetot/8 %waktu pelayanan BPSK 1/2
miu_qpsk12=C_qpsk12/Wframetot/8 %waktu pelayanan QPSK 1/2
miu_qpsk34=C_qpsk34/Wframetot/8 %waktu pelayanan QPSK 3/4
miu_16qam12=C_16qam12/Wframetot/8 %waktu pelayanan 16QAM 1/2
miu_16qam34=C_16qam34/Wframetot/8 %waktu pelayanan 16QAM 3/4
miu_64qam23=C_64qam23/Wframetot/8 %waktu pelayanan 64QAM 2/3
miu_64qam34=C_64qam34/Wframetot/8 %waktu pelayanan 64QAM 3/4
utilitas=[0.1:0.1:0.9] %faktor utilitas
tw_bpsk12=((miu_bpsk12.*utilitas)./((miu_bpsk12^2)-
(miu_bpsk12.*miu_bpsk12.*utilitas)))+(1./miu_bpsk12) %delay antrian BPSK
1/2
tw_qpsk12=((miu_qpsk12.*utilitas)./((miu_qpsk12^2)-
(miu_qpsk12.*miu_qpsk12.*utilitas)))+(1./miu_qpsk12) %delay antrian QPSK
1/2
tw_qpsk34=((miu_qpsk34.*utilitas)./((miu_qpsk34^2)-
(miu_qpsk34.*miu_qpsk34.*utilitas)))+(1./miu_qpsk34) %delay antrian QPSK
3/4
tw_16qam12=((miu_16qam12.*utilitas)./((miu_16qam12^2)-
(miu_16qam12.*miu_16qam12.*utilitas)))+(1./miu_16qam12) %delay antrian
16QAM 1/2
tw_16qam34=((miu_16qam34.*utilitas)./((miu_16qam34^2)-
(miu_16qam34.*miu_16qam34.*utilitas)))+(1./miu_16qam34) %delay antrian
16QAM 3/4
tw_64qam23=((miu_64qam23.*utilitas)./((miu_64qam23^2)-
(miu_64qam23.*miu_64qam23.*utilitas)))+(1./miu_64qam23) %delay antrian
64QAM 2/3
tw_64qam34=((miu_64qam34.*utilitas)./((miu_64qam34^2)-
(miu_64qam34.*miu_64qam34.*utilitas)))+(1./miu_64qam34) %delay antrian
64QAM 3/4
%delay man urban
tman_bpsk12u=tproc_bpsk12+tprop_bpsk12u+ttrans_bpsk12+tw_bpsk12
tman_qpsk12u=tproc_qpsk12+tprop_qpsk12u+ttrans_qpsk12+tw_qpsk12
tman_qpsk34u=tproc_qpsk34+tprop_qpsk34u+ttrans_qpsk34+tw_qpsk34
```

tman_16qam12u=tproc_16qam12+tprop_16qam12u+ttrans_16qam12+tw_16qa
m12
tman_16qam34u=tproc_16qam34+tprop_16qam34u+ttrans_16qam34+tw_16qa
m34
tman_64qam23u=tproc_64qam23+tprop_64qam23u+ttrans_64qam23+tw_64qa
m23
tman_64qam34u=tproc_64qam34+tprop_64qam34u+ttrans_64qam34+tw_64qa
m34
%delay man suburban
tman_bpsk12s=tproc_bpsk12+tprop_bpsk12s+ttrans_bpsk12+tw_bpsk12
tman_qpsk12s=tproc_qpsk12+tprop_qpsk12s+ttrans_qpsk12+tw_qpsk12
tman_qpsk34s=tproc_qpsk34+tprop_qpsk34s+ttrans_qpsk34+tw_qpsk34
tman_16qam12s=tproc_16qam12+tprop_16qam12s+ttrans_16qam12+tw_16qa
m12
tman_16qam34s=tproc_16qam34+tprop_16qam34s+ttrans_16qam34+tw_16qa
m34
tman_64qam23s=tproc_64qam23+tprop_64qam23s+ttrans_64qam23+tw_64qa
m23
tman_64qam34s=tproc_64qam34+tprop_64qam34s+ttrans_64qam34+tw_64qa
m34
%delay man rural
tman_bpsk12r=tproc_bpsk12+tprop_bpsk12r+ttrans_bpsk12+tw_bpsk12
tman_qpsk12r=tproc_qpsk12+tprop_qpsk12r+ttrans_qpsk12+tw_qpsk12
tman_qpsk34r=tproc_qpsk34+tprop_qpsk34r+ttrans_qpsk34+tw_qpsk34
tman_16qam12r=tproc_16qam12+tprop_16qam12r+ttrans_16qam12+tw_16qa
m12
tman_16qam34r=tproc_16qam34+tprop_16qam34r+ttrans_16qam34+tw_16qa
m34
tman_64qam23r=tproc_64qam23+tprop_64qam23r+ttrans_64qam23+tw_64qa
m23
tman_64qam34r=tproc_64qam34+tprop_64qam34r+ttrans_64qam34+tw_64qa
m34

%delay end to end urban
dend_bpsk12u=tcodec+(2.*(tproc_bpsk12+tprop_bpsk12u+ttrans_bpsk12+tw_
bpsk12))
dend_qpsk12u=tcodec+(2.*(tproc_qpsk12+tprop_qpsk12u+ttrans_qpsk12+tw_
qpsk12))
dend_qpsk34u=tcodec+(2.*(tproc_qpsk34+tprop_qpsk34u+ttrans_qpsk34+tw_
qpsk34))
dend_16qam12u=tcodec+(2.*(tproc_16qam12+tprop_16qam12u+ttrans_16qam
12+tw_16qam12))
dend_16qam34u=tcodec+(2.*(tproc_16qam34+tprop_16qam34u+ttrans_16qam
34+tw_16qam34))

```
dend_64qam23u=tcodec+(2.*(tproc_64qam23+tprop_64qam23u+ttrans_64qam
23+tw_64qam23))
dend_64qam34u=tcodec+(2.*(tproc_64qam34+tprop_64qam34u+ttrans_64qam
34+tw_64qam34))
%delay end to end suburban
dend_bpsk12s=tcodec+(2.*(tproc_bpsk12+tprop_bpsk12s+ttrans_bpsk12+tw_b
psk12))
dend_qpsk12s=tcodec+(2.*(tproc_qpsk12+tprop_qpsk12s+ttrans_qpsk12+tw_q
psk12))
dend_qpsk34s=tcodec+(2.*(tproc_qpsk34+tprop_qpsk34s+ttrans_qpsk34+tw_q
psk34))
dend_16qam12s=tcodec+(2.*(tproc_16qam12+tprop_16qam12s+ttrans_16qam
12+tw_16qam12))
dend_16qam34s=tcodec+(2.*(tproc_16qam34+tprop_16qam34s+ttrans_16qam
34+tw_16qam34))
dend_64qam23s=tcodec+(2.*(tproc_64qam23+tprop_64qam23s+ttrans_64qam
23+tw_64qam23))
dend_64qam34s=tcodec+(2.*(tproc_64qam34+tprop_64qam34s+ttrans_64qam
34+tw_64qam34))
%delay end to end rural
dend_bpsk12r=tcodec+(2.*(tproc_bpsk12+tprop_bpsk12r+ttrans_bpsk12+tw_b
psk12))
dend_qpsk12r=tcodec+(2.*(tproc_qpsk12+tprop_qpsk12r+ttrans_qpsk12+tw_q
psk12))
dend_qpsk34r=tcodec+(2.*(tproc_qpsk34+tprop_qpsk34r+ttrans_qpsk34+tw_q
psk34))
dend_16qam12r=tcodec+(2.*(tproc_16qam12+tprop_16qam12r+ttrans_16qam
12+tw_16qam12))
dend_16qam34r=tcodec+(2.*(tproc_16qam34+tprop_16qam34r+ttrans_16qam
34+tw_16qam34))
dend_64qam23r=tcodec+(2.*(tproc_64qam23+tprop_64qam23r+ttrans_64qam
23+tw_64qam23))
dend_64qam34r=tcodec+(2.*(tproc_64qam34+tprop_64qam34r+ttrans_64qam
34+tw_64qam34))


plot
(utilitas,dend_bpsk12u,utilitas,dend_qpsk12u,utilitas,dend_qpsk34u,utilitas,den
d_16qam12u,utilitas,dend_16qam34u,utilitas,dend_64qam23u,utilitas,dend_64
qam34u);
grid on
xlabel('Faktor Utilitas');
ylabel('Delay End to End (s)');
title('Grafik Pengaruh Faktor Utilitas terhadap delay end to end daerah urban');
```

```
plot
(utilitas,dend_bpsk12s,utilitas,dend_qpsk12s,utilitas,dend_qpsk34s,utilitas,dend
_16qam12s,utilitas,dend_16qam34s,utilitas,dend_64qam23s,utilitas,dend_64qa
m34s);
grid on
xlabel('Faktor Utilitas');
ylabel('Delay End to End (s)');
title('Grafik Pengaruh Faktor Utilitas terhadap delay end to end daerah
suburban');

plot
(utilitas,dend_bpsk12r,utilitas,dend_qpsk12r,utilitas,dend_qpsk34r,utilitas,dend
_16qam12r,utilitas,dend_16qam34r,utilitas,dend_64qam23r,utilitas,dend_64qa
m34r);
grid on
xlabel('Faktor Utilitas');
ylabel('Delay End to End (s)');
title('Grafik Pengaruh Faktor Utilitas terhadap Delay End to End Daerah
Rural');
```

Lampiran 3. Perhitungan *Throughput* Sistem

```
%Mencari Bit Rate
Nfft=1024
Nused=841
B=10000000                          %bandwidth 10 MHz
fsampling=28/25                      %frekuensi sampling
Ts=Nfft/B/fsampling                 %periode sampling
br_bpsk12=Nused*1*0.5/Ts            %bitrate modulasi BPSK 1/2
br_qpsk12=Nused*2*0.5/Ts            %bitrate modulasi QPSK 1/2
br_qpsk34=Nused*2*0.75/Ts           %bitrate modulasi QPSK 3/4
br_16qam12=Nused*4*0.5/Ts           %bitrate modulasi 16QAM 1/2
br_16qam34=Nused*4*0.75/Ts          %bitrate modulasi 16QAM 3/4
br_64qam23=Nused*6*0.67/Ts          %bitrate modulasi 64QAM 2/3
br_64qam34=Nused*6*0.75/Ts          %bitrate modulasi 64QAM 3/4
%Mencari Eb/N0
SNR_bpsk12=6.4                      %signal to noise ratio BPSK 1/2
SNR_qpsk12=9.4                      %signal to noise ratio QPSK 1/2
SNR_qpsk34=11.2                     %signal to noise ratio QPSK 3/4
SNR_16qam12=16.4                    %signal to noise ratio 16QAM 1/2
SNR_16qam34=18.2                    %signal to noise ratio 16QAM 3/4
SNR_64qam23=22.7                    %signal to noise ratio 64QAM 2/3
SNR_64qam34=24.4                    %signal to noise ratio 64QAM 3/4
Ebno_bpsk12=SNR_bpsk12-(10*log10(B/br_bpsk12))     %energy bit per
noise ratio BPSK 1/2
Ebno_qpsk12=SNR_qpsk12-(10*log10(B/br_qpsk12))     %energy bit per
noise ratio QPSK 1/2
Ebno_qpsk34=SNR_qpsk34-(10*log10(B/br_qpsk34))     %energy bit per
noise ratio QPSK 3/4
Ebno_16qam12=SNR_16qam12-(10*log10(B/br_16qam12))  %energy bit per
noise ratio 16QAM 1/2
Ebno_16qam34=SNR_16qam34-(10*log10(B/br_16qam34))  %energy bit per
noise ratio 16QAM 3/4
Ebno_64qam23=SNR_64qam23-(10*log10(B/br_64qam23))  %energy bit per
noise ratio 64QAM 2/3
Ebno_64qam34=SNR_64qam34-(10*log10(B/br_64qam34))  %energy bit per
noise ratio 64QAM 3/4
%Mencari BER
BER_bpsk12=0.5*erfc(sqrt(Ebno_bpsk12))          %bit error rate BPSK 1/2
BER_qpsk12=0.5*erfc(sqrt(Ebno_qpsk12))          %bit error rate QPSK 1/2
BER_qpsk34=0.5*erfc(sqrt(Ebno_qpsk34))          %bit error rate QPSK 3/4
BER_16qam12=(4*(sqrt(16)-
1))/(sqrt(16)*log2(16))*erfc(sqrt((3*log2(16))/(4*(16-1))*Ebno_16qam12))
                                    %bit error rate 16QAM 1/2
```

```
BER_16qam34=(4*(sqrt(16)-
1))/(sqrt(16)*log2(16))*erfc(sqrt((3*log2(16))/(4*(16-1))*Ebno_16qam34))
                                        %bit error rate 16QAM 3/4
BER_64qam23=(4*(sqrt(64)-
1))/(sqrt(64)*log2(64))*erfc(sqrt((3*log2(64))/(4*(64-1))*Ebno_64qam23))
                                        %bit error rate 64QAM 2/3
BER_64qam34=(4*(sqrt(64)-
1))/(sqrt(64)*log2(64))*erfc(sqrt((3*log2(64))/(4*(64-1))*Ebno_64qam34))
                                        %bit error rate 64QAM 3/4
%Menghitung payload
B_codeca=64000                          %bandwidth audio
B_codecv=384000                         %bandwidth video
framerate=0.033                         %frame rate
Pla_max=160                             %payload audio maksimal
Plv_max=254                             %payload video maksimal
NALU=8                                  %header NALU
Hrtpv=96                                %header RTP video
conference
Hudpv=64                                %header UDP video
conference
Hipv=320                                %header IP video
conference
Pla=B_codeca*framerate                  %payload audio
Plv=B_codecv*framerate                  %payload video
Pa=Pla/Pla_max                          %paket audio
Pv=Plv/Plv_max                          %paket video
P_dataa=Pla+(Pa*(NALU+Hrtpv+Hudpv+Hipv))  %paket data audio
P_datav=Plv+(Pv*(NALU+Hrtpv+Hudpv+Hipv))  %paket data video
Wdata=(P_dataa+P_datav)/8               %panjang paket data video
conference
%Menghitung Delay Codec
ta=0.00075                              %delay audio
tv=0.15                                 %delay video
tcodec=2*(ta+tv)                        %delay codec video
conference
%Menghitung delay proses
Hrtp=12                                 %header RTP
Hudp=8                                  %header UDP
Hip=20                                  %header IP
Hethernet=18                            %header ethernet
Hmac=6                                  %header MAC
MSS1=1460                               %maximum segmen size
Nframe=4                                %banyak frame
Wmessage=Wdata+Hrtp                     %panjang message
Nsegmen=Wmessage/MSS1                   %banyak segmen
```

```
Wsegmen=Wmessage+(Nframe*Hudp)          %panjang segmen
Wdatagram=Wsegmen+Hip                   %panjang datagram
Wframe_eth=Wdatagram+Hethernet          %panjang frame ethernet
Wframetot=Wframe_eth+Hmac               %panjang frame total
%Delay Propagasi Urban
v=300000000                             %cepat rambat udara
tprop_bpsk12u=2176.66/v                 %delay propagasi BPSK
1/2 urban
tprop_qpsk12u=1879.15/v                 %delay propagasi QPSK
1/2 urban
tprop_qpsk34u=1720.54/v                 %delay propagasi QPSK
3/4 urban
tprop_16qam12u=1333.6/v                 %delay propagasi 16QAM
1/2 urban
tprop_16qam34u=1221.03/v                %delay propagasi 16QAM
3/4 urban
tprop_64qam23u=979.45/v                 %delay propagasi 64QAM
2/3 urban
tprop_64qam34u=901.18/v                 %delay propagasi 64QAM
3/4 urban
%Delay Propagasi Suburban
tprop_bpsk12s=2839.96/v                 %delay propagasi BPSK
1/2 suburban
tprop_qpsk12s=2420.88/v                 %delay propagasi QPSK 1/2
suburban
tprop_qpsk34s=2199.72/v                 %delay propagasi QPSK 3/4
suburban
tprop_16qam12s=1667.92/v                %delay propagasi 16QAM 1/2
suburban
tprop_16qam34s=1515.55/v                %delay propagasi 16QAM 3/4
suburban
tprop_64qam23s=1192.77/v                %delay propagasi 64QAM 2/3
suburban
tprop_64qam34s=1089.59/v                %delay propagasi 64QAM 3/4
suburban
%Delay Propagasi Rural
tprop_bpsk12r=13346.97/v                %delay propagasi BPSK 1/2 rural
tprop_qpsk12r=11261.13/v                %delay propagasi QPSK 1/2 rural
tprop_qpsk34r=10169.54/v                %delay propagasi QPSK 3/4 rural
tprop_16qam12r=7574.96/v                %delay propagasi 16QAM 1/2
rural
tprop_16qam34r=6840.69/v                %delay propagasi 16QAM 3/4
rural
tprop_64qam23r=5301.5/v                 %delay propagasi 64QAM 2/3
rural
```

```
tprop_64qam34r=4814.8/v                    %delay propagasi 64QAM 3/4
rural
%Delay transmisi
ttrans_bpsk12=Wframetot/C_bpsk12*8         %delay transmisi BPSK 1/2
ttrans_qpsk12=Wframetot/C_qpsk12*8         %delay transmisi QPSK 1/2
ttrans_qpsk34=Wframetot/C_qpsk34*8         %delay transmisi QPSK 3/4
ttrans_16qam12=Wframetot/C_16qam12*8 %delay transmisi 16QAM 1/2
ttrans_16qam34=Wframetot/C_16qam34*8 %delay transmisi 16QAM 3/4
ttrans_64qam23=Wframetot/C_64qam23*8 %delay transmisi 64QAM 2/3
ttrans_64qam34=Wframetot/C_64qam34*8 %delay transmisi 64QAM 3/4
%Mencari throughput
Plos_vicon=0.001
BER_bpsk12=0.5*erfc(sqrt(Ebno_bpsk12))
BER_qpsk12=0.5*erfc(sqrt(Ebno_qpsk12))
BER_qpsk34=0.5*erfc(sqrt(Ebno_qpsk34))
BER_16qam12=(4*(sqrt(16)-
1))/(sqrt(16)*log2(16))*erfc(sqrt((3*log2(16))/(4*(16-1))*Ebno_16qam12))
BER_16qam34=(4*(sqrt(16)-
1))/(sqrt(16)*log2(16))*erfc(sqrt((3*log2(16))/(4*(16-1))*Ebno_16qam34))
BER_64qam23=(4*(sqrt(64)-
1))/(sqrt(64)*log2(64))*erfc(sqrt((3*log2(64))/(4*(64-1))*Ebno_64qam23))
BER_64qam34=(4*(sqrt(64)-
1))/(sqrt(64)*log2(64))*erfc(sqrt((3*log2(64))/(4*(64-1))*Ebno_64qam34))
%Mencari Paket loss
Plos_totbpsk12=1-((1-Plos_vicon)*(1-BER_bpsk12))
Plos_totqpsk12=1-((1-Plos_vicon)*(1-BER_qpsk12))
Plos_totqpsk34=1-((1-Plos_vicon)*(1-BER_qpsk34))
Plos_tot16qam12=1-((1-Plos_vicon)*(1-BER_16qam12))
Plos_tot16qam34=1-((1-Plos_vicon)*(1-BER_16qam34))
Plos_tot64qam23=1-((1-Plos_vicon)*(1-BER_64qam23))
Plos_tot64qam34=1-((1-Plos_vicon)*(1-BER_64qam34))
%Mencari throughput urban
through_bpsk12u=((1-
Plos_totbpsk12)/(ttrans_bpsk12*(1+(1+(((2*tprop_bpsk12u)+(2*ttrans_bpsk12
))/ttrans_bpsk12)-1)*Plos_totbpsk12)))*Wdata*8
through_qpsk12u=((1-
Plos_totqpsk12)/(ttrans_qpsk12*(1+(1+(((2*tprop_qpsk12u)+(2*ttrans_qpsk12
))/ttrans_qpsk12)-1)*Plos_totqpsk12)))*Wdata*8
through_qpsk34u=((1-
Plos_totqpsk34)/(ttrans_qpsk34*(1+(1+(((2*tprop_qpsk34u)+(2*ttrans_qpsk34
))/ttrans_qpsk34)-1)*Plos_totqpsk34)))*Wdata*8
through_16qam12u=((1-
Plos_tot16qam12)/(ttrans_16qam12*(1+(1+(((2*tprop_16qam12u)+(2*ttrans_1
6qam12))/ttrans_16qam12)-1)*Plos_tot16qam12)))*Wdata*8
```

```
through_16qam34u=((1-
Plos_tot16qam34)/(ttrans_16qam34*(1+(1+(((2*tprop_16qam34u)+(2*ttrans_1
6qam34))/ttrans_16qam34)-1)*Plos_tot16qam34)))*Wdata*8
through_64qam23u=((1-
Plos_tot64qam23)/(ttrans_64qam23*(1+(1+(((2*tprop_64qam23u)+(2*ttrans_6
4qam23))/ttrans_64qam23)-1)*Plos_tot64qam23)))*Wdata*8
through_64qam34u=((1-
Plos_tot64qam34)/(ttrans_64qam34*(1+(1+(((2*tprop_64qam34u)+(2*ttrans_6
4qam34))/ttrans_64qam34)-1)*Plos_tot64qam34)))*Wdata*8
%Mencari throughput suburban
through_bpsk12s=((1-
Plos_totbpsk12)/(ttrans_bpsk12*(1+(1+(((2*tprop_bpsk12s)+(2*ttrans_bpsk12)
)/ttrans_bpsk12)-1)*Plos_totbpsk12)))*Wdata*8
through_qpsk12s=((1-
Plos_totqpsk12)/(ttrans_qpsk12*(1+(1+(((2*tprop_qpsk12s)+(2*ttrans_qpsk12)
)/ttrans_qpsk12)-1)*Plos_totqpsk12)))*Wdata*8
through_qpsk34s=((1-
Plos_totqpsk34)/(ttrans_qpsk34*(1+(1+(((2*tprop_qpsk34s)+(2*ttrans_qpsk34)
)/ttrans_qpsk34)-1)*Plos_totqpsk34)))*Wdata*8
through_16qam12s=((1-
Plos_tot16qam12)/(ttrans_16qam12*(1+(1+(((2*tprop_16qam12s)+(2*ttrans_1
6qam12))/ttrans_16qam12)-1)*Plos_tot16qam12)))*Wdata*8
through_16qam34s=((1-
Plos_tot16qam34)/(ttrans_16qam34*(1+(1+(((2*tprop_16qam34s)+(2*ttrans_1
6qam34))/ttrans_16qam34)-1)*Plos_tot16qam34)))*Wdata*8
through_64qam23s=((1-
Plos_tot64qam23)/(ttrans_64qam23*(1+(1+(((2*tprop_64qam23s)+(2*ttrans_6
4qam23))/ttrans_64qam23)-1)*Plos_tot64qam23)))*Wdata*8
through_64qam34s=((1-
Plos_tot64qam34)/(ttrans_64qam34*(1+(1+(((2*tprop_64qam34s)+(2*ttrans_6
4qam34))/ttrans_64qam34)-1)*Plos_tot64qam34)))*Wdata*8

%Mencari throughput rural
through_bpsk12r=((1-
Plos_totbpsk12)/(ttrans_bpsk12*(1+(1+(((2*tprop_bpsk12r)+(2*ttrans_bpsk12)
)/ttrans_bpsk12)-1)*Plos_totbpsk12)))*Wdata*8
through_qpsk12r=((1-
Plos_totqpsk12)/(ttrans_qpsk12*(1+(1+(((2*tprop_qpsk12r)+(2*ttrans_qpsk12)
)/ttrans_qpsk12)-1)*Plos_totqpsk12)))*Wdata*8
through_qpsk34r=((1-
Plos_totqpsk34)/(ttrans_qpsk34*(1+(1+(((2*tprop_qpsk34r)+(2*ttrans_qpsk34)
)/ttrans_qpsk34)-1)*Plos_totqpsk34)))*Wdata*8
through_16qam12r=((1-
Plos_tot16qam12)/(ttrans_16qam12*(1+(1+(((2*tprop_16qam12r)+(2*ttrans_1
6qam12))/ttrans_16qam12)-1)*Plos_tot16qam12)))*Wdata*8
```

```
through_16qam34r=((1-
Plos_tot16qam34)/(ttrans_16qam34*(1+(1+(((2*tprop_16qam34r)+(2*ttrans_1
6qam34))/ttrans_16qam34)-1)*Plos_tot16qam34)))*Wdata*8
through_64qam23r=((1-
Plos_tot64qam23)/(ttrans_64qam23*(1+(1+(((2*tprop_64qam23r)+(2*ttrans_6
4qam23))/ttrans_64qam23)-1)*Plos_tot64qam23)))*Wdata*8
through_64qam34r=((1-
Plos_tot64qam34)/(ttrans_64qam34*(1+(1+(((2*tprop_64qam34r)+(2*ttrans_6
4qam34))/ttrans_64qam34)-1)*Plos_tot64qam34)))*Wdata*8

x1=[2176.66 1879.15 1720.54 1333.6 1221.03 979.45 901.18];
y1=[2.3667e+007 3.2695e+007 3.8146e+007 5.3937e+007 6.0136e+007
6.9731e+007 7.5884e+007];
plot(x1,y1);
grid on;
xlabel('Jarak (m)');
ylabel('Throughput (bps)');
title('Grafik Pengaruh Jarak terhadap Throughput Daerah Urban');

x2=[2839.96 2420.88 2199.72 1667.92 1515.55 1192.77 1089.59];
y2=[2.3667e+007 3.2695e+007 3.8145e+007 5.3936e+007 6.0135e+007
6.9727e+007 7.5881e+007];
plot(x2,y2);
grid on;
xlabel('Jarak (m)');
ylabel('Throughput (bps)');
title('Grafik Pengaruh Jarak terhadap Throughput Daerah Suburban');

x3=[13346.97 11261.13 10169.54 7574.96 6840.69 5301.5 4814.8];
y3=[2.3660e+007 3.2693e+007 3.8144e+007 5.3923e+007 6.0127e+007
6.9648e+007 7.5810e+007];
plot(x3,y3);
grid on;
xlabel('Jarak (m)');
ylabel('Throughput (bps)');
title('Grafik Pengaruh Jarak terhadap Throughput Daerah Rural');
```