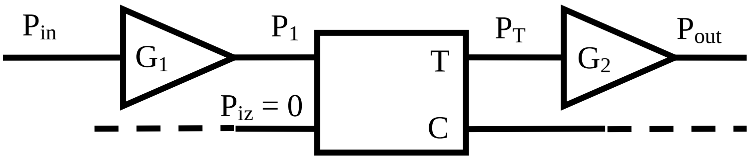
Subject no. 1

1. z = 0.735 + j·1.035; Y = 1 / 50Ω / (0.735 + j·1.035) = 0.0091S + j·(-0.0128)S ; Γ = (z-1)/(z+1) = (0.735 + j·1.035-1)/(0.735 + j·1.035+1) = 0.150+j·(0.507) = 0.529∠73.5°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.65mW = 2.17dBm ; P_1 = Pin + G_1 = 2.17dBm + 9.3dB = 11.47dBm = 14.04mW ; Pc = P_1 – C = 11.47dBm - 4.25dB = 7.22dBm = 5.28mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 14.04mW - 5.28mW = 8.77mW= 9.43dBm ; Pout = P_T + G_2 = 9.43dBm + 11.1dB = 20.53dBm = 112.92**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.323 + j·0.314 + 1)/[1 − (-0.323 + j·0.314)] = 21.56Ω + j·16.98Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 10.78Ω + j·8.49Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.614+j·0.225 = 0.654∠159.8°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.654, arg(Γ) = 159.8°
θ_{S1} = 165.5° ; Im(y_S) = -1.729 ; θ_{P1} = 120.0° **and** θ_{S2} = 34.7° ; Im(y_S) = 1.729 ; θ_{P2} = 60.0°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.90dB): G(1,2) = G_1 + G_2 = 8.3 + 11.6 = 19.9dB; G(1,4) = G_1 + G_4 = 8.3 + 8.0 = 16.3dB; G(2,3) = G_2 + G_3 = 11.6 + 6.5 = 18.1dB; G(2,4) = G_2 + G_4 = 11.6 + 8.0 = 19.6dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.92dB=1.236, F_2 = 1.23dB=1.327, F_3 = 0.50dB=1.122, F_4 = 0.85dB=1.216, G_3 = 6.5dB=4.467, G_4 = 8.0dB=6.310;
F(4,1) = 1.216 + (1.236−1)/6.310 = 1.254 = 0.98dB; F(3,2) = 1.122 + (1.327−1)/4.467 = 1.195 = 0.77dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

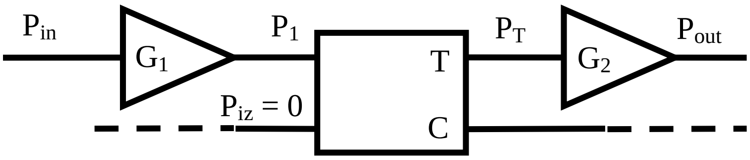
f [GHz]	Δ	|Δ|	K	μ
1.4	0.216+ j·(-0.302)	0.372	0.601	0.551
3.1	-0.031+ j·(-0.576)	0.577	0.959	0.911

b) μ (1.4GHz) < μ (3.1 GHz) so the transistor has better stability at 3.1 GHz
c) we use S parameters for f = 3.1 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 36.22 = 15.59dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.150, U_minus = -1.217dB, U_plus = 1.416dB (L8/2021, S142)

Subject no. 2

1. $z = 1.190 + j\cdot1.110$; $Y = 1 / 50\Omega / (1.190 + j\cdot1.110) = 0.0090S + j\cdot(-0.0084)S$; $\Gamma = (z-1)/(z+1) = (1.190 + j\cdot1.110-1)/(1.190 + j\cdot1.110+1) = 0.273+j\cdot(0.368) = 0.459\angle53.4°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.15mW = 3.32dBm ; P_1 = Pin + G_1 = 3.32dBm + 8.2dB = 11.52dBm = 14.20mW ; Pc = P_1 – C = 11.52dBm - 6.25dB = 5.27dBm = 3.37mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 14.20mW - 3.37mW = 10.84mW= 10.35dBm ; Pout = $P_T + G_2$ = 10.35dBm + 10.5dB = 20.85dBm = 121.59**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.296 + j\cdot0.365 + 1)/[1 - (-0.296 + j\cdot0.365)] = 21.49\Omega + j\cdot20.13\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 10.74\Omega + j\cdot10.07\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.602+j\cdot0.266 = 0.658\angle156.2°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.658$, $\arg(\Gamma) = 156.2°$
$\theta_{S1} = 167.5°$; $Im(y_S) = -1.748$; $\theta_{P1} = 119.8°$ **and** $\theta_{S2} = 36.3°$; $Im(y_S) = 1.748$; $\theta_{P2} = 60.2°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.60dB): $G(1,2) = G_1 + G_2 = 8.4 + 10.5 = 18.9dB$; $G(1,4) = G_1 + G_4 = 8.4 + 7.4 = 15.8dB$; $G(2,3) = G_2 + G_3 = 10.5 + 5.8 = 16.3dB$; $G(2,4) = G_2 + G_4 = 10.5 + 7.4 = 17.9dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.97dB=1.250, F_2 = 1.28dB=1.343, F_3 = 0.53dB=1.130, F_4 = 0.84dB=1.213, G_3 = 5.8dB=3.802, G_4 = 7.4dB=5.495;
F(4,1) = 1.213 + (1.250−1)/5.495 = 1.259 = 1.00dB; F(3,2) = 1.130 + (1.343−1)/3.802 = 1.220 = 0.86dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
0.1	0.275+ j·(0.048)	0.280	0.112	0.095
1.5	0.429+ j·(-0.311)	0.530	0.188	0.212

b) μ (0.1GHz) < μ (1.5 GHz) so the transistor has better stability at 1.5 GHz

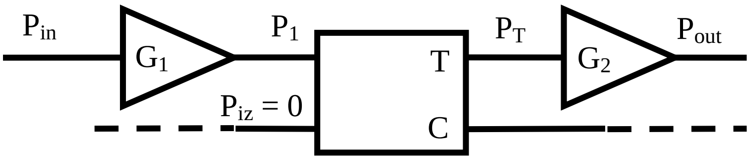
c) we use S parameters for f = 1.5 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 1029.20 = 30.12dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 1.717$, U_minus = -8.683dB, U_plus = 2.885dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 3

1. $z = 1.260 - j\cdot 0.850$; $Y = 1 / 50\Omega / (1.260 - j\cdot 0.850) = 0.0109S + j\cdot(0.0074)S$; $\Gamma = (z-1)/(z+1) = (1.260 - j\cdot 0.850-1)/(1.260 - j\cdot 0.850+1) = 0.225+j\cdot(-0.292) = 0.368\angle -52.4°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.15mW = 0.61dBm ; P_1 = Pin + G_1 = 0.61dBm + 6.0dB = 6.61dBm = 4.58mW ; Pc = P_1 – C = 6.61dBm - 4.85dB = 1.76dBm = 1.50mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 4.58mW - 1.50mW = 3.08mW= 4.88dBm ; Pout = $P_T + G_2$ = 4.88dBm + 10.1dB = 14.98dBm = 31.51**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.272 + j\cdot 0.688 + 1)/[1 - (-0.272 + j\cdot 0.688)] = 10.82\Omega + j\cdot 32.90\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 5.41\Omega + j\cdot 16.45\Omega$;

$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.659+j\cdot 0.492 = 0.822\angle 143.2°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.822$, $\arg(\Gamma) = 143.2°$

$\theta_{S1} = 1.0°$; $Im(y_S) = -2.889$; $\theta_{P1} = 109.1°$ **and** $\theta_{S2} = 35.7°$; $Im(y_S) = 2.889$; $\theta_{P2} = 70.9°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 14.35dB): $G(1,2) = G_1 + G_2 = 8.3 + 10.2 = 18.5dB$; $G(1,4) = G_1 + G_4 = 8.3 + 8.2 = 16.5dB$; $G(2,3) = G_2 + G_3 = 10.2 + 5.8 = 16.0dB$; $G(2,4) = G_2 + G_4 = 10.2 + 8.2 = 18.4dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 1.05dB=1.274, F_2 = 1.20dB=1.318, F_3 = 0.57dB=1.140, F_4 = 0.78dB=1.197, G_3 = 5.8dB=3.802, G_4 = 8.2dB=6.607;

$F(4,1) = 1.197 + (1.274-1)/6.607 = 1.238$ = 0.93dB; $F(3,2) = 1.140 + (1.318-1)/3.802 = 1.224$ = 0.88dB;

$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
3.1	-0.058+ j·(-0.345)	0.350	0.952	0.970
2.0	0.355+ j·(-0.385)	0.523	0.229	0.836

b) μ' (3.1GHz) > μ' (2.0 GHz) so the transistor has better stability at 3.1 GHz

c) we use S parameters for f = 3.1 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

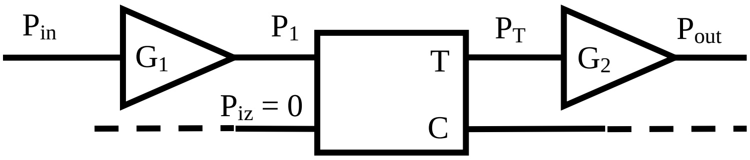
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 37.08$ = 15.69dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.044$, U_minus = -0.372dB, U_plus = 0.389dB (L8/2021, S142)

Subject no. 4

1. z = 1.045 − j·0.955; Y = 1 / 50Ω / (1.045 − j·0.955) = 0.0104S + j·(0.0095)S ; Γ = (z-1)/(z+1) = (1.045 − j·0.955-1)/(1.045 − j·0.955+1) = 0.197+j·(-0.375) = 0.424∠-62.3°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.80mW = 2.55dBm ; P_1 = Pin + G_1 = 2.55dBm + 9.5dB = 12.05dBm = 16.04mW ; Pc = P_1 – C = 12.05dBm - 4.25dB = 7.80dBm = 6.03mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 16.04mW - 6.03mW = 10.01mW= 10.01dBm ; Pout = P_T + G_2 = 10.01dBm + 9.4dB = 19.41dBm = 87.21**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.186 + j·0.223 + 1)/[1 − (-0.186 + j·0.223)] = 31.44Ω + j·15.31Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 15.72Ω + j·7.66Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.501+j·0.175 = 0.531∠160.8°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.531, arg(Γ) = 160.8°
θ_{S1} = 160.7° ; Im(y_S) = -1.253 ; θ_{P1} = 128.6° **and** θ_{S2} = 38.6° ; Im(y_S) = 1.253 ; θ_{P2} = 51.4°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.05dB): G(1,2) = G_1 + G_2 = 8.0 + 11.2 = 19.2dB; G(1,4) = G_1 + G_4 = 8.0 + 8.6 = 16.6dB; G(2,3) = G_2 + G_3 = 11.2 + 5.7 = 16.9dB; G(2,4) = G_2 + G_4 = 11.2 + 8.6 = 19.8dB
b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.04dB=1.271, F_2 = 1.18dB=1.312, F_3 = 0.66dB=1.164, F_4 = 0.85dB=1.216, G_3 = 5.7dB=3.715, G_4 = 8.6dB=7.244;
F(4,1) = 1.216 + (1.271−1)/7.244 = 1.254 = 0.98dB; F(3,2) = 1.164 + (1.312−1)/3.715 = 1.248 = 0.96dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

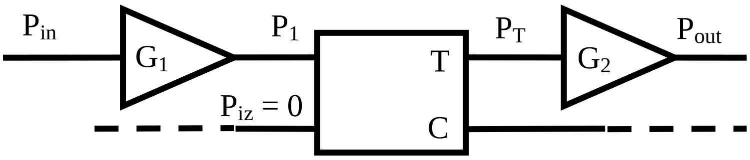
f [GHz]	Δ	|Δ|	K	μ
2.5	0.046+ j·(-0.344)	0.347	0.862	0.825
3.2	0.138+ j·(-0.486)	0.505	0.314	0.344

b) μ (2.5GHz) > μ (3.2 GHz) so the transistor has better stability at 2.5 GHz
c) we use S parameters for f = 2.5 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 55.64 = 17.45dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.063, U_minus = -0.530dB, U_plus = 0.564dB (L8/2021, S142)

Subject no. 5

1. $z = 1.225 + j\cdot1.045$; $Y = 1 / 50\Omega / (1.225 + j\cdot1.045) = 0.0094S + j\cdot(-0.0081)S$; $\Gamma = (z-1)/(z+1) = (1.225 + j\cdot1.045-1)/(1.225 + j\cdot1.045+1) = 0.264+j\cdot(0.346) = 0.435\angle52.7°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.15mW = 0.61dBm ; P_1 = Pin + G_1 = 0.61dBm + 8.9dB = 9.51dBm = 8.93mW ; Pc = P_1 – C = 9.51dBm - 5.50dB = 4.01dBm = 2.52mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 8.93mW - 2.52mW = 6.41mW= 8.07dBm ; Pout = $P_T + G_2$ = 8.07dBm + 11.9dB = 19.97dBm = 99.29**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.468 + j\cdot0.605 + 1)/[1 - (-0.468 + j\cdot0.605)] = 8.23\Omega + j\cdot24.00\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 4.11\Omega + j\cdot12.00\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.761+j\cdot0.391 = 0.856\angle152.8°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.856$, $\arg(\Gamma) = 152.8°$
$\theta_{S1} = 178.0°$; $Im(y_S) = -3.307$; $\theta_{P1} = 106.8°$ **and** $\theta_{S2} = 29.2°$; $Im(y_S) = 3.307$; $\theta_{P2} = 73.2°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 17.15dB): $G(1,2) = G_1 + G_2 = 8.9 + 11.6 = 20.5dB$; $G(1,4) = G_1 + G_4 = 8.9 + 8.6 = 17.5dB$; $G(2,3) = G_2 + G_3 = 11.6 + 6.9 = 18.5dB$; $G(2,4) = G_2 + G_4 = 11.6 + 8.6 = 20.2dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 0.93dB=1.239$, $F_2 = 1.20dB=1.318$, $F_3 = 0.64dB=1.159$, $F_4 = 0.71dB=1.178$, $G_3 = 6.9dB=4.898$, $G_4 = 8.6dB=7.244$;
$F(4,1) = 1.178 + (1.239-1)/7.244 = 1.211 = 0.83dB$; $F(3,2) = 1.159 + (1.318-1)/4.898 = 1.224 = 0.88dB$;
$F(4,1) < F(3,2)$ → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
0.5	0.437+ j·(0.045)	0.439	0.349	0.272
2.1	0.337+ j·(-0.397)	0.521	0.234	0.263

b) μ (0.5GHz) > μ (2.1 GHz) so the transistor has better stability at 0.5 GHz

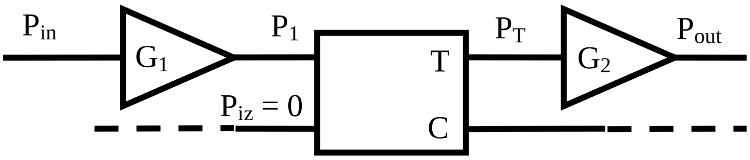
c) we use S parameters for f = 0.5 GHz and assume $S12 = 0\angle0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 1049.68 = 30.21dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2) = 0.474$, U_minus = -3.372dB, U_plus = 5.585dB (L8/2021, S142)

Subject no. 6

1. $z = 0.800 - j\cdot1.065$; $Y = 1 / 50\Omega / (0.800 - j\cdot1.065) = 0.0090S + j\cdot(0.0120)S$; $\Gamma = (z-1)/(z+1) = (0.800 - j\cdot1.065-1)/(0.800 - j\cdot1.065+1) = 0.177+j\cdot(-0.487) = 0.518\angle-70.0°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.60mW = 4.15dBm ; $P_1 = Pin + G_1$ = 4.15dBm + 6.4dB = 10.55dBm = 11.35mW ; $Pc = P_1 - C$ = 10.55dBm - 6.85dB = 3.70dBm = 2.34mW ; Lossless coupler: $P_T = P_1 - Pc - Piz$ = 11.35mW - 2.34mW = 9.01mW= 9.54dBm ; Pout = $P_T + G_2$ = 9.54dBm + 11.9dB = 21.44dBm = 139.48**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.184 + j\cdot0.176 + 1)/[1 - (0.184 + j\cdot0.176)] = 67.10\Omega + j\cdot25.26\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 33.55\Omega + j\cdot12.63\Omega$;

$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.170+j\cdot0.177 = 0.245\angle133.9°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.245$, $\arg(\Gamma) = 133.9°$

$\theta_{S1} = 165.2°$; $Im(y_S) = -0.506$; $\theta_{P1} = 153.1°$ **and** $\theta_{S2} = 61.0°$; $Im(y_S) = 0.506$; $\theta_{P2} = 26.9°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 15.45dB): $G(1,2) = G_1 + G_2 = 8.3 + 10.3 = 18.6dB$; $G(1,4) = G_1 + G_4 = 8.3 + 7.5 = 15.8dB$; $G(2,3) = G_2 + G_3 = 10.3 + 6.1 = 16.4dB$; $G(2,4) = G_2 + G_4 = 10.3 + 7.5 = 17.8dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 0.94dB=1.242, F_2 = 1.24dB=1.330, F_3 = 0.66dB=1.164, F_4 = 0.89dB=1.227, G_3 = 6.1dB=4.074, G_4 = 7.5dB=5.623;

$F(4,1) = 1.227 + (1.242-1)/5.623 = 1.270$ = 1.04dB; $F(3,2) = 1.164 + (1.330-1)/4.074 = 1.245$ = 0.95dB;

$F(4,1) > F(3,2) \rightarrow$ minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
1.2	0.482+ j·(-0.208)	0.525	0.641	0.723
2.8	0.215+ j·(-0.465)	0.512	0.285	0.802

b) μ' (1.2GHz) < μ' (2.8 GHz) so the transistor has better stability at 2.8 GHz

c) we use S parameters for f = 2.8 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

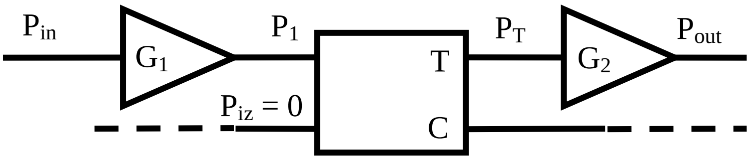
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 373.35 = 25.72dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 1.070$, U_minus = -6.319dB, U_plus = 23.118dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 7

1. z = 1.035 + j·0.745; Y = 1 / 50Ω / (1.035 + j·0.745) = 0.0127S + j·(-0.0092)S ; Γ = (z-1)/(z+1) = (1.035 + j·0.745-1)/(1.035 + j·0.745+1) = 0.133+j·(0.317) = 0.344∠67.2°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 4.05mW = 6.07dBm ; P_1 = Pin + G_1 = 6.07dBm + 8.7dB = 14.77dBm = 30.02mW ; Pc = P_1 – C = 14.77dBm - 5.50dB = 9.27dBm = 8.46mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 30.02mW - 8.46mW = 21.56mW= 13.34dBm ; Pout = P_T + G_2 = 13.34dBm + 10.3dB = 23.64dBm = 231.03**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.699 + j·0.258 + 1)/[1 − (-0.699 + j·0.258)] = 7.53Ω + j·8.74Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 3.77Ω + j·4.37Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.848+j·0.150 = 0.861∠170.0°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.861, arg(Γ) = 170.0°
θ_{S1} = 169.7° ; Im(y_S) = -3.384 ; θ_{P1} = 106.5° **and** θ_{S2} = 20.3° ; Im(y_S) = 3.384 ; θ_{P2} = 73.5°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 13.60dB): G(1,2) = G_1 + G_2 = 8.0 + 11.4 = 19.4dB; G(1,4) = G_1 + G_4 = 8.0 + 7.2 = 15.2dB; G(2,3) = G_2 + G_3 = 11.4 + 5.2 = 16.6dB; G(2,4) = G_2 + G_4 = 11.4 + 7.2 = 18.6dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.00dB=1.259, F_2 = 1.19dB=1.315, F_3 = 0.52dB=1.127, F_4 = 0.74dB=1.186, G_3 = 5.2dB=3.311, G_4 = 7.2dB=5.248;
F(4,1) = 1.186 + (1.259−1)/5.248 = 1.235 = 0.92dB; F(3,2) = 1.127 + (1.315−1)/3.311 = 1.222 = 0.87dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

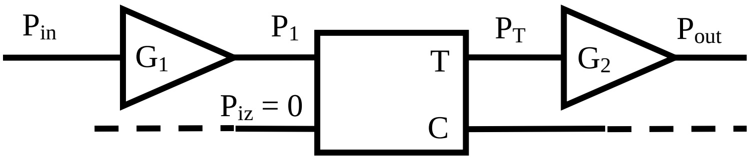
f [GHz]	Δ	|Δ|	K	μ
1.8	0.157+ j·(-0.322)	0.358	0.715	0.665
3.5	0.081+ j·(-0.492)	0.498	0.345	0.375

b) μ (1.8GHz) > μ (3.5 GHz) so the transistor has better stability at 1.8 GHz
c) we use S parameters for f = 1.8 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 104.32 = 20.18dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.108, U_minus = -0.888dB, U_plus = 0.989dB (L8/2021, S142)

Subject no. 8

1. z = 0.970 + j·1.190; Y = 1 / 50Ω / (0.970 + j·1.190) = 0.0082S + j·(-0.0101)S ; Γ = (z-1)/(z+1) = (0.970 + j·1.190-1)/(0.970 + j·1.190+1) = 0.256+j·(0.449) = 0.517∠60.3°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.10mW = 4.91dBm ; P_1 = Pin + G_1 = 4.91dBm + 9.0dB = 13.91dBm = 24.62mW ; Pc = P_1 – C = 13.91dBm - 5.20dB = 8.71dBm = 7.44mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 24.62mW - 7.44mW = 17.19mW= 12.35dBm ; Pout = P_T + G_2 = 12.35dBm + 8.3dB = 20.65dBm = 116.20**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.296 + j·0.359 + 1)/[1 − (-0.296 + j·0.359)] = 21.66Ω + j·19.85Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 10.83Ω + j·9.93Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.601+j·0.261 = 0.656∠156.5°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.656, arg(Γ) = 156.5°
θ_{S1} = 167.2° ; Im(y_S) = -1.736 ; θ_{P1} = 119.9° **and** θ_{S2} = 36.3° ; Im(y_S) = 1.736 ; θ_{P2} = 60.1°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.60dB): G(1,2) = G_1 + G_2 = 8.5 + 11.1 = 19.6dB; G(1,4) = G_1 + G_4 = 8.5 + 8.8 = 17.3dB; G(2,3) = G_2 + G_3 = 11.1 + 5.7 = 16.8dB; G(2,4) = G_2 + G_4 = 11.1 + 8.8 = 19.9dB
b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.95dB=1.245, F_2 = 1.25dB=1.334, F_3 = 0.54dB=1.132, F_4 = 0.79dB=1.199, G_3 = 5.7dB=3.715, G_4 = 8.8dB=7.586;
F(4,1) = 1.199 + (1.245−1)/7.586 = 1.232 = 0.91dB; F(3,2) = 1.132 + (1.334−1)/3.715 = 1.222 = 0.87dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

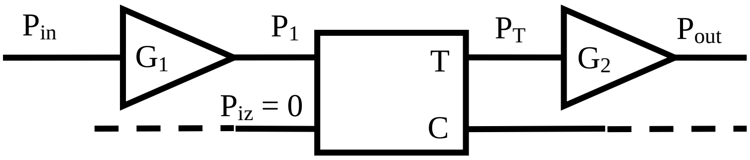
f [GHz]	Δ	|Δ|	K	μ
2.8	0.076+ j·(-0.565)	0.570	0.933	0.866
0.8	0.508+ j·(-0.179)	0.539	0.111	0.127

b) μ (2.8GHz) > μ (0.8 GHz) so the transistor has better stability at 2.8 GHz
c) we use S parameters for f = 2.8 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 43.68 = 16.40dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.150, U_minus = -1.212dB, U_plus = 1.408dB (L8/2021, S142)

Subject no. 9

1. z = 0.945 − j·1.160; Y = 1 / 50Ω / (0.945 − j·1.160) = 0.0084S + j·(0.0104)S ; Γ = (z-1)/(z+1) = (0.945 − j·1.160-1)/(0.945 − j·1.160+1) = 0.242+j·(-0.452) = 0.513∠-61.9°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.90mW = 4.62dBm ; P_1 = Pin + G_1 = 4.62dBm + 9.4dB = 14.02dBm = 25.26mW ; Pc = P_1 – C = 14.02dBm - 4.30dB = 9.72dBm = 9.38mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 25.26mW - 9.38mW = 15.87mW= 12.01dBm ; Pout = P_T + G_2 = 12.01dBm + 8.5dB = 20.51dBm = 112.38**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.119 + j·0.398 + 1)/[1 − (0.119 + j·0.398)] = 44.27Ω + j·42.59Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 22.13Ω + j·21.29Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.275+j·0.376 = 0.466∠126.2°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.466, arg(Γ) = 126.2°
θ_{S1} = 175.8° ; Im(y_S) = -1.054 ; θ_{P1} = 133.5° **and** θ_{S2} = 58.0° ; Im(y_S) = 1.054 ; θ_{P2} = 46.5°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.95dB): G(1,2) = G_1 + G_2 = 9.3 + 10.9 = 20.2dB; G(1,4) = G_1 + G_4 = 9.3 + 8.5 = 17.8dB; G(2,3) = G_2 + G_3 = 10.9 + 5.6 = 16.5dB; G(2,4) = G_2 + G_4 = 10.9 + 8.5 = 19.4dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.94dB=1.242, F_2 = 1.15dB=1.303, F_3 = 0.66dB=1.164, F_4 = 0.86dB=1.219, G_3 = 5.6dB=3.631, G_4 = 8.5dB=7.079;
F(4,1) = 1.219 + (1.242−1)/7.079 = 1.253 = 0.98dB; F(3,2) = 1.164 + (1.303−1)/3.631 = 1.248 = 0.96dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

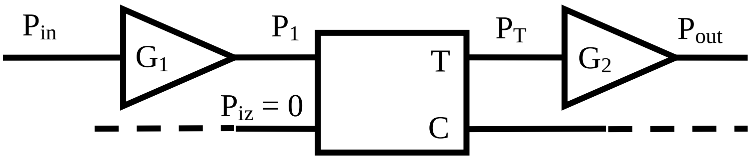
f [GHz]	Δ	|Δ|	K	μ'
1.8	0.384+ j·(-0.394)	0.550	0.795	0.832
2.5	0.270+ j·(-0.440)	0.516	0.262	0.811

b) μ' (1.8GHz) > μ' (2.5 GHz) so the transistor has better stability at 1.8 GHz
c) we use S parameters for f = 1.8 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 99.35 = 19.97dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.180, U_minus = -1.441dB, U_plus = 1.729dB (L8/2021, S142)

Subject no. 10

1. z = 0.980 + j·0.740; Y = 1 / 50Ω / (0.980 + j·0.740) = 0.0130S + j·(-0.0098)S ; Γ = (z-1)/(z+1) = (0.980 + j·0.740-1)/(0.980 + j·0.740+1) = 0.114+j·(0.331) = 0.350∠71.1°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.60mW = 2.04dBm ; P_1 = Pin + G_1 = 2.04dBm + 7.5dB = 9.54dBm = 9.00mW ; Pc = P_1 – C = 9.54dBm - 4.05dB = 5.49dBm = 3.54mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 9.00mW - 3.54mW = 5.46mW= 7.37dBm ; Pout = P_T + G_2 = 7.37dBm + 8.7dB = 16.07dBm = 40.45**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.065 + j·0.637 + 1)/[1 − (-0.065 + j·0.637)] = 19.16Ω + j·41.36Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 9.58Ω + j·20.68Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.498+j·0.520 = 0.720∠133.8°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.720, arg(Γ) = 133.8°
θ_{S1} = 1.1° ; Im(y_S) = -2.075 ; θ_{P1} = 115.7° **and** θ_{S2} = 45.1° ; Im(y_S) = 2.075 ; θ_{P2} = 64.3°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.35dB): G(1,2) = G_1 + G_2 = 9.3 + 10.2 = 19.5dB; G(1,4) = G_1 + G_4 = 9.3 + 7.4 = 16.7dB; G(2,3) = G_2 + G_3 = 10.2 + 6.9 = 17.1dB; G(2,4) = G_2 + G_4 = 10.2 + 7.4 = 17.6dB
b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.91dB=1.233, F_2 = 1.20dB=1.318, F_3 = 0.64dB=1.159, F_4 = 0.89dB=1.227, G_3 = 6.9dB=4.898, G_4 = 7.4dB=5.495;
F(4,1) = 1.227 + (1.233−1)/5.495 = 1.270 = 1.04dB; F(3,2) = 1.159 + (1.318−1)/4.898 = 1.224 = 0.88dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

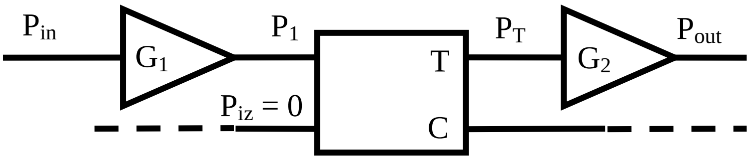
f [GHz]	Δ	|Δ|	K	μ
1.6	0.187+ j·(-0.311)	0.363	0.661	0.611
4.1	-0.022+ j·(-0.487)	0.488	0.399	0.428

b) μ (1.6GHz) > μ (4.1 GHz) so the transistor has better stability at 1.6 GHz
c) we use S parameters for f = 1.6 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 131.20 = 21.18dB
d) $U = |S_{11}| \cdot |S_{12}| \cdot |S_{21}| \cdot |S_{22}| / (1-|S_{11}|^2) / (1-|S_{22}|^2)$ = 0.131, U_minus = -1.067dB, U_plus = 1.217dB (L8/2021, S142)

Subject no. 11

1. $z = 0.750 + j\cdot 1.105$; $Y = 1 / 50\Omega / (0.750 + j\cdot 1.105) = 0.0084S + j\cdot(-0.0124)S$; $\Gamma = (z-1)/(z+1) = (0.750 + j\cdot 1.105-1)/(0.750 + j\cdot 1.105+1) = 0.183+j\cdot(0.516) = 0.547\angle 70.5°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.20mW = 5.05dBm ; P_1 = Pin + G_1 = 5.05dBm + 7.3dB = 12.35dBm = 17.19mW ; Pc = P_1 – C = 12.35dBm - 6.60dB = 5.75dBm = 3.76mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 17.19mW - 3.76mW = 13.43mW= 11.28dBm ; Pout = $P_T + G_2$ = 11.28dBm + 10.3dB = 21.58dBm = 143.86**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.713 + j\cdot 0.180 + 1)/[1 - (0.713 + j\cdot 0.180)] = 200.07\Omega + j\cdot 156.84\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 100.03\Omega + j\cdot 78.42\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = 0.476+j\cdot 0.274 = 0.549\angle 29.9°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.549$, $\arg(\Gamma) = 29.9°$
$\theta_{S1} = 46.7°$; $Im(y_S) = -1.315$; $\theta_{P1} = 127.2°$ **and** $\theta_{S2} = 103.4°$; $Im(y_S) = 1.315$; $\theta_{P2} = 52.8°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.40dB): $G(1,2) = G_1 + G_2 = 9.7 + 10.6 = 20.3dB$; $G(1,4) = G_1 + G_4 = 9.7 + 8.3 = 18.0dB$; $G(2,3) = G_2 + G_3 = 10.6 + 6.0 = 16.6dB$; $G(2,4) = G_2 + G_4 = 10.6 + 8.3 = 18.9dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.99dB=1.256, F_2 = 1.18dB=1.312, F_3 = 0.65dB=1.161, F_4 = 0.77dB=1.194, G_3 = 6.0dB=3.981, G_4 = 8.3dB=6.761;
F(4,1) = 1.194 + (1.256−1)/6.761 = 1.232 = 0.91dB; F(3,2) = 1.161 + (1.312−1)/3.981 = 1.240 = 0.93dB;
F(4,1) < F(3,2) → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
1.4	0.461+ j·(-0.278)	0.538	0.699	0.574
2.4	0.289+ j·(-0.431)	0.519	0.254	0.278

b) μ (1.4GHz) > μ (2.4 GHz) so the transistor has better stability at 1.4 GHz

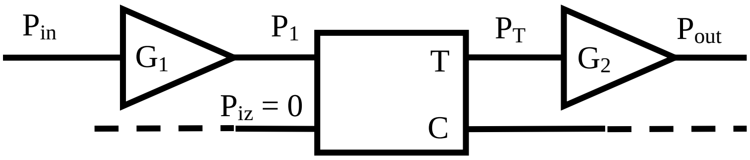
c) we use S parameters for f = 1.4 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 160.09 = 22.04dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.215$, U_minus = -1.691dB, U_plus = 2.101dB (L8/2021, S142)

Subject no. 12

1. $z = 0.750 - j\cdot 0.940$; $Y = 1 / 50\Omega / (0.750 - j\cdot 0.940) = 0.0104S + j\cdot(0.0130)S$; $\Gamma = (z-1)/(z+1) = (0.750 - j\cdot 0.940-1)/(0.750 - j\cdot 0.940+1) = 0.113+j\cdot(-0.476) = 0.490\angle -76.7°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.95mW = 5.97dBm ; $P_1 = Pin + G_1$ = 5.97dBm + 6.9dB = 12.87dBm = 19.35mW ; $Pc = P_1 - C$ = 12.87dBm - 4.70dB = 8.17dBm = 6.56mW ; Lossless coupler: $P_T = P_1 - Pc - Piz$ = 19.35mW - 6.56mW = 12.79mW= 11.07dBm ; $Pout = P_T + G_2$ = 11.07dBm + 11.2dB = 22.27dBm = 168.62**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.379 + j\cdot 0.251 + 1)/[1 - (-0.379 + j\cdot 0.251)] = 20.19\Omega + j\cdot 12.78\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 10.10\Omega + j\cdot 6.39\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.645+j\cdot 0.175 = 0.669\angle 164.8°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.669$, $\arg(\Gamma) = 164.8°$
$\theta_{S1} = 163.6°$; $Im(y_S) = -1.799$; $\theta_{P1} = 119.1°$ **and** $\theta_{S2} = 31.6°$; $Im(y_S) = 1.799$; $\theta_{P2} = 60.9°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.60dB): $G(1,2) = G_1 + G_2 = 9.0 + 10.8 = 19.8dB$; $G(1,4) = G_1 + G_4 = 9.0 + 8.0 = 17.0dB$; $G(2,3) = G_2 + G_3 = 10.8 + 6.0 = 16.8dB$; $G(2,4) = G_2 + G_4 = 10.8 + 8.0 = 18.8dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 0.97dB=1.250$, $F_2 = 1.13dB=1.297$, $F_3 = 0.51dB=1.125$, $F_4 = 0.83dB=1.211$, $G_3 = 6.0dB=3.981$, $G_4 = 8.0dB=6.310$;
$F(4,1) = 1.211 + (1.250-1)/6.310 = 1.250 = 0.97dB$; $F(3,2) = 1.125 + (1.297-1)/3.981 = 1.199 = 0.79dB$;
$F(4,1) > F(3,2) \rightarrow$ minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
1.6	0.424+ j·(-0.335)	0.541	0.754	0.802
2.6	0.252+ j·(-0.449)	0.515	0.270	0.809

b) μ' (1.6GHz) < μ' (2.6 GHz) so the transistor has better stability at 2.6 GHz

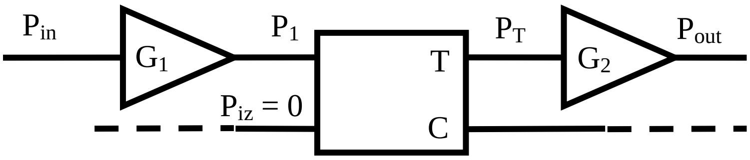
c) we use S parameters for f = 2.6 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 421.63 = 26.25dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 1.144$, U_minus = -6.625dB, U_plus = 16.819dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 13

1. $z = 0.890 - j \cdot 0.950$; $Y = 1 / 50\Omega / (0.890 - j \cdot 0.950) = 0.0105S + j \cdot (0.0112)S$; $\Gamma = (z-1)/(z+1) = (0.890 - j \cdot 0.950-1)/(0.890 - j \cdot 0.950+1) = 0.155+j \cdot (-0.425) = 0.452\angle -69.9°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.25mW = 5.12dBm ; P_1 = Pin + G_1 = 5.12dBm + 6.6dB = 11.72dBm = 14.86mW ; Pc = P_1 – C = 11.72dBm - 5.25dB = 6.47dBm = 4.43mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 14.86mW - 4.43mW = 10.42mW= 10.18dBm ; Pout = $P_T + G_2$ = 10.18dBm + 11.9dB = 22.08dBm = 161.39**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega \cdot (1+\Gamma)/(1-\Gamma) = 50\Omega \cdot (0.062 + j \cdot 0.446 + 1)/[1 - (0.062 + j \cdot 0.446)] = 36.95\Omega + j \cdot 41.34\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 18.48\Omega + j \cdot 20.67\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.338+j \cdot 0.404 = 0.527\angle 129.9°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.527$, $\arg(\Gamma) = 129.9°$
$\theta_{S1} = 175.9°$; $Im(y_S) = -1.240$; $\theta_{P1} = 128.9°$ **and** $\theta_{S2} = 54.1°$; $Im(y_S) = 1.240$; $\theta_{P2} = 51.1°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.65dB): $G(1,2) = G_1 + G_2 = 9.2 + 10.1 = 19.3dB$; $G(1,4) = G_1 + G_4 = 9.2 + 7.1 = 16.3dB$; $G(2,3) = G_2 + G_3 = 10.1 + 5.3 = 15.4dB$; $G(2,4) = G_2 + G_4 = 10.1 + 7.1 = 17.2dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.00dB=1.259, F_2 = 1.21dB=1.321, F_3 = 0.59dB=1.146, F_4 = 0.70dB=1.175, G_3 = 5.3dB=3.388, G_4 = 7.1dB=5.129;
$F(4,1) = 1.175 + (1.259-1)/5.129 = 1.225 = 0.88dB$; $F(3,2) = 1.146 + (1.321-1)/3.388 = 1.240 = 0.94dB$;
$F(4,1) < F(3,2)$ → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

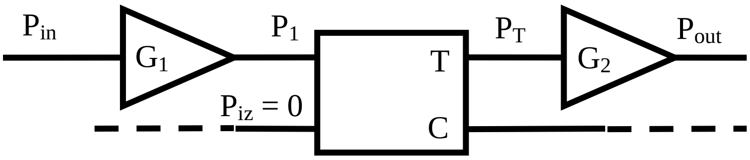
f [GHz]	Δ	|Δ|	K	μ
1.2	0.250+ j·(-0.294)	0.386	0.538	0.489
3.8	0.027+ j·(-0.492)	0.493	0.371	0.402

b) μ (1.2GHz) > μ (3.8 GHz) so the transistor has better stability at 1.2 GHz
c) we use S parameters for f = 1.2 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 232.30 = 23.66dB$
d) $U = |S_{11}| \cdot |S_{12}| \cdot |S_{21}| \cdot |S_{22}| / (1-|S_{11}|^2) / (1-|S_{22}|^2) = 0.213$, U_minus = -1.674dB, U_plus = 2.075dB (L8/2021, S142)

Subject no. 14

1. z = 0.830 − j·0.955; Y = 1 / 50Ω / (0.830 − j·0.955) = 0.0104S + j·(0.0119)S ; Γ = (z-1)/(z+1) = (0.830 − j·0.955-1)/(0.830 − j·0.955+1) = 0.141+j·(-0.448) = 0.470∠-72.5°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.55mW = 4.07dBm ; P_1 = Pin + G_1 = 4.07dBm + 6.4dB = 10.47dBm = 11.13mW ; Pc = P_1 – C = 10.47dBm - 4.10dB = 6.37dBm = 4.33mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 11.13mW - 4.33mW = 6.80mW= 8.33dBm ; Pout = P_T + G_2 = 8.33dBm + 9.4dB = 17.73dBm = 59.23**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.006 + j·0.340 + 1)/[1 − (0.006 + j·0.340)] = 40.07Ω + j·30.81Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 20.03Ω + j·15.40Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.362+j·0.300 = 0.470∠140.4°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.470, arg(Γ) = 140.4°
θ_{S1} = 168.8° ; Im(y_S) = -1.065 ; θ_{P1} = 133.2° **and** θ_{S2} = 50.8° ; Im(y_S) = 1.065 ; θ_{P2} = 46.8°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.70dB): G(1,2) = G_1 + G_2 = 9.4 + 10.5 = 19.9dB; G(1,4) = G_1 + G_4 = 9.4 + 8.1 = 17.5dB; G(2,3) = G_2 + G_3 = 10.5 + 5.1 = 15.6dB; G(2,4) = G_2 + G_4 = 10.5 + 8.1 = 18.6dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.04dB=1.271, F_2 = 1.25dB=1.334, F_3 = 0.62dB=1.153, F_4 = 0.77dB=1.194, G_3 = 5.1dB=3.236, G_4 = 8.1dB=6.457;
F(4,1) = 1.194 + (1.271−1)/6.457 = 1.236 = 0.92dB; F(3,2) = 1.153 + (1.334−1)/3.236 = 1.257 = 0.99dB;
F(4,1) < F(3,2) → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

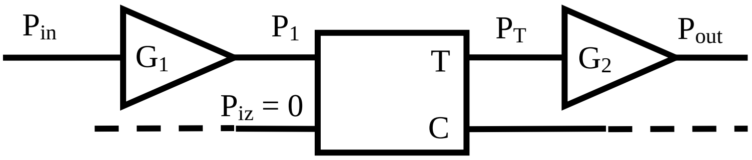
f [GHz]	Δ	|Δ|	K	μ
1.1	0.268+ j·(-0.287)	0.392	0.507	0.460
3.0	0.177+ j·(-0.477)	0.509	0.297	0.326

b) μ (1.1GHz) > μ (3.0 GHz) so the transistor has better stability at 1.1 GHz
c) we use S parameters for f = 1.1 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 275.89 = 24.41dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.243, U_minus = -1.892dB, U_plus = 2.422dB (L8/2021, S142)

Subject no. 15

1. $z = 0.795 - j\cdot0.735$; $Y = 1 / 50\Omega / (0.795 - j\cdot0.735) = 0.0136S + j\cdot(0.0125)S$; $\Gamma = (z-1)/(z+1) = (0.795 - j\cdot0.735-1)/(0.795 - j\cdot0.735+1) = 0.046+j\cdot(-0.391) = 0.393\angle-83.3°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. $P_{in} = 2.85mW = 4.55dBm$; $P_1 = P_{in} + G_1 = 4.55dBm + 7.9dB = 12.45dBm = 17.57mW$; $P_c = P_1 - C = 12.45dBm - 5.15dB = 7.30dBm = 5.37mW$; Lossless coupler: $P_T = P_1 - P_c - P_{iz} = 17.57mW - 5.37mW = 12.20mW= 10.87dBm$; $P_{out} = P_T + G_2 = 10.87dBm + 10.0dB = 20.87dBm = 122.05$**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.210 + j\cdot0.145 + 1)/[1 - (-0.210 + j\cdot0.145)] = 31.47\Omega + j\cdot9.76\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 15.74\Omega + j\cdot4.88\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.513+j\cdot0.112 = 0.525\angle167.6°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.525$, $\arg(\Gamma) = 167.6°$
$\theta_{S1} = 157.0°$; $\mathrm{Im}(y_S) = -1.234$; $\theta_{P1} = 129.0°$ **and** $\theta_{S2} = 35.3°$; $\mathrm{Im}(y_S) = 1.234$; $\theta_{P2} = 51.0°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations ($G > 16.10dB$): $G(1,2) = G_1 + G_2 = 9.0 + 11.9 = 20.9dB$; $G(1,4) = G_1 + G_4 = 9.0 + 7.8 = 16.8dB$; $G(2,3) = G_2 + G_3 = 11.9 + 6.7 = 18.6dB$; $G(2,4) = G_2 + G_4 = 11.9 + 7.8 = 19.7dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 1.03dB=1.268$, $F_2 = 1.24dB=1.330$, $F_3 = 0.67dB=1.167$, $F_4 = 0.71dB=1.178$, $G_3 = 6.7dB=4.677$, $G_4 = 7.8dB=6.026$;
$F(4,1) = 1.178 + (1.268-1)/6.026 = 1.222 = 0.87dB$; $F(3,2) = 1.167 + (1.330-1)/4.677 = 1.237 = 0.93dB$;
$F(4,1) < F(3,2) \rightarrow$ minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
2.2	0.275+ j·(-0.485)	0.558	0.862	0.763
3.2	-0.064+ j·(-0.575)	0.578	0.966	0.925

b) μ (2.2GHz) < μ (3.2 GHz) so the transistor has better stability at 3.2 GHz

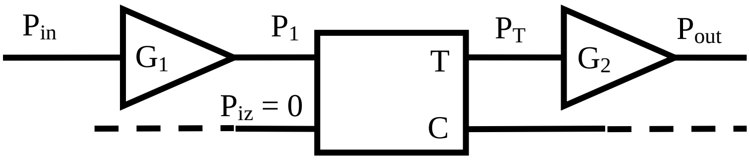
c) we use S parameters for f = 3.2 GHz and assume $S12 = 0\angle0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 34.28 = 15.35dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.152$, U_minus = -1.231dB, U_plus = 1.435dB (L8/2021, S142)

Subject no. 16

1. $z = 0.810 - j\cdot 0.770$; $Y = 1 / 50\Omega / (0.810 - j\cdot 0.770) = 0.0130S + j\cdot(0.0123)S$; $\Gamma = (z-1)/(z+1) = (0.810 - j\cdot 0.770-1)/(0.810 - j\cdot 0.770+1) = 0.064+j\cdot(-0.398) = 0.403\angle -80.8°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. $Pin = 3.75mW = 5.74dBm$; $P_1 = Pin + G_1 = 5.74dBm + 8.9dB = 14.64dBm = 29.11mW$; $Pc = P_1 – C = 14.64dBm - 6.55dB = 8.09dBm = 6.44mW$; Lossless coupler: $P_T = P_1 – Pc – Piz = 29.11mW - 6.44mW = 22.67mW= 13.55dBm$; $Pout = P_T + G_2 = 13.55dBm + 9.6dB = 23.15dBm = 206.73$**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.099 + j\cdot 0.092 + 1)/[1 - (0.099 + j\cdot 0.092)] = 59.84\Omega + j\cdot 11.22\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 29.92\Omega + j\cdot 5.61\Omega$;

$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.245+j\cdot 0.087 = 0.260\angle 160.4°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.260$, $\arg(\Gamma) = 160.4°$

$\theta_{S1} = 152.4°$; $Im(y_S) = -0.539$; $\theta_{P1} = 151.7°$ **and** $\theta_{S2} = 47.3°$; $Im(y_S) = 0.539$; $\theta_{P2} = 28.3°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 14.30dB): $G(1,2) = G_1 + G_2 = 8.0 + 10.7 = 18.7dB$; $G(1,4) = G_1 + G_4 = 8.0 + 7.7 = 15.7dB$; $G(2,3) = G_2 + G_3 = 10.7 + 5.0 = 15.7dB$; $G(2,4) = G_2 + G_4 = 10.7 + 7.7 = 18.4dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

$F_1 = 1.00dB=1.259$, $F_2 = 1.25dB=1.334$, $F_3 = 0.52dB=1.127$, $F_4 = 0.71dB=1.178$, $G_3 = 5.0dB=3.162$, $G_4 = 7.7dB=5.888$;

$F(4,1) = 1.178 + (1.259-1)/5.888 = 1.222 = 0.87dB$; $F(3,2) = 1.127 + (1.334-1)/3.162 = 1.233 = 0.91dB$;

$F(4,1) < F(3,2) \rightarrow$ minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
0.2	0.324+ j·(0.084)	0.335	0.188	0.151
3.0	0.007+ j·(-0.572)	0.572	0.952	0.900

b) μ (0.2GHz) < μ (3.0 GHz) so the transistor has better stability at 3.0 GHz

c) we use S parameters for f = 3.0 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)

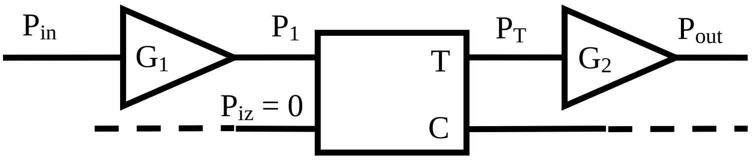
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 38.54 = 15.86dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.150$, U_minus = -1.212dB, U_plus = 1.409dB (L8/2021, S142)

Subject no. 17

1. $z = 1.105 - j\cdot 1.140$; $Y = 1 / 50\Omega / (1.105 - j\cdot 1.140) = 0.0088S + j\cdot(0.0090)S$; $\Gamma = (z-1)/(z+1) = (1.105 - j\cdot 1.140-1)/(1.105 - j\cdot 1.140+1) = 0.265+j\cdot(-0.398) = 0.478\angle -56.3°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.75mW = 2.43dBm ; P_1 = Pin + G_1 = 2.43dBm + 8.7dB = 11.13dBm = 12.97mW ; Pc = P_1 – C = 11.13dBm - 4.30dB = 6.83dBm = 4.82mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 12.97mW - 4.82mW = 8.15mW= 9.11dBm ; Pout = $P_T + G_2$ = 9.11dBm + 10.0dB = 19.11dBm = 81.53**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.065 + j\cdot 0.107 + 1)/[1 - (0.065 + j\cdot 0.107)] = 55.57\Omega + j\cdot 12.08\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 27.78\Omega + j\cdot 6.04\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.278+j\cdot 0.099 = 0.295\angle 160.3°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.295$, $\arg(\Gamma) = 160.3°$
$\theta_{S1} = 153.4°$; $Im(y_S) = -0.618$; $\theta_{P1} = 148.3°$ **and** $\theta_{S2} = 46.2°$; $Im(y_S) = 0.618$; $\theta_{P2} = 31.7°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.70dB): $G(1,2) = G_1 + G_2 = 9.9 + 11.4 = 21.3dB$; $G(1,4) = G_1 + G_4 = 9.9 + 7.1 = 17.0dB$; $G(2,3) = G_2 + G_3 = 11.4 + 5.9 = 17.3dB$; $G(2,4) = G_2 + G_4 = 11.4 + 7.1 = 18.5dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.03dB=1.268, F_2 = 1.29dB=1.346, F_3 = 0.68dB=1.169, F_4 = 0.83dB=1.211, G_3 = 5.9dB=3.890, G_4 = 7.1dB=5.129;
$F(4,1) = 1.211 + (1.268-1)/5.129 = 1.263$ = 1.01dB; $F(3,2) = 1.169 + (1.346-1)/3.890 = 1.258$ = 1.00dB;
$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
2.2	0.093+ j·(-0.339)	0.351	0.800	0.755
3.1	0.156+ j·(-0.482)	0.507	0.302	0.331

b) μ (2.2GHz) > μ (3.1 GHz) so the transistor has better stability at 2.2 GHz

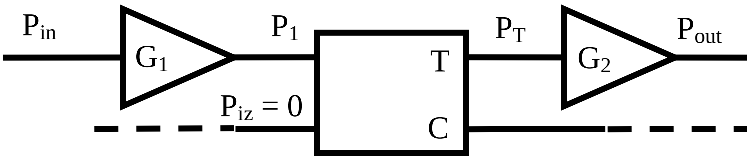
c) we use S parameters for f = 2.2 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 71.34$ = 18.53dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.079$, U_minus = -0.663dB, U_plus = 0.718dB (L8/2021, S142)

Subject no. 18

1. z = 0.810 − j·1.140; Y = 1 / 50Ω / (0.810 − j·1.140) = 0.0083S + j·(0.0117)S ; Γ = (z-1)/(z+1) = (0.810 − j·1.140-1)/(0.810 − j·1.140+1) = 0.209+j·(-0.498) = 0.540∠-67.3°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.45mW = 5.38dBm ; P_1 = Pin + G_1 = 5.38dBm + 9.0dB = 14.38dBm = 27.40mW ; Pc = P_1 – C = 14.38dBm - 4.60dB = 9.78dBm = 9.50mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 27.40mW - 9.50mW = 17.90mW= 12.53dBm ; Pout = P_T + G_2 = 12.53dBm + 8.8dB = 21.33dBm = 135.80**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.503 + j·0.257 + 1)/[1 − (-0.503 + j·0.257)] = 14.64Ω + j·11.05Ω

b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 7.32Ω + j·5.53Ω;

Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.728+j·0.167 = 0.747∠167.1°;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.747, arg(Γ) = 167.1°

θ_{S1} = 165.6° ; Im(y_S) = -2.249 ; θ_{P1} = 114.0° **and** θ_{S2} = 27.3° ; Im(y_S) = 2.249 ; θ_{P2} = 66.0°, all lines with Z_0 = 50Ω

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 14.30dB): G(1,2) = G_1 + G_2 = 8.2 + 10.9 = 19.1dB; G(1,4) = G_1 + G_4 = 8.2 + 7.0 = 15.2dB; G(2,3) = G_2 + G_3 = 10.9 + 5.0 = 15.9dB; G(2,4) = G_2 + G_4 = 10.9 + 7.0 = 17.9dB

b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise.   From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 1.03dB=1.268, F_2 = 1.14dB=1.300, F_3 = 0.55dB=1.135, F_4 = 0.79dB=1.199, G_3 = 5.0dB=3.162, G_4 = 7.0dB=5.012;

F(4,1) = 1.199 + (1.268−1)/5.012 = 1.253 = 0.98dB; F(3,2) = 1.135 + (1.300−1)/3.162 = 1.230 = 0.90dB; F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either µ or µ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	µ'
0.8	0.495+ j·(-0.064)	0.499	0.488	0.626
1.0	0.490+ j·(-0.218)	0.536	0.130	0.895

b) µ' (0.8GHz) < µ' (1.0 GHz) so the transistor has better stability at 1.0 GHz

c) we use S parameters for f = 1.0 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

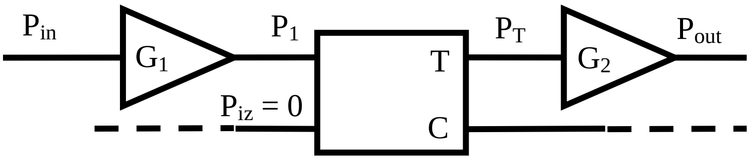
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 2196.07 = 33.42dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 2.578, U_minus = -11.073dB, U_plus = -3.963dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 19

1. z = 0.765 + j·1.005; Y = 1 / 50Ω / (0.765 + j·1.005) = 0.0096S + j·(-0.0126)S ; Γ = (z-1)/(z+1) = (0.765 + j·1.005-1)/(0.765 + j·1.005+1) = 0.144+j·(0.487) = 0.508∠73.5°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 4.05mW = 6.07dBm ; P_1 = Pin + G_1 = 6.07dBm + 6.4dB = 12.47dBm = 17.68mW ; Pc = P_1 – C = 12.47dBm - 6.80dB = 5.67dBm = 3.69mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 17.68mW - 3.69mW = 13.99mW= 11.46dBm ; Pout = P_T + G_2 = 11.46dBm + 9.4dB = 20.86dBm = 121.81**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.281 + j·0.668 + 1)/[1 − (-0.281 + j·0.668)] = 11.37Ω + j·32.00Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 5.69Ω + j·16.00Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.659+j·0.477 = 0.813∠144.1°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.813, arg(Γ) = 144.1°
θ_{S1} = 0.1° ; Im(y_S) = -2.794 ; θ_{P1} = 109.7° **and** θ_{S2} = 35.7° ; Im(y_S) = 2.794 ; θ_{P2} = 70.3°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.80dB): G(1,2) = G_1 + G_2 = 9.1 + 10.3 = 19.4dB; G(1,4) = G_1 + G_4 = 9.1 + 7.1 = 16.2dB; G(2,3) = G_2 + G_3 = 10.3 + 5.6 = 15.9dB; G(2,4) = G_2 + G_4 = 10.3 + 7.1 = 17.4dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.92dB=1.236, F_2 = 1.27dB=1.340, F_3 = 0.51dB=1.125, F_4 = 0.70dB=1.175, G_3 = 5.6dB=3.631, G_4 = 7.1dB=5.129;
F(4,1) = 1.175 + (1.236−1)/5.129 = 1.221 = 0.87dB; F(3,2) = 1.125 + (1.340−1)/3.631 = 1.218 = 0.86dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

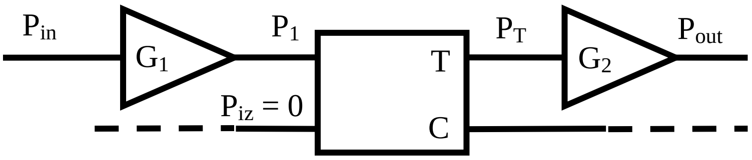
f [GHz]	Δ	|Δ|	K	μ'
2.9	-0.024+ j·(-0.347)	0.348	0.922	0.951
1.8	0.388+ j·(-0.355)	0.526	0.207	0.843

b) μ' (2.9GHz) > μ' (1.8 GHz) so the transistor has better stability at 2.9 GHz
c) we use S parameters for f = 2.9 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 42.21 = 16.25dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.049, U_minus = -0.418dB, U_plus = 0.439dB (L8/2021, S142)

Subject no. 20

1. $z = 1.230 - j\cdot 0.950$; $Y = 1 / 50\Omega / (1.230 - j\cdot 0.950) = 0.0102S + j\cdot(0.0079)S$; $\Gamma = (z-1)/(z+1) = (1.230 - j\cdot 0.950-1)/(1.230 - j\cdot 0.950+1) = 0.241+j\cdot(-0.323) = 0.403\angle -53.3°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.75mW = 5.74dBm ; P_1 = Pin + G_1 = 5.74dBm + 8.6dB = 14.34dBm = 27.17mW ; Pc = P_1 – C = 14.34dBm - 4.40dB = 9.94dBm = 9.86mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 27.17mW - 9.86mW = 17.30mW= 12.38dBm ; Pout = $P_T + G_2$ = 12.38dBm + 11.9dB = 24.28dBm = 267.99**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.193 + j\cdot 0.052 + 1)/[1 - (0.193 + j\cdot 0.052)] = 73.40\Omega + j\cdot 7.95\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 36.70\Omega + j\cdot 3.98\Omega$;

$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.151+j\cdot 0.053 = 0.160\angle 160.7°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.160$, $\arg(\Gamma) = 160.7°$

$\theta_{S1} = 149.2°$; $Im(y_S) = -0.324$; $\theta_{P1} = 162.0°$ **and** $\theta_{S2} = 50.0°$; $Im(y_S) = 0.324$; $\theta_{P2} = 18.0°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 15.70dB): $G(1,2) = G_1 + G_2 = 9.6 + 10.5 = 20.1dB$; $G(1,4) = G_1 + G_4 = 9.6 + 7.3 = 16.9dB$; $G(2,3) = G_2 + G_3 = 10.5 + 6.0 = 16.5dB$; $G(2,4) = G_2 + G_4 = 10.5 + 7.3 = 17.8dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 0.98dB=1.253, F_2 = 1.18dB=1.312, F_3 = 0.58dB=1.143, F_4 = 0.75dB=1.189, G_3 = 6.0dB=3.981, G_4 = 7.3dB=5.370;

$F(4,1) = 1.189 + (1.253-1)/5.370 = 1.236 = 0.92dB$; $F(3,2) = 1.143 + (1.312-1)/3.981 = 1.221 = 0.87dB$; $F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
1.1	0.493+ j·(-0.174)	0.523	0.609	0.699
1.1	0.478+ j·(-0.239)	0.535	0.153	0.891

b) μ' (1.1GHz) < μ' (1.1 GHz) so the transistor has better stability at 1.1 GHz

c) we use S parameters for f = 1.1 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

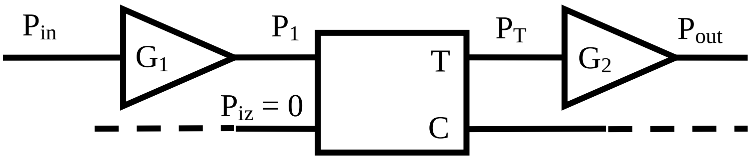
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 1668.44 = 32.22dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 2.099$, U_minus = -9.825dB, U_plus = -0.821dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 21

1. $z = 0.960 - j\cdot0.850$; $Y = 1 / 50\Omega / (0.960 - j\cdot0.850) = 0.0117S + j\cdot(0.0103)S$; $\Gamma = (z-1)/(z+1) = (0.960 - j\cdot0.850-1)/(0.960 - j\cdot0.850+1) = 0.141+j\cdot(-0.372) = 0.398\angle-69.2°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.10mW = 0.41dBm ; P_1 = Pin + G_1 = 0.41dBm + 7.7dB = 8.11dBm = 6.48mW ; Pc = P_1 – C = 8.11dBm - 4.50dB = 3.61dBm = 2.30mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 6.48mW - 2.30mW = 4.18mW= 6.21dBm ; Pout = P_T + G_2 = 6.21dBm + 8.3dB = 14.51dBm = 28.25**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.367 + j\cdot0.183 + 1)/[1 - (0.367 + j\cdot0.183)] = 95.79\Omega + j\cdot42.15\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 47.90\Omega + j\cdot21.07\Omega$;

$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = 0.024+j\cdot0.210 = 0.211\angle83.6°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.211$, $\arg(\Gamma) = 83.6°$

$\theta_{S1} = 9.3°$; $\mathrm{Im}(y_S) = -0.433$; $\theta_{P1} = 156.6°$ **and** $\theta_{S2} = 87.1°$; $\mathrm{Im}(y_S) = 0.433$; $\theta_{P2} = 23.4°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 15.50dB): $G(1,2) = G_1 + G_2 = 8.8 + 10.6 = 19.4$dB; $G(1,4) = G_1 + G_4 = 8.8 + 7.3 = 16.1$dB; $G(2,3) = G_2 + G_3 = 10.6 + 6.5 = 17.1$dB; $G(2,4) = G_2 + G_4 = 10.6 + 7.3 = 17.9$dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 0.92dB=1.236, F_2 = 1.17dB=1.309, F_3 = 0.53dB=1.130, F_4 = 0.75dB=1.189, G_3 = 6.5dB=4.467, G_4 = 7.3dB=5.370;

$F(4,1) = 1.189 + (1.236-1)/5.370 = 1.232 = 0.91$dB; $F(3,2) = 1.130 + (1.309-1)/4.467 = 1.199 = 0.79$dB;

$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
1.3	0.232+ j·(-0.294)	0.374	0.576	0.712
1.7	0.403+ j·(-0.340)	0.528	0.197	0.847

b) μ' (1.3GHz) < μ' (1.7 GHz) so the transistor has better stability at 1.7 GHz

c) we use S parameters for f = 1.7 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

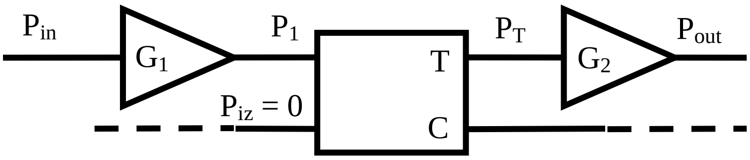
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 856.64 = 29.33$dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2) = 1.640$, U_minus = -8.432dB, U_plus = 3.876dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 22

1. $z = 1.205 - j\cdot1.270$; $Y = 1 / 50\Omega / (1.205 - j\cdot1.270) = 0.0079S + j\cdot(0.0083)S$; $\Gamma = (z-1)/(z+1) = (1.205 - j\cdot1.270-1)/(1.205 - j\cdot1.270+1) = 0.319+j\cdot(-0.392) = 0.506\angle-50.9°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.30mW = 5.19dBm ; P_1 = Pin + G_1 = 5.19dBm + 8.8dB = 13.99dBm = 25.03mW ; Pc = P_1 – C = 13.99dBm - 5.00dB = 8.99dBm = 7.92mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 25.03mW - 7.92mW = 17.12mW= 12.33dBm ; Pout = $P_T + G_2$ = 12.33dBm + 9.0dB = 21.33dBm = 135.96**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.606 + j\cdot0.132 + 1)/[1 - (-0.606 + j\cdot0.132)] = 11.85\Omega + j\cdot5.08\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 5.92\Omega + j\cdot2.54\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.784+j\cdot0.081 = 0.789\angle174.1°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.789$, $\arg(\Gamma) = 174.1°$
$\theta_{S1} = 164.0°$; $Im(y_S) = -2.565$; $\theta_{P1} = 111.3°$ **and** $\theta_{S2} = 21.9°$; $Im(y_S) = 2.565$; $\theta_{P2} = 68.7°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.40dB): $G(1,2) = G_1 + G_2 = 9.4 + 11.4 = 20.8dB$; $G(1,4) = G_1 + G_4 = 9.4 + 8.8 = 18.2dB$; $G(2,3) = G_2 + G_3 = 11.4 + 5.1 = 16.5dB$; $G(2,4) = G_2 + G_4 = 11.4 + 8.8 = 20.2dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.93dB=1.239, F_2 = 1.24dB=1.330, F_3 = 0.58dB=1.143, F_4 = 0.85dB=1.216, G_3 = 5.1dB=3.236, G_4 = 8.8dB=7.586;
F(4,1) = 1.216 + (1.239−1)/7.586 = 1.248 = 0.96dB; F(3,2) = 1.143 + (1.330−1)/3.236 = 1.245 = 0.95dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
1.0	0.501+ j·(-0.139)	0.520	0.571	0.454
3.3	-0.099+ j·(-0.571)	0.580	0.973	0.940

b) μ (1.0GHz) < μ (3.3 GHz) so the transistor has better stability at 3.3 GHz

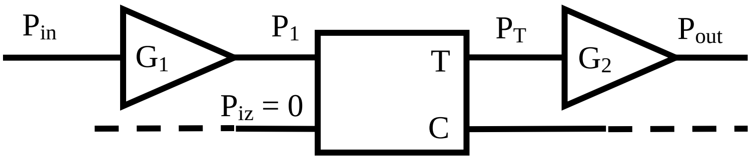
c) we use S parameters for f = 3.3 GHz and assume $S12 = 0\angle0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 32.49 = 15.12dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.153$, U_minus = -1.239dB, U_plus = 1.445dB (L8/2021, S142)

Subject no. 23

1. $z = 1.195 + j\cdot 0.920$; $Y = 1 / 50\Omega / (1.195 + j\cdot 0.920) = 0.0105S + j\cdot(-0.0081)S$; $\Gamma = (z-1)/(z+1) = (1.195 + j\cdot 0.920-1)/(1.195 + j\cdot 0.920+1) = 0.225+j\cdot(0.325) = 0.395\angle 55.3°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.15mW = 4.98dBm ; P_1 = Pin + G_1 = 4.98dBm + 7.0dB = 11.98dBm = 15.79mW ; Pc = P_1 – C = 11.98dBm - 4.55dB = 7.43dBm = 5.54mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 15.79mW - 5.54mW = 10.25mW= 10.11dBm ; Pout = $P_T + G_2$ = 10.11dBm + 11.0dB = 21.11dBm = 129.04**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.334 + j\cdot 0.212 + 1)/[1 - (0.334 + j\cdot 0.212)] = 86.34\Omega + j\cdot 43.40\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 43.17\Omega + j\cdot 21.70\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.018+j\cdot 0.237 = 0.238\angle 94.4°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.238$, $\arg(\Gamma) = 94.4°$
$\theta_{S1} = 4.7°$; $Im(y_S) = -0.490$; $\theta_{P1} = 153.9°$ **and** $\theta_{S2} = 80.9°$; $Im(y_S) = 0.490$; $\theta_{P2} = 26.1°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.65dB): $G(1,2) = G_1 + G_2 = 8.9 + 11.7 = 20.6$dB; $G(1,4) = G_1 + G_4 = 8.9 + 8.3 = 17.2$dB; $G(2,3) = G_2 + G_3 = 11.7 + 5.5 = 17.2$dB; $G(2,4) = G_2 + G_4 = 11.7 + 8.3 = 20.0$dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.05dB=1.274, F_2 = 1.15dB=1.303, F_3 = 0.52dB=1.127, F_4 = 0.85dB=1.216, G_3 = 5.5dB=3.548, G_4 = 8.3dB=6.761;
F(4,1) = 1.216 + (1.274−1)/6.761 = 1.257 = 0.99dB; F(3,2) = 1.127 + (1.303−1)/3.548 = 1.213 = 0.84dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

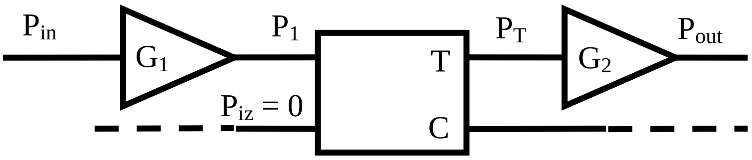
f [GHz]	Δ	|Δ|	K	μ'
2.1	0.305+ j·(-0.466)	0.557	0.848	0.872
3.6	0.064+ j·(-0.493)	0.497	0.350	0.785

b) μ' (2.1GHz) > μ' (3.6 GHz) so the transistor has better stability at 2.1 GHz
c) we use S parameters for f = 2.1 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 74.31 = 18.71$dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.165$, U_minus = -1.325dB, U_plus = 1.563dB (L8/2021, S142)

Subject no. 24

1. $z = 1.100 + j\cdot 1.285$; $Y = 1 / 50\Omega / (1.100 + j\cdot 1.285) = 0.0077S + j\cdot(-0.0090)S$; $\Gamma = (z-1)/(z+1) = (1.100 + j\cdot 1.285-1)/(1.100 + j\cdot 1.285+1) = 0.307+j\cdot(0.424) = 0.524\angle 54.1°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.65mW = 5.62dBm ; P_1 = Pin + G_1 = 5.62dBm + 9.0dB = 14.62dBm = 28.99mW ; Pc = P_1 – C = 14.62dBm - 4.70dB = 9.92dBm = 9.82mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 28.99mW - 9.82mW = 19.17mW= 12.83dBm ; Pout = $P_T + G_2$ = 12.83dBm + 9.1dB = 21.93dBm = 155.81**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.415 + j\cdot 0.337 + 1)/[1 - (-0.415 + j\cdot 0.337)] = 16.88\Omega + j\cdot 15.93\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 8.44\Omega + j\cdot 7.96\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.680+j\cdot 0.229 = 0.717\angle 161.4°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.717$, $\arg(\Gamma) = 161.4°$
$\theta_{S1} = 167.2°$; $Im(y_S) = -2.060$; $\theta_{P1} = 115.9°$ **and** $\theta_{S2} = 31.4°$; $Im(y_S) = 2.060$; $\theta_{P2} = 64.1°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.25dB): $G(1,2) = G_1 + G_2 = 9.2 + 11.7 = 20.9$dB; $G(1,4) = G_1 + G_4 = 9.2 + 7.2 = 16.4$dB; $G(2,3) = G_2 + G_3 = 11.7 + 6.2 = 17.9$dB; $G(2,4) = G_2 + G_4 = 11.7 + 7.2 = 18.9$dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.91dB=1.233, F_2 = 1.19dB=1.315, F_3 = 0.57dB=1.140, F_4 = 0.84dB=1.213, G_3 = 6.2dB=4.169, G_4 = 7.2dB=5.248;
$F(4,1) = 1.213 + (1.233-1)/5.248 = 1.258$ = 1.00dB; $F(3,2) = 1.140 + (1.315-1)/4.169 = 1.216$ = 0.85dB;
$F(4,1) > F(3,2) \rightarrow$ minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
3.0	-0.041+ j·(-0.349)	0.352	0.933	0.958
2.3	0.306+ j·(-0.420)	0.519	0.245	0.818

b) μ' (3.0GHz) > μ' (2.3 GHz) so the transistor has better stability at 3.0 GHz

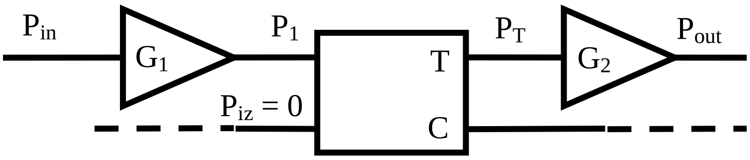
c) we use S parameters for f = 3.0 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 39.53$ = 15.97dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.047$, U_minus = -0.398dB, U_plus = 0.417dB (L8/2021, S142)

Subject no. 25

1. $z = 1.035 + j\cdot0.820$; $Y = 1 / 50\Omega / (1.035 + j\cdot0.820) = 0.0119S + j\cdot(-0.0094)S$; $\Gamma = (z-1)/(z+1) = (1.035 + j\cdot0.820-1)/(1.035 + j\cdot0.820+1) = 0.154+j\cdot(0.341) = 0.374\angle65.6°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.20mW = 0.79dBm ; P_1 = Pin + G_1 = 0.79dBm + 8.4dB = 9.19dBm = 8.30mW ; Pc = P_1 – C = 9.19dBm - 6.40dB = 2.79dBm = 1.90mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 8.30mW - 1.90mW = 6.40mW= 8.06dBm ; Pout = $P_T + G_2$ = 8.06dBm + 10.6dB = 18.66dBm = 73.48**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.658 + j\cdot0.359 + 1)/[1 - (0.658 + j\cdot0.359)] = 89.11\Omega + j\cdot146.03\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 44.56\Omega + j\cdot73.01\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = 0.337+j\cdot0.512 = 0.613\angle56.6°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.613$, $\arg(\Gamma) = 56.6°$
$\theta_{S1} = 35.6°$; $Im(y_S) = -1.551$; $\theta_{P1} = 122.8°$ **and** $\theta_{S2} = 87.8°$; $Im(y_S) = 1.551$; $\theta_{P2} = 57.2°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.40dB): $G(1,2) = G_1 + G_2 = 8.3 + 10.2 = 18.5dB$; $G(1,4) = G_1 + G_4 = 8.3 + 7.3 = 15.6dB$; $G(2,3) = G_2 + G_3 = 10.2 + 5.9 = 16.1dB$; $G(2,4) = G_2 + G_4 = 10.2 + 7.3 = 17.5dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.99dB=1.256, F_2 = 1.23dB=1.327, F_3 = 0.60dB=1.148, F_4 = 0.81dB=1.205, G_3 = 5.9dB=3.890, G_4 = 7.3dB=5.370;
$F(4,1) = 1.205 + (1.256-1)/5.370 = 1.253 = 0.98dB$; $F(3,2) = 1.148 + (1.327-1)/3.890 = 1.232 = 0.91dB$;
$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
1.5	0.444+ j·(-0.307)	0.540	0.727	0.781
4.6	-0.112+ j·(-0.459)	0.472	0.461	0.791

b) μ' (1.5GHz) < μ' (4.6 GHz) so the transistor has better stability at 4.6 GHz

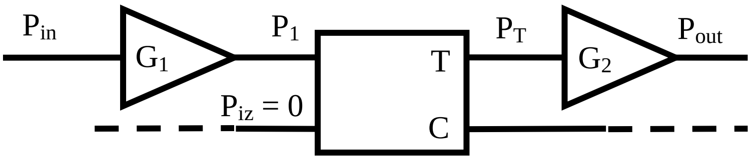
c) we use S parameters for f = 4.6 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 141.31 = 21.50dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.555$, U_minus = -3.833dB, U_plus = 7.028dB (L8/2021, S142)

Subject no. 26

1. z = 0.720 + j·1.235; Y = 1 / 50Ω / (0.720 + j·1.235) = 0.0070S + j·(-0.0121)S ; Γ = (z-1)/(z+1) = (0.720 + j·1.235-1)/(0.720 + j·1.235+1) = 0.233+j·(0.551) = 0.598∠67.1°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.75mW = 2.43dBm ; P_1 = Pin + G_1 = 2.43dBm + 7.0dB = 9.43dBm = 8.77mW ; Pc = P_1 – C = 9.43dBm - 5.95dB = 3.48dBm = 2.23mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 8.77mW - 2.23mW = 6.54mW= 8.16dBm ; Pout = P_T + G_2 = 8.16dBm + 9.7dB = 17.86dBm = 61.05**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.351 + j·0.499 + 1)/[1 − (0.351 + j·0.499)] = 46.84Ω + j·74.46Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 23.42Ω + j·37.23Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.083+j·0.549 = 0.556∠98.6°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.556, arg(Γ) = 98.6°
θ_{S1} = 12.6° ; Im(y_S) = -1.337 ; θ_{P1} = 126.8° **and** θ_{S2} = 68.8° ; Im(y_S) = 1.337 ; θ_{P2} = 53.2°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.80dB): G(1,2) = G_1 + G_2 = 8.5 + 10.7 = 19.2dB; G(1,4) = G_1 + G_4 = 8.5 + 8.2 = 16.7dB; G(2,3) = G_2 + G_3 = 10.7 + 5.8 = 16.5dB; G(2,4) = G_2 + G_4 = 10.7 + 8.2 = 18.9dB
b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.90dB=1.230, F_2 = 1.20dB=1.318, F_3 = 0.60dB=1.148, F_4 = 0.84dB=1.213, G_3 = 5.8dB=3.802, G_4 = 8.2dB=6.607;
F(4,1) = 1.213 + (1.230−1)/6.607 = 1.248 = 0.96dB; F(3,2) = 1.148 + (1.318−1)/3.802 = 1.232 = 0.91dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

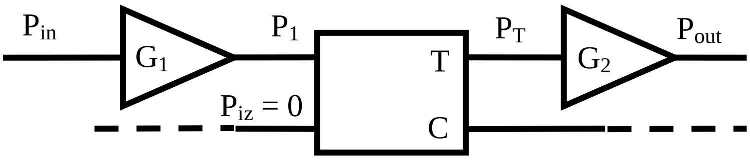
f [GHz]	Δ	|Δ|	K	μ
1.9	0.357+ j·(-0.418)	0.550	0.811	0.698
2.7	0.233+ j·(-0.458)	0.513	0.279	0.306

b) μ (1.9GHz) > μ (2.7 GHz) so the transistor has better stability at 1.9 GHz
c) we use S parameters for f = 1.9 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 90.26 = 19.56dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.175, U_minus = -1.398dB, U_plus = 1.666dB (L8/2021, S142)

Subject no. 27

1. $z = 1.220 - j\cdot 0.980$; $Y = 1 / 50\Omega / (1.220 - j\cdot 0.980) = 0.0100S + j\cdot(0.0080)S$; $\Gamma = (z-1)/(z+1) = (1.220 - j\cdot 0.980-1)/(1.220 - j\cdot 0.980+1) = 0.246+j\cdot(-0.333) = 0.414\angle{-53.5°}$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.90mW = 5.91dBm ; P_1 = Pin + G_1 = 5.91dBm + 7.1dB = 13.01dBm = 20.00mW ; Pc = P_1 – C = 13.01dBm - 5.75dB = 7.26dBm = 5.32mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 20.00mW - 5.32mW = 14.68mW= 11.67dBm ; Pout = $P_T + G_2$ = 11.67dBm + 10.7dB = 22.37dBm = 172.47**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.498 + j\cdot 0.110 + 1)/[1 - (0.498 + j\cdot 0.110)] = 140.08\Omega + j\cdot 41.65\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 70.04\Omega + j\cdot 20.83\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = 0.191+j\cdot 0.140 = 0.237\angle 36.3°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.237$, $\arg(\Gamma) = 36.3°$
$\theta_{S1} = 33.7°$; $Im(y_S) = -0.488$; $\theta_{P1} = 154.0°$ **and** $\theta_{S2} = 110.0°$; $Im(y_S) = 0.488$; $\theta_{P2} = 26.0°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 14.95dB): $G(1,2) = G_1 + G_2 = 8.3 + 11.9 = 20.2dB$; $G(1,4) = G_1 + G_4 = 8.3 + 7.3 = 15.6dB$; $G(2,3) = G_2 + G_3 = 11.9 + 6.1 = 18.0dB$; $G(2,4) = G_2 + G_4 = 11.9 + 7.3 = 19.2dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 0.99dB=1.256, F_2 = 1.10dB=1.288, F_3 = 0.65dB=1.161, F_4 = 0.74dB=1.186, G_3 = 6.1dB=4.074, G_4 = 7.3dB=5.370;

$F(4,1) = 1.186 + (1.256-1)/5.370 = 1.233 = 0.91dB$; $F(3,2) = 1.161 + (1.288-1)/4.074 = 1.232 = 0.91dB$;
$F(4,1) > F(3,2) \rightarrow$ minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
0.7	0.482+ j·(-0.024)	0.483	0.443	0.604
4.5	-0.093+ j·(-0.467)	0.476	0.442	0.785

b) μ' (0.7GHz) < μ' (4.5 GHz) so the transistor has better stability at 4.5 GHz

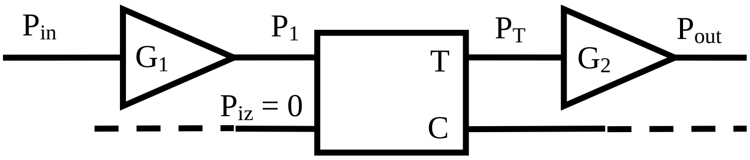
c) we use S parameters for f = 4.5 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 149.13 = 21.74dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.589$, U_minus = -4.021dB, U_plus = 7.716dB (L8/2021, S142)

Subject no. 28

1. $z = 1.095 + j\cdot 1.065$; $Y = 1 / 50\Omega / (1.095 + j\cdot 1.065) = 0.0094S + j\cdot(-0.0091)S$; $\Gamma = (z-1)/(z+1) = (1.095 + j\cdot 1.065-1)/(1.095 + j\cdot 1.065+1) = 0.241+j\cdot(0.386) = 0.455\angle 58.0°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.65mW = 4.23dBm ; P_1 = Pin + G_1 = 4.23dBm + 8.1dB = 12.33dBm = 17.11mW ; Pc = P_1 – C = 12.33dBm - 4.45dB = 7.88dBm = 6.14mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 17.11mW - 6.14mW = 10.97mW= 10.40dBm ; Pout = $P_T + G_2$ = 10.40dBm + 11.1dB = 21.50dBm = 141.30**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.018 + j\cdot 0.720 + 1)/[1 - (-0.018 + j\cdot 0.720)] = 15.48\Omega + j\cdot 46.31\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 7.74\Omega + j\cdot 23.16\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.492+j\cdot 0.598 = 0.775\angle 129.4°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.775$, $\arg(\Gamma) = 129.4°$
$\theta_{S1} = 5.7°$; $\mathrm{Im}(y_S) = -2.450$; $\theta_{P1} = 112.2°$ **and** $\theta_{S2} = 44.9°$; $\mathrm{Im}(y_S) = 2.450$; $\theta_{P2} = 67.8°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.30dB): $G(1,2) = G_1 + G_2 = 8.6 + 10.0 = 18.6$dB; $G(1,4) = G_1 + G_4 = 8.6 + 7.0 = 15.6$dB; $G(2,3) = G_2 + G_3 = 10.0 + 6.5 = 16.5$dB; $G(2,4) = G_2 + G_4 = 10.0 + 7.0 = 17.0$dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.93dB=1.239, F_2 = 1.16dB=1.306, F_3 = 0.67dB=1.167, F_4 = 0.78dB=1.197, G_3 = 6.5dB=4.467, G_4 = 7.0dB=5.012;
$F(4,1) = 1.197 + (1.239-1)/5.012 = 1.244 = 0.95$dB; $F(3,2) = 1.167 + (1.306-1)/4.467 = 1.235 = 0.92$dB;
$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

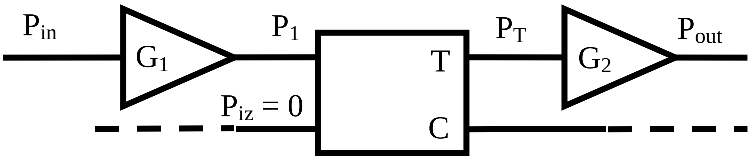
f [GHz]	Δ	|Δ|	K	μ'
2.0	0.334+ j·(-0.446)	0.557	0.828	0.856
0.9	0.498+ j·(-0.203)	0.538	0.121	0.909

b) μ' (2.0GHz) < μ' (0.9 GHz) so the transistor has better stability at 0.9 GHz
c) we use S parameters for f = 0.9 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 2614.62 = 34.17$dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 2.639$, U_minus = -11.220dB, U_plus = -4.292dB (L8/2021, S142) (irrelevant plus gain deviation, U>1)

Subject no. 29

1. $z = 1.010 - j\cdot 1.015$; $Y = 1 / 50\Omega / (1.010 - j\cdot 1.015) = 0.0099S + j\cdot(0.0099)S$; $\Gamma = (z-1)/(z+1) = (1.010 - j\cdot 1.015-1)/(1.010 - j\cdot 1.015+1) = 0.207+j\cdot(-0.400) = 0.451\angle -62.6°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.65mW = 4.23dBm ; P_1 = Pin + G_1 = 4.23dBm + 9.9dB = 14.13dBm = 25.90mW ; Pc = P_1 – C = 14.13dBm - 5.70dB = 8.43dBm = 6.97mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 25.90mW - 6.97mW = 18.93mW= 12.77dBm ; Pout = $P_T + G_2$ = 12.77dBm + 8.8dB = 21.57dBm = 143.57**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.485 + j\cdot 0.279 + 1)/[1 - (0.485 + j\cdot 0.279)] = 100.12\Omega + j\cdot 81.33\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 50.06\Omega + j\cdot 40.66\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = 0.142+j\cdot 0.349 = 0.376\angle 67.8°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.376$, $\arg(\Gamma) = 67.8°$
$\theta_{S1} = 22.2°$; $\mathrm{Im}(y_S) = -0.813$; $\theta_{P1} = 140.9°$ **and** $\theta_{S2} = 90.0°$; $\mathrm{Im}(y_S) = 0.813$; $\theta_{P2} = 39.1°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.10dB): $G(1,2) = G_1 + G_2 = 9.3 + 11.0 = 20.3$dB; $G(1,4) = G_1 + G_4 = 9.3 + 8.6 = 17.9$dB; $G(2,3) = G_2 + G_3 = 11.0 + 5.3 = 16.3$dB; $G(2,4) = G_2 + G_4 = 11.0 + 8.6 = 19.6$dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.08dB=1.282, F_2 = 1.28dB=1.343, F_3 = 0.64dB=1.159, F_4 = 0.76dB=1.191, G_3 = 5.3dB=3.388, G_4 = 8.6dB=7.244;
$F(4,1) = 1.191 + (1.282-1)/7.244 = 1.230 = 0.90$dB; $F(3,2) = 1.159 + (1.343-1)/3.388 = 1.260 = 1.00$dB;
$F(4,1) < F(3,2) \rightarrow$ minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

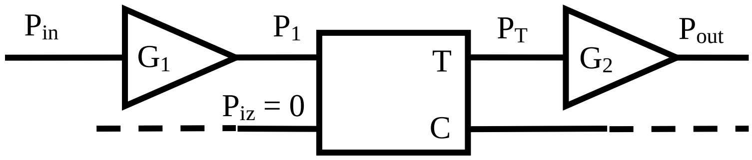
f [GHz]	Δ	|Δ|	K	μ'
2.3	0.245+ j·(-0.506)	0.563	0.874	0.893
1.2	0.466+ j·(-0.259)	0.533	0.162	0.886

b) μ' (2.3GHz) > μ' (1.2 GHz) so the transistor has better stability at 2.3 GHz
c) we use S parameters for f = 2.3 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 62.71 = 17.97$dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2) = 0.159$, U_minus = -1.285dB, U_plus = 1.508dB (L8/2021, S142)

Subject no. 30

1. z = 1.260 + j·1.295; Y = 1 / 50Ω / (1.260 + j·1.295) = 0.0077S + j·(-0.0079)S ; Γ = (z-1)/(z+1) = (1.260 + j·1.295-1)/(1.260 + j·1.295+1) = 0.334+j·(0.382) = 0.507∠48.8°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.85mW = 4.55dBm ; P_1 = Pin + G_1 = 4.55dBm + 8.0dB = 12.55dBm = 17.98mW ; Pc = P_1 – C = 12.55dBm - 6.15dB = 6.40dBm = 4.36mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 17.98mW - 4.36mW = 13.62mW= 11.34dBm ; Pout = P_T + G_2 = 11.34dBm + 11.7dB = 23.04dBm = 201.44**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.072 + j·0.459 + 1)/[1 − (-0.072 + j·0.459)] = 28.83Ω + j·33.75Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 14.42Ω + j·16.88Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.453+j·0.381 = 0.591∠139.9°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.591, arg(Γ) = 139.9°
θ_{S1} = 173.2° ; Im(y_S) = -1.467 ; θ_{P1} = 124.3° **and** θ_{S2} = 46.9° ; Im(y_S) = 1.467 ; θ_{P2} = 55.7°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.35dB): G(1,2) = G_1 + G_2 = 9.9 + 11.1 = 21.0dB; G(1,4) = G_1 + G_4 = 9.9 + 7.6 = 17.5dB; G(2,3) = G_2 + G_3 = 11.1 + 6.4 = 17.5dB; G(2,4) = G_2 + G_4 = 11.1 + 7.6 = 18.7dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.94dB=1.242, F_2 = 1.27dB=1.340, F_3 = 0.67dB=1.167, F_4 = 0.79dB=1.199, G_3 = 6.4dB=4.365, G_4 = 7.6dB=5.754;
F(4,1) = 1.199 + (1.242−1)/5.754 = 1.241 = 0.94dB; F(3,2) = 1.167 + (1.340−1)/4.365 = 1.245 = 0.95dB;
F(4,1) < F(3,2) → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

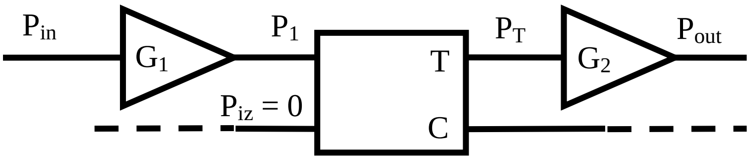
f [GHz]	Δ	|Δ|	K	μ
1.5	0.200+ j·(-0.302)	0.362	0.635	0.586
5.0	-0.166+ j·(-0.425)	0.457	0.515	0.550

b) μ (1.5GHz) > μ (5.0 GHz) so the transistor has better stability at 1.5 GHz
c) we use S parameters for f = 1.5 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 149.06 = 21.73dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2)$ = 0.144, U_minus = -1.171dB, U_plus = 1.354dB (L8/2021, S142)

Subject no. 31

1. $z = 1.120 - j\cdot 1.025$; $Y = 1 / 50\Omega / (1.120 - j\cdot 1.025) = 0.0097S + j\cdot(0.0089)S$; $\Gamma = (z-1)/(z+1) = (1.120 - j\cdot 1.025-1)/(1.120 - j\cdot 1.025+1) = 0.235+j\cdot(-0.370) = 0.438\angle -57.5°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 4.05mW = 6.07dBm ; P_1 = Pin + G_1 = 6.07dBm + 9.5dB = 15.57dBm = 36.10mW ; Pc = P_1 – C = 15.57dBm - 5.35dB = 10.22dBm = 10.53mW ; Lossless coupler: $P_T = P_1 - Pc - Piz$ = 36.10mW - 10.53mW = 25.57mW= 14.08dBm ; Pout = $P_T + G_2$ = 14.08dBm + 10.3dB = 24.38dBm = 273.93**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.066 + j\cdot 0.323 + 1)/[1 - (0.066 + j\cdot 0.323)] = 45.63\Omega + j\cdot 33.07\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 22.81\Omega + j\cdot 16.54\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.306+j\cdot 0.297 = 0.426\angle 135.9°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.426$, $\arg(\Gamma) = 135.9°$
$\theta_{S1} = 169.7°$; $Im(y_S) = -0.942$; $\theta_{P1} = 136.7°$ **and** $\theta_{S2} = 54.4°$; $Im(y_S) = 0.942$; $\theta_{P2} = 43.3°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.65dB): $G(1,2) = G_1 + G_2 = 8.5 + 11.8 = 20.3dB$; $G(1,4) = G_1 + G_4 = 8.5 + 7.8 = 16.3dB$; $G(2,3) = G_2 + G_3 = 11.8 + 5.7 = 17.5dB$; $G(2,4) = G_2 + G_4 = 11.8 + 7.8 = 19.6dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.99dB=1.256, F_2 = 1.12dB=1.294, F_3 = 0.67dB=1.167, F_4 = 0.72dB=1.180, G_3 = 5.7dB=3.715, G_4 = 7.8dB=6.026;
F(4,1) = 1.180 + (1.256−1)/6.026 = 1.223 = 0.87dB; F(3,2) = 1.167 + (1.294−1)/3.715 = 1.246 = 0.96dB;
F(4,1) < F(3,2) → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

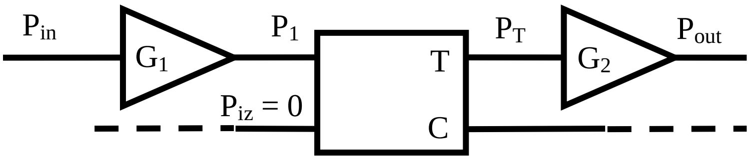
f [GHz]	Δ	|Δ|	K	μ
1.7	0.408+ j·(-0.368)	0.549	0.770	0.649
4.9	-0.151+ j·(-0.435)	0.461	0.497	0.530

b) μ (1.7GHz) > μ (4.9 GHz) so the transistor has better stability at 1.7 GHz
c) we use S parameters for f = 1.7 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 111.05 = 20.46dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.190$, U_minus = -1.508dB, U_plus = 1.827dB (L8/2021, S142)

Subject no. 32

1. $z = 0.925 - j\cdot 0.760$; $Y = 1 / 50\Omega / (0.925 - j\cdot 0.760) = 0.0129S + j\cdot(0.0106)S$; $\Gamma = (z-1)/(z+1) = (0.925 - j\cdot 0.760-1)/(0.925 - j\cdot 0.760+1) = 0.101+j\cdot(-0.355) = 0.369\angle -74.1°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.15mW = 0.61dBm ; P_1 = Pin + G_1 = 0.61dBm + 9.6dB = 10.21dBm = 10.49mW ; Pc = P_1 – C = 10.21dBm - 6.95dB = 3.26dBm = 2.12mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 10.49mW - 2.12mW = 8.37mW= 9.23dBm ; Pout = P_T + G_2 = 9.23dBm + 10.7dB = 19.93dBm = 98.35**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.093 + j\cdot 0.067 + 1)/[1 - (0.093 + j\cdot 0.067)] = 59.66\Omega + j\cdot 8.10\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 29.83\Omega + j\cdot 4.05\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.249+j\cdot 0.063 = 0.257\angle 165.7°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.257$, $\arg(\Gamma) = 165.7°$
$\theta_{S1} = 149.6°$; $Im(y_S) = -0.533$; $\theta_{P1} = 152.0°$ **and** $\theta_{S2} = 44.7°$; $Im(y_S) = 0.533$; $\theta_{P2} = 28.0°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 17.25dB): $G(1,2) = G_1 + G_2 = 9.8 + 10.7 = 20.5dB$; $G(1,4) = G_1 + G_4 = 9.8 + 7.9 = 17.7dB$; $G(2,3) = G_2 + G_3 = 10.7 + 6.8 = 17.5dB$; $G(2,4) = G_2 + G_4 = 10.7 + 7.9 = 18.6dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 1.06dB=1.276$, $F_2 = 1.20dB=1.318$, $F_3 = 0.56dB=1.138$, $F_4 = 0.72dB=1.180$, $G_3 = 6.8dB=4.786$, $G_4 = 7.9dB=6.166$;
$F(4,1) = 1.180 + (1.276-1)/6.166 = 1.225 = 0.88dB$; $F(3,2) = 1.138 + (1.318-1)/4.786 = 1.204 = 0.81dB$;
$F(4,1) > F(3,2) \rightarrow$ minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

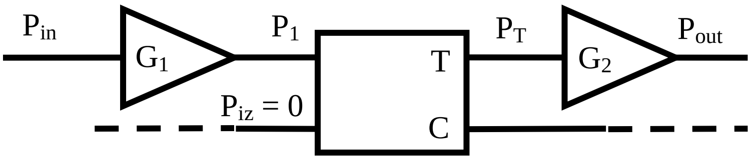
f [GHz]	Δ	|Δ|	K	μ
2.0	0.125+ j·(-0.330)	0.353	0.760	0.713
2.2	0.325+ j·(-0.407)	0.521	0.243	0.269

b) μ (2.0GHz) > μ (2.2 GHz) so the transistor has better stability at 2.0 GHz
c) we use S parameters for f = 2.0 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 85.05 = 19.30dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.092$, U_minus = -0.761dB, U_plus = 0.835dB (L8/2021, S142)

Subject no. 33

1. z = 1.095 − j·0.755; Y = 1 / 50Ω / (1.095 − j·0.755) = 0.0124S + j·(0.0085)S ; Γ = (z-1)/(z+1) = (1.095 − j·0.755-1)/(1.095 − j·0.755+1) = 0.155+j·(-0.304) = 0.342∠-63.0°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.95mW = 2.90dBm ; P_1 = Pin + G_1 = 2.90dBm + 8.2dB = 11.10dBm = 12.88mW ; Pc = P_1 – C = 11.10dBm - 5.55dB = 5.55dBm = 3.59mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 12.88mW - 3.59mW = 9.29mW= 9.68dBm ; Pout = P_T + G_2 = 9.68dBm + 10.4dB = 20.08dBm = 101.91**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.623 + j·0.246 + 1)/[1 − (-0.623 + j·0.246)] = 10.23Ω + j·9.13Ω

b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 5.12Ω + j·4.56Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.802+j·0.149 = 0.816∠169.5°;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.816, arg(Γ) = 169.5°
θ_{S1} = 167.6° ; Im(y_S) = -2.821 ; θ_{P1} = 109.5° **and** θ_{S2} = 22.9° ; Im(y_S) = 2.821 ; θ_{P2} = 70.5°, all lines with Z_0 = 50Ω

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.65dB): G(1,2) = G_1 + G_2 = 8.6 + 10.2 = 18.8dB; G(1,4) = G_1 + G_4 = 8.6 + 7.8 = 16.4dB; G(2,3) = G_2 + G_3 = 10.2 + 6.0 = 16.2dB; G(2,4) = G_2 + G_4 = 10.2 + 7.8 = 18.0dB

b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.08dB=1.282, F_2 = 1.18dB=1.312, F_3 = 0.55dB=1.135, F_4 = 0.71dB=1.178, G_3 = 6.0dB=3.981, G_4 = 7.8dB=6.026;
F(4,1) = 1.178 + (1.282−1)/6.026 = 1.224 = 0.88dB; F(3,2) = 1.135 + (1.312−1)/3.981 = 1.213 = 0.84dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
0.4	0.402+ j·(0.068)	0.408	0.250	0.557
5.3	-0.201+ j·(-0.397)	0.445	0.556	0.813

b) μ' (0.4GHz) < μ' (5.3 GHz) so the transistor has better stability at 5.3 GHz

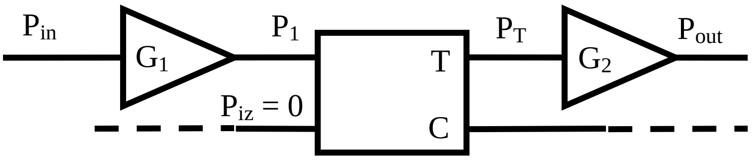
c) we use S parameters for f = 5.3 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 99.58 = 19.98dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.408, U_minus = -2.972dB, U_plus = 4.553dB (L8/2021, S142)

Subject no. 34

1. z = 1.005 + j·1.000; Y = 1 / 50Ω / (1.005 + j·1.000) = 0.0100S + j·(-0.0100)S ; Γ = (z-1)/(z+1) = (1.005 + j·1.000-1)/(1.005 + j·1.000+1) = 0.201+j·(0.398) = 0.446∠63.2°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.20mW = 0.79dBm ; P_1 = Pin + G_1 = 0.79dBm + 6.1dB = 6.89dBm = 4.89mW ; Pc = P_1 – C = 6.89dBm - 6.60dB = 0.29dBm = 1.07mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 4.89mW - 1.07mW = 3.82mW= 5.82dBm ; Pout = $P_T + G_2$ = 5.82dBm + 11.3dB = 17.12dBm = 51.52**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(-0.077 + j·0.311 + 1)/[1 − (-0.077 + j·0.311)] = 35.70Ω + j·24.75Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 17.85Ω + j·12.37Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.426+j·0.260 = 0.499∠148.6°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.499, arg(Γ) = 148.6°
θ_{S1} = 165.7° ; Im(y_S) = -1.153 ; θ_{P1} = 130.9° **and** θ_{S2} = 45.7° ; Im(y_S) = 1.153 ; θ_{P2} = 49.1°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.90dB): G(1,2) = $G_1 + G_2$ = 8.6 + 11.0 = 19.6dB; G(1,4) = $G_1 + G_4$ = 8.6 + 8.6 = 17.2dB; G(2,3) = $G_2 + G_3$ = 11.0 + 6.4 = 17.4dB; G(2,4) = $G_2 + G_4$ = 11.0 + 8.6 = 19.6dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.09dB=1.285, F_2 = 1.22dB=1.324, F_3 = 0.63dB=1.156, F_4 = 0.82dB=1.208, G_3 = 6.4dB=4.365, G_4 = 8.6dB=7.244;
F(4,1) = 1.208 + (1.285−1)/7.244 = 1.247 = 0.96dB; F(3,2) = 1.156 + (1.324−1)/4.365 = 1.230 = 0.90dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

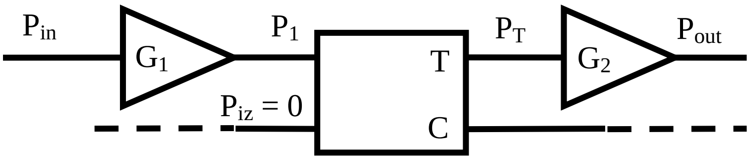
f [GHz]	Δ	|Δ|	K	μ
2.3	0.077+ j·(-0.339)	0.347	0.826	0.784
4.0	-0.009+ j·(-0.489)	0.489	0.387	0.418

b) μ (2.3GHz) > μ (4.0 GHz) so the transistor has better stability at 2.3 GHz
c) we use S parameters for f = 2.3 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 65.10 = 18.14dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.072, U_minus = -0.605dB, U_plus = 0.651dB (L8/2021, S142)

Subject no. 35

1. z = 1.135 + j·0.885; Y = 1 / 50Ω / (1.135 + j·0.885) = 0.0110S + j·(-0.0085)S ; Γ = (z-1)/(z+1) = (1.135 + j·0.885-1)/(1.135 + j·0.885+1) = 0.201+j·(0.331) = 0.387∠58.8°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.25mW = 0.97dBm ; P_1 = Pin + G_1 = 0.97dBm + 9.9dB = 10.87dBm = 12.22mW ; Pc = P_1 – C = 10.87dBm - 5.90dB = 4.97dBm = 3.14mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 12.22mW - 3.14mW = 9.08mW= 9.58dBm ; Pout = P_T + G_2 = 9.58dBm + 9.6dB = 19.18dBm = 82.77**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.191 + j·0.767 + 1)/[1 − (0.191 + j·0.767)] = 15.10Ω + j·61.72Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 7.55Ω + j·30.86Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.350+j·0.724 = 0.804∠115.8°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.804, arg(Γ) = 115.8°
θ_{S1} = 13.9° ; Im(y_S) = -2.701 ; θ_{P1} = 110.3° **and** θ_{S2} = 50.4° ; Im(y_S) = 2.701 ; θ_{P2} = 69.7°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.85dB): G(1,2) = G_1 + G_2 = 9.8 + 10.3 = 20.1dB; G(1,4) = G_1 + G_4 = 9.8 + 8.7 = 18.5dB; G(2,3) = G_2 + G_3 = 10.3 + 6.7 = 17.0dB; G(2,4) = G_2 + G_4 = 10.3 + 8.7 = 19.0dB
b) Friis formula (L8/2021, S177), F = F_a + (F_b−1)/G_a; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.08dB=1.282, F_2 = 1.12dB=1.294, F_3 = 0.62dB=1.153, F_4 = 0.73dB=1.183, G_3 = 6.7dB=4.677, G_4 = 8.7dB=7.413;
F(4,1) = 1.183 + (1.282−1)/7.413 = 1.221 = 0.87dB; F(3,2) = 1.153 + (1.294−1)/4.677 = 1.216 = 0.85dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

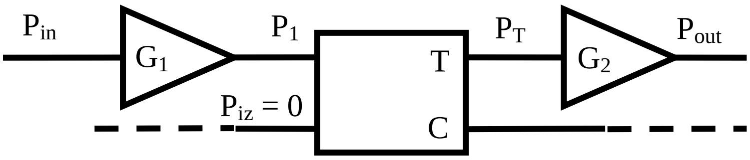
f [GHz]	Δ	|Δ|	K	μ'
2.8	-0.007+ j·(-0.350)	0.350	0.908	0.942
1.3	0.454+ j·(-0.280)	0.533	0.169	0.880

b) μ' (2.8GHz) > μ' (1.3 GHz) so the transistor has better stability at 2.8 GHz
c) we use S parameters for f = 2.8 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 44.84 = 16.52dB
d) U = $|S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2)$ = 0.052, U_minus = -0.443dB, U_plus = 0.467dB (L8/2021, S142)

Subject no. 36

1. $z = 0.725 - j\cdot0.960$; $Y = 1 / 50\Omega / (0.725 - j\cdot0.960) = 0.0100S + j\cdot(0.0133)S$; $\Gamma = (z-1)/(z+1) = (0.725 - j\cdot0.960-1)/(0.725 - j\cdot0.960+1) = 0.115+j\cdot(-0.493) = 0.506\angle-76.9°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.50mW = 3.98dBm ; P_1 = Pin + G_1 = 3.98dBm + 8.0dB = 11.98dBm = 15.77mW ; Pc = P_1 – C = 11.98dBm - 5.20dB = 6.78dBm = 4.76mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 15.77mW - 4.76mW = 11.01mW= 10.42dBm ; Pout = P_T + G_2 = 10.42dBm + 9.3dB = 19.72dBm = 93.71**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.093 + j\cdot0.068 + 1)/[1 - (0.093 + j\cdot0.068)] = 59.64\Omega + j\cdot8.22\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 29.82\Omega + j\cdot4.11\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.250+j\cdot0.064 = 0.258\angle165.5°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.258$, $\arg(\Gamma) = 165.5°$
$\theta_{S1} = 149.7°$; $Im(y_S) = -0.533$; $\theta_{P1} = 151.9°$ **and** $\theta_{S2} = 44.8°$; $Im(y_S) = 0.533$; $\theta_{P2} = 28.1°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.85dB): G(1,2) = $G_1 + G_2$ = 9.2 + 10.0 = 19.2dB; G(1,4) = $G_1 + G_4$ = 9.2 + 8.5 = 17.7dB; G(2,3) = $G_2 + G_3$ = 10.0 + 6.3 = 16.3dB; G(2,4) = $G_2 + G_4$ = 10.0 + 8.5 = 18.5dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.92dB=1.236, F_2 = 1.15dB=1.303, F_3 = 0.66dB=1.164, F_4 = 0.74dB=1.186, G_3 = 6.3dB=4.266, G_4 = 8.5dB=7.079;
F(4,1) = 1.186 + (1.236−1)/7.079 = 1.219 = 0.86dB; F(3,2) = 1.164 + (1.303−1)/4.266 = 1.235 = 0.92dB;
F(4,1) < F(3,2) → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

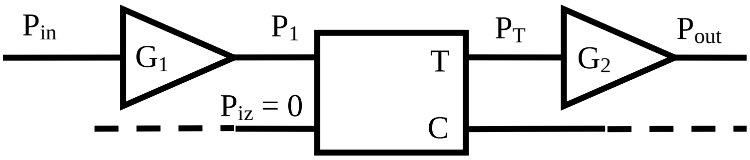
f [GHz]	Δ	|Δ|	K	μ
1.9	0.138+ j·(-0.322)	0.350	0.737	0.689
4.8	-0.137+ j·(-0.444)	0.464	0.484	0.517

b) μ (1.9GHz) > μ (4.8 GHz) so the transistor has better stability at 1.9 GHz
c) we use S parameters for f = 1.9 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 94.46 = 19.75dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2) = 0.100$, U_minus = -0.826dB, U_plus = 0.913dB (L8/2021, S142)

Subject no. 37

1. $z = 0.920 - j\cdot 0.915$; $Y = 1 / 50\Omega / (0.920 - j\cdot 0.915) = 0.0109S + j\cdot(0.0109)S$; $\Gamma = (z-1)/(z+1) = (0.920 - j\cdot 0.915-1)/(0.920 - j\cdot 0.915+1) = 0.151+j\cdot(-0.405) = 0.432\angle -69.5°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.15mW = 0.61dBm ; P_1 = Pin + G_1 = 0.61dBm + 8.9dB = 9.51dBm = 8.93mW ; Pc = P_1 – C = 9.51dBm - 4.50dB = 5.01dBm = 3.17mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 8.93mW - 3.17mW = 5.76mW= 7.60dBm ; Pout = $P_T + G_2$ = 7.60dBm + 8.9dB = 16.50dBm = 44.71**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.088 + j\cdot 0.785 + 1)/[1 - (-0.088 + j\cdot 0.785)] = 10.45\Omega + j\cdot 43.61\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 5.22\Omega + j\cdot 21.81\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.567+j\cdot 0.619 = 0.839\angle 132.5°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.839$, $\arg(\Gamma) = 132.5°$
$\theta_{S1} = 7.3°$; $Im(y_S) = -3.082$; $\theta_{P1} = 108.0°$ **and** $\theta_{S2} = 40.2°$; $Im(y_S) = 3.082$; $\theta_{P2} = 72.0°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.05dB): $G(1,2) = G_1 + G_2 = 8.1 + 11.2 = 19.3dB$; $G(1,4) = G_1 + G_4 = 8.1 + 8.5 = 16.6dB$; $G(2,3) = G_2 + G_3 = 11.2 + 6.9 = 18.1dB$; $G(2,4) = G_2 + G_4 = 11.2 + 8.5 = 19.7dB$

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.02dB=1.265, F_2 = 1.20dB=1.318, F_3 = 0.53dB=1.130, F_4 = 0.77dB=1.194, G_3 = 6.9dB=4.898, G_4 = 8.5dB=7.079;
F(4,1) = 1.194 + (1.265−1)/7.079 = 1.231 = 0.90dB; F(3,2) = 1.130 + (1.318−1)/4.898 = 1.195 = 0.77dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
2.7	0.011+ j·(-0.347)	0.347	0.895	0.934
3.3	0.119+ j·(-0.488)	0.502	0.325	0.791

b) μ' (2.7GHz) > μ' (3.3 GHz) so the transistor has better stability at 2.7 GHz

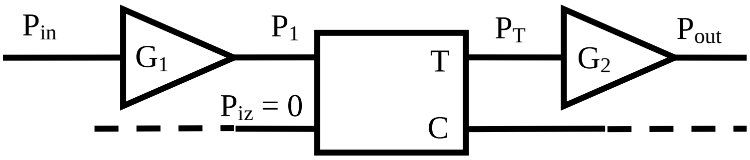
c) we use S parameters for f = 2.7 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 48.10 = 16.82dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.055$, U_minus = -0.468dB, U_plus = 0.495dB (L8/2021, S142)

Subject no. 38

1. $z = 1.010 - j\cdot 0.865$; $Y = 1 / 50\Omega / (1.010 - j\cdot 0.865) = 0.0114S + j\cdot(0.0098)S$; $\Gamma = (z-1)/(z+1) = (1.010 - j\cdot 0.865-1)/(1.010 - j\cdot 0.865+1) = 0.160+j\cdot(-0.361) = 0.395\angle -66.1°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.15mW = 3.32dBm ; P_1 = Pin + G_1 = 3.32dBm + 9.8dB = 13.12dBm = 20.53mW ; Pc = P_1 – C = 13.12dBm - 4.35dB = 8.77dBm = 7.54mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 20.53mW - 7.54mW = 12.99mW= 11.14dBm ; Pout = $P_T + G_2$ = 11.14dBm + 8.8dB = 19.94dBm = 98.55**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.318 + j\cdot 0.652 + 1)/[1 - (-0.318 + j\cdot 0.652)] = 10.96\Omega + j\cdot 30.15\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 5.48\Omega + j\cdot 15.08\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.679+j\cdot 0.456 = 0.818\angle 146.1°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.818$, $\arg(\Gamma) = 146.1°$
$\theta_{S1} = 179.4°$; $\text{Im}(y_S) = -2.840$; $\theta_{P1} = 109.4°$ **and** $\theta_{S2} = 34.5°$; $\text{Im}(y_S) = 2.840$; $\theta_{P2} = 70.6°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.75dB): $G(1,2) = G_1 + G_2 = 9.4 + 10.4 = 19.8$dB; $G(1,4) = G_1 + G_4 = 9.4 + 7.1 = 16.5$dB; $G(2,3) = G_2 + G_3 = 10.4 + 5.7 = 16.1$dB; $G(2,4) = G_2 + G_4 = 10.4 + 7.1 = 17.5$dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.96dB=1.247, F_2 = 1.21dB=1.321, F_3 = 0.61dB=1.151, F_4 = 0.73dB=1.183, G_3 = 5.7dB=3.715, G_4 = 7.1dB=5.129;
$F(4,1) = 1.183 + (1.247-1)/5.129 = 1.231 = 0.90$dB; $F(3,2) = 1.151 + (1.321-1)/3.715 = 1.237 = 0.92$dB;
$F(4,1) < F(3,2)$ → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
2.5	0.182+ j·(-0.534)	0.564	0.902	0.917
1.6	0.414+ j·(-0.328)	0.529	0.192	0.859

b) μ' (2.5GHz) > μ' (1.6 GHz) so the transistor has better stability at 2.5 GHz

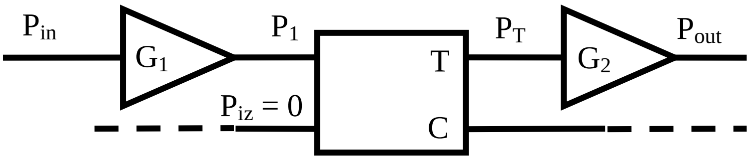
c) we use S parameters for f = 2.5 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 53.79 = 17.31$dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.155$, U_minus = -1.249dB, U_plus = 1.460dB (L8/2021, S142)

Subject no. 39

1. $z = 1.175 - j\cdot 0.910$; $Y = 1 / 50\Omega / (1.175 - j\cdot 0.910) = 0.0106S + j\cdot(0.0082)S$; $\Gamma = (z-1)/(z+1) = (1.175 - j\cdot 0.910-1)/(1.175 - j\cdot 0.910+1) = 0.217+j\cdot(-0.327) = 0.393\angle -56.4°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.65mW = 2.17dBm ; P_1 = Pin + G_1 = 2.17dBm + 7.2dB = 9.37dBm = 8.66mW ; Pc = P_1 – C = 9.37dBm - 4.25dB = 5.12dBm = 3.25mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 8.66mW - 3.25mW = 5.40mW= 7.33dBm ; Pout = $P_T + G_2$ = 7.33dBm + 9.7dB = 17.03dBm = 50.44**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.444 + j\cdot 0.229 + 1)/[1 - (-0.444 + j\cdot 0.229)] = 17.55\Omega + j\cdot 10.71\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 8.78\Omega + j\cdot 5.36\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.687+j\cdot 0.154 = 0.704\angle 167.4°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.704$, $\arg(\Gamma) = 167.4°$
$\theta_{S1} = 163.7°$; $Im(y_S) = -1.984$; $\theta_{P1} = 116.7°$ **and** $\theta_{S2} = 28.9°$; $Im(y_S) = 1.984$; $\theta_{P2} = 63.3°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 17.50dB): $G(1,2) = G_1 + G_2 = 9.7 + 11.3 = 21.0dB$; $G(1,4) = G_1 + G_4 = 9.7 + 8.9 = 18.6dB$; $G(2,3) = G_2 + G_3 = 11.3 + 6.6 = 17.9dB$; $G(2,4) = G_2 + G_4 = 11.3 + 8.9 = 20.2dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 0.99dB=1.256$, $F_2 = 1.15dB=1.303$, $F_3 = 0.60dB=1.148$, $F_4 = 0.85dB=1.216$, $G_3 = 6.6dB=4.571$, $G_4 = 8.9dB=7.762$;
$F(4,1) = 1.216 + (1.256-1)/7.762 = 1.249 = 0.97dB$; $F(3,2) = 1.148 + (1.303-1)/4.571 = 1.214 = 0.84dB$;
$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

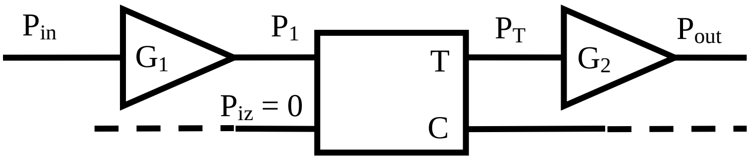
f [GHz]	Δ	|Δ|	K	μ'
2.6	0.026+ j·(-0.349)	0.350	0.875	0.921
4.3	-0.062+ j·(-0.478)	0.482	0.418	0.783

b) μ' (2.6GHz) > μ' (4.3 GHz) so the transistor has better stability at 2.6 GHz
c) we use S parameters for f = 2.6 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 51.69 = 17.13dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.059$, U_minus = -0.498dB, U_plus = 0.528dB (L8/2021, S142)

Subject no. 40

1. $z = 0.950 + j\cdot1.240$; $Y = 1 / 50\Omega / (0.950 + j\cdot1.240) = 0.0078S + j\cdot(-0.0102)S$; $\Gamma = (z-1)/(z+1) = (0.950 + j\cdot1.240-1)/(0.950 + j\cdot1.240+1) = 0.270+j\cdot(0.464) = 0.537\angle59.9°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.10mW = 3.22dBm ; P_1 = Pin + G_1 = 3.22dBm + 6.1dB = 9.32dBm = 8.55mW ; Pc = P_1 – C = 9.32dBm - 5.70dB = 3.62dBm = 2.30mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 8.55mW - 2.30mW = 6.25mW= 7.96dBm ; Pout = $P_T + G_2$ = 7.96dBm + 11.2dB = 19.16dBm = 82.42**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.020 + j\cdot0.209 + 1)/[1 - (-0.020 + j\cdot0.209)] = 44.09\Omega + j\cdot19.28\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 22.04\Omega + j\cdot9.64\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.364+j\cdot0.182 = 0.407\angle153.4°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.407$, $\arg(\Gamma) = 153.4°$
$\theta_{S1} = 160.3°$; $Im(y_S) = -0.891$; $\theta_{P1} = 138.3°$ **and** $\theta_{S2} = 46.3°$; $Im(y_S) = 0.891$; $\theta_{P2} = 41.7°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 17.15dB): $G(1,2) = G_1 + G_2 = 9.0 + 11.5 = 20.5dB$; $G(1,4) = G_1 + G_4 = 9.0 + 8.3 = 17.3dB$; $G(2,3) = G_2 + G_3 = 11.5 + 6.0 = 17.5dB$; $G(2,4) = G_2 + G_4 = 11.5 + 8.3 = 19.8dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.05dB=1.274, F_2 = 1.22dB=1.324, F_3 = 0.65dB=1.161, F_4 = 0.77dB=1.194, G_3 = 6.0dB=3.981, G_4 = 8.3dB=6.761;
$F(4,1) = 1.194 + (1.274-1)/6.761 = 1.234$ = 0.91dB; $F(3,2) = 1.161 + (1.324-1)/3.981 = 1.243$ = 0.94dB;
$F(4,1) < F(3,2)$ → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

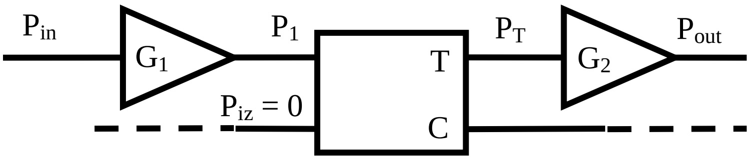
f [GHz]	Δ	|Δ|	K	μ
1.3	0.479+ j·(-0.246)	0.539	0.671	0.545
1.9	0.372+ j·(-0.372)	0.526	0.217	0.240

b) μ (1.3GHz) > μ (1.9 GHz) so the transistor has better stability at 1.3 GHz
c) we use S parameters for f = 1.3 GHz and assume $S12 = 0\angle0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 183.89$ = 22.65dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2) = 0.229$, U_minus = -1.794dB, U_plus = 2.263dB (L8/2021, S142)

Subject no. 41

1. $z = 0.720 + j\cdot1.115$; $Y = 1 / 50\Omega / (0.720 + j\cdot1.115) = 0.0082S + j\cdot(-0.0127)S$; $\Gamma = (z-1)/(z+1) = (0.720 + j\cdot1.115-1)/(0.720 + j\cdot1.115+1) = 0.181+j\cdot(0.531) = 0.561\angle71.1°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.65mW = 2.17dBm ; P_1 = Pin + G_1 = 2.17dBm + 8.6dB = 10.77dBm = 11.95mW ; Pc = P_1 – C = 10.77dBm - 5.00dB = 5.77dBm = 3.78mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 11.95mW - 3.78mW = 8.17mW= 9.12dBm ; Pout = P_T + G_2 = 9.12dBm + 9.4dB = 18.52dBm = 71.19**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.338 + j\cdot0.327 + 1)/[1 - (-0.338 + j\cdot0.327)] = 20.53\Omega + j\cdot17.24\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 10.26\Omega + j\cdot8.62\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.626+j\cdot0.233 = 0.668\angle159.6°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.668$, $\arg(\Gamma) = 159.6°$
$\theta_{S1} = 166.1°$; $Im(y_S) = -1.795$; $\theta_{P1} = 119.1°$ **and** $\theta_{S2} = 34.2°$; $Im(y_S) = 1.795$; $\theta_{P2} = 60.9°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.55dB): $G(1,2) = G_1 + G_2 = 8.4 + 10.0 = 18.4dB$; $G(1,4) = G_1 + G_4 = 8.4 + 8.8 = 17.2dB$; $G(2,3) = G_2 + G_3 = 10.0 + 6.9 = 16.9dB$; $G(2,4) = G_2 + G_4 = 10.0 + 8.8 = 18.8dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 0.98dB=1.253$, $F_2 = 1.17dB=1.309$, $F_3 = 0.65dB=1.161$, $F_4 = 0.86dB=1.219$, $G_3 = 6.9dB=4.898$, $G_4 = 8.8dB=7.586$;
$F(4,1) = 1.219 + (1.253-1)/7.586 = 1.252 = 0.98dB$; $F(3,2) = 1.161 + (1.309-1)/4.898 = 1.225 = 0.88dB$;
$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

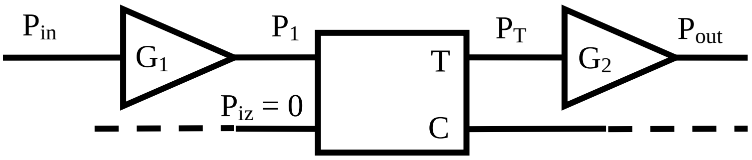
f [GHz]	Δ	|Δ|	K	μ'
0.9	0.506+ j·(-0.105)	0.517	0.530	0.645
3.7	0.047+ j·(-0.490)	0.492	0.385	0.791

b) μ' (0.9GHz) < μ' (3.7 GHz) so the transistor has better stability at 3.7 GHz
c) we use S parameters for f = 3.7 GHz and assume $S12 = 0\angle0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 206.58 = 23.15dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.724$, U_minus = -4.731dB, U_plus = 11.184dB (L8/2021, S142)

Subject no. 42

1. $z = 0.985 - j\cdot 1.175$; $Y = 1 / 50\Omega / (0.985 - j\cdot 1.175) = 0.0084S + j\cdot(0.0100)S$; $\Gamma = (z-1)/(z+1) = (0.985 - j\cdot 1.175-1)/(0.985 - j\cdot 1.175+1) = 0.254+j\cdot(-0.442) = 0.509\angle -60.1°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.25mW = 0.97dBm ; P_1 = Pin + G_1 = 0.97dBm + 8.8dB = 9.77dBm = 9.48mW ; Pc = P_1 – C = 9.77dBm - 6.35dB = 3.42dBm = 2.20mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 9.48mW - 2.20mW = 7.28mW= 8.62dBm ; Pout = $P_T + G_2$ = 8.62dBm + 10.7dB = 19.32dBm = 85.59**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.097 + j\cdot 0.071 + 1)/[1 - (-0.097 + j\cdot 0.071)] = 40.78\Omega + j\cdot 5.88\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 20.39\Omega + j\cdot 2.94\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.418+j\cdot 0.059 = 0.422\angle 171.9°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.422$, $\arg(\Gamma) = 171.9°$
$\theta_{S1} = 151.5°$; $\text{Im}(y_S) = -0.932$; $\theta_{P1} = 137.0°$ **and** $\theta_{S2} = 36.5°$; $\text{Im}(y_S) = 0.932$; $\theta_{P2} = 43.0°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.90dB): $G(1,2) = G_1 + G_2 = 9.7 + 11.1 = 20.8$dB; $G(1,4) = G_1 + G_4 = 9.7 + 7.3 = 17.0$dB; $G(2,3) = G_2 + G_3 = 11.1 + 6.9 = 18.0$dB; $G(2,4) = G_2 + G_4 = 11.1 + 7.3 = 18.4$dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.97dB=1.250, F_2 = 1.17dB=1.309, F_3 = 0.62dB=1.153, F_4 = 0.87dB=1.222, G_3 = 6.9dB=4.898, G_4 = 7.3dB=5.370;
$F(4,1) = 1.222 + (1.250-1)/5.370 = 1.268$ = 1.03dB; $F(3,2) = 1.153 + (1.309-1)/4.898 = 1.217$ = 0.85dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
1.7	0.169+ j·(-0.312)	0.355	0.689	0.640
4.7	-0.125+ j·(-0.451)	0.468	0.472	0.505

b) μ (1.7GHz) > μ (4.7 GHz) so the transistor has better stability at 1.7 GHz

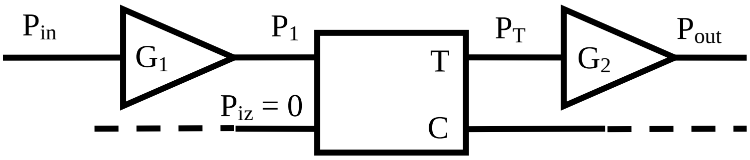
c) we use S parameters for f = 1.7 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 116.95$ = 20.68dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.119$, U_minus = -0.974dB, U_plus = 1.097dB (L8/2021, S142)

Subject no. 43

1. $z = 0.745 - j\cdot0.835$; $Y = 1 / 50\Omega / (0.745 - j\cdot0.835) = 0.0119S + j\cdot(0.0133)S$; $\Gamma = (z-1)/(z+1) = (0.745 - j\cdot0.835-1)/(0.745 - j\cdot0.835+1) = 0.067+j\cdot(-0.446) = 0.451\angle-81.4°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.10mW = 0.41dBm ; P_1 = Pin + G_1 = 0.41dBm + 7.6dB = 8.01dBm = 6.33mW ; Pc = P_1 – C = 8.01dBm - 6.45dB = 1.56dBm = 1.43mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 6.33mW - 1.43mW = 4.90mW= 6.90dBm ; Pout = $P_T + G_2$ = 6.90dBm + 9.5dB = 16.40dBm = 43.64**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.308 + j\cdot0.105 + 1)/[1 - (-0.308 + j\cdot0.105)] = 25.96\Omega + j\cdot6.10\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 12.98\Omega + j\cdot3.05\Omega$;

$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.584+j\cdot0.077 = 0.589\angle172.5°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.589$, $\arg(\Gamma) = 172.5°$

$\theta_{S1} = 156.8°$; $Im(y_S) = -1.458$; $\theta_{P1} = 124.4°$ **and** $\theta_{S2} = 30.7°$; $Im(y_S) = 1.458$; $\theta_{P2} = 55.6°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 16.90dB): $G(1,2) = G_1 + G_2$ = 8.9 + 10.9 = 19.8dB; $G(1,4) = G_1 + G_4$ = 8.9 + 8.5 = 17.4dB; $G(2,3) = G_2 + G_3$ = 10.9 + 6.6 = 17.5dB; $G(2,4) = G_2 + G_4$ = 10.9 + 8.5 = 19.4dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 1.02dB=1.265, F_2 = 1.26dB=1.337, F_3 = 0.50dB=1.122, F_4 = 0.75dB=1.189, G_3 = 6.6dB=4.571, G_4 = 8.5dB=7.079;

F(4,1) = 1.189 + (1.265−1)/7.079 = 1.226 = 0.88dB; F(3,2) = 1.122 + (1.337−1)/4.571 = 1.196 = 0.78dB;

F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
2.7	0.111+ j·(-0.558)	0.569	0.922	0.933
4.4	-0.079+ j·(-0.473)	0.479	0.431	0.784

b) μ' (2.7GHz) > μ' (4.4 GHz) so the transistor has better stability at 2.7 GHz

c) we use S parameters for f = 2.7 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

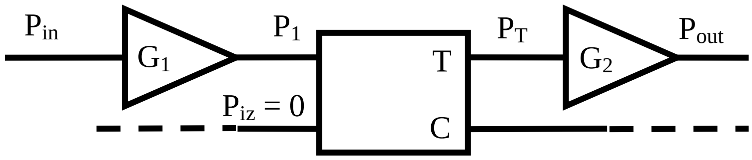
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 46.65 = 16.69dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.151$, U_minus = -1.224dB, U_plus = 1.425dB (L8/2021, S142)

Subject no. 44

1. z = 1.280 + j·1.205; Y = 1 / 50Ω / (1.280 + j·1.205) = 0.0083S + j·(-0.0078)S ; Γ = (z-1)/(z+1) = (1.280 + j·1.205-1)/(1.280 + j·1.205+1) = 0.314+j·(0.362) = 0.480∠49.1°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.45mW = 5.38dBm ; P_1 = Pin + G_1 = 5.38dBm + 6.9dB = 12.28dBm = 16.90mW ; Pc = P_1 – C = 12.28dBm - 4.30dB = 7.98dBm = 6.28mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 16.90mW - 6.28mW = 10.62mW= 10.26dBm ; Pout = P_T + G_2 = 10.26dBm + 8.3dB = 18.56dBm = 71.80**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.262 + j·0.099 + 1)/[1 − (0.262 + j·0.099)] = 83.11Ω + j·17.86Ω

b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 41.55Ω + j·8.93Ω;

Γ = (Z/2−50Ω)/(Z/2+50Ω) = -0.082+j·0.106 = 0.134∠127.8°;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.134, arg(Γ) = 127.8°

θ_{S1} = 164.9° ; Im(y_S) = -0.270 ; θ_{P1} = 164.9° **and** θ_{S2} = 67.2° ; Im(y_S) = 0.270 ; θ_{P2} = 15.1°, all lines with Z_0 = 50Ω

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).

The 4 possible combinations (G > 16.45dB): G(1,2) = G_1 + G_2 = 8.8 + 10.6 = 19.4dB; G(1,4) = G_1 + G_4 = 8.8 + 8.2 = 17.0dB; G(2,3) = G_2 + G_3 = 10.6 + 6.6 = 17.2dB; G(2,4) = G_2 + G_4 = 10.6 + 8.2 = 18.8dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;

For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 0.90dB=1.230, F_2 = 1.23dB=1.327, F_3 = 0.58dB=1.143, F_4 = 0.89dB=1.227, G_3 = 6.6dB=4.571, G_4 = 8.2dB=6.607;

F(4,1) = 1.227 + (1.230−1)/6.607 = 1.262 = 1.01dB; F(3,2) = 1.143 + (1.327−1)/4.571 = 1.215 = 0.84dB; F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
2.6	0.146+ j·(-0.550)	0.569	0.910	0.922
2.9	0.195+ j·(-0.470)	0.509	0.293	0.800

b) μ' (2.6GHz) > μ' (2.9 GHz) so the transistor has better stability at 2.6 GHz

c) we use S parameters for f = 2.6 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)

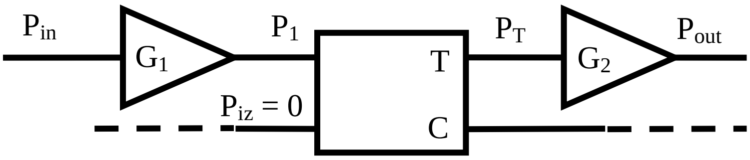
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 50.09 = 17.00dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.153, U_minus = -1.236dB, U_plus = 1.442dB (L8/2021, S142)

Subject no. 45

1. $z = 0.910 - j\cdot 1.295$; $Y = 1 / 50\Omega / (0.910 - j\cdot 1.295) = 0.0073S + j\cdot(0.0103)S$; $\Gamma = (z-1)/(z+1) = (0.910 - j\cdot 1.295-1)/(0.910 - j\cdot 1.295+1) = 0.283+j\cdot(-0.486) = 0.563\angle -59.8°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 1.20mW = 0.79dBm ; P_1 = Pin + G_1 = 0.79dBm + 7.9dB = 8.69dBm = 7.40mW ; Pc = P_1 – C = 8.69dBm - 5.85dB = 2.84dBm = 1.92mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 7.40mW - 1.92mW = 5.48mW= 7.38dBm ; Pout = $P_T + G_2$ = 7.38dBm + 8.3dB = 15.68dBm = 37.02**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(-0.345 + j\cdot 0.191 + 1)/[1 - (-0.345 + j\cdot 0.191)] = 22.88\Omega + j\cdot 10.35\Omega$

b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 11.44\Omega + j\cdot 5.17\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.616+j\cdot 0.136 = 0.631\angle 167.5°$;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.631$, $\arg(\Gamma) = 167.5°$
$\theta_{S1} = 160.8°$; $Im(y_S) = -1.627$; $\theta_{P1} = 121.6°$ **and** $\theta_{S2} = 31.7°$; $Im(y_S) = 1.627$; $\theta_{P2} = 58.4°$, all lines with $Z_0 = 50\Omega$

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.35dB): $G(1,2) = G_1 + G_2$ = 8.9 + 11.6 = 20.5dB; $G(1,4) = G_1 + G_4$ = 8.9 + 8.1 = 17.0dB; $G(2,3) = G_2 + G_3$ = 11.6 + 6.2 = 17.8dB; $G(2,4) = G_2 + G_4$ = 11.6 + 8.1 = 19.7dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.01dB=1.262, F_2 = 1.25dB=1.334, F_3 = 0.64dB=1.159, F_4 = 0.70dB=1.175, G_3 = 6.2dB=4.169, G_4 = 8.1dB=6.457;
F(4,1) = 1.175 + (1.262−1)/6.457 = 1.215 = 0.85dB; F(3,2) = 1.159 + (1.334−1)/4.169 = 1.239 = 0.93dB;
F(4,1) < F(3,2) → minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
0.6	0.467+ j·(0.010)	0.467	0.394	0.305
3.4	0.100+ j·(-0.492)	0.502	0.330	0.360

b) μ (0.6GHz) < μ (3.4 GHz) so the transistor has better stability at 3.4 GHz

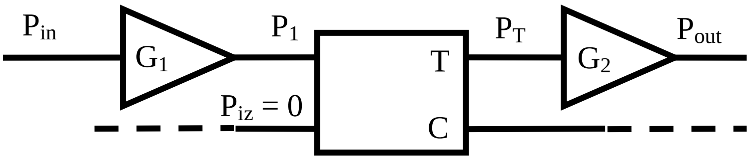
c) we use S parameters for f = 3.4 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 266.21 = 24.25dB$

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.884$, U_minus = -5.499dB, U_plus = 18.674dB (L8/2021, S142)

Subject no. 46

1. $z = 1.125 - j\cdot 1.015$; $Y = 1 / 50\Omega / (1.125 - j\cdot 1.015) = 0.0098S + j\cdot(0.0088)S$; $\Gamma = (z-1)/(z+1) = (1.125 - j\cdot 1.015-1)/(1.125 - j\cdot 1.015+1) = 0.234+j\cdot(-0.366) = 0.434\angle -57.4°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.30mW = 3.62dBm ; P_1 = Pin + G_1 = 3.62dBm + 9.7dB = 13.32dBm = 21.46mW ; Pc = P_1 – C = 13.32dBm - 6.20dB = 7.12dBm = 5.15mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 21.46mW - 5.15mW = 16.32mW= 12.13dBm ; Pout = $P_T + G_2$ = 12.13dBm + 9.7dB = 21.83dBm = 152.27**<u>mW</u>**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.043 + j\cdot 0.433 + 1)/[1 - (0.043 + j\cdot 0.433)] = 36.74\Omega + j\cdot 39.24\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 18.37\Omega + j\cdot 19.62\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.351+j\cdot 0.388 = 0.523\angle 132.2°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.523$, $\arg(\Gamma) = 132.2°$
$\theta_{S1} = 174.7°$; $Im(y_S) = -1.228$; $\theta_{P1} = 129.2°$ **<u>and</u>** $\theta_{S2} = 53.1°$; $Im(y_S) = 1.228$; $\theta_{P2} = 50.8°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.40dB): $G(1,2) = G_1 + G_2 = 8.1 + 10.5 = 18.6dB$; $G(1,4) = G_1 + G_4 = 8.1 + 8.4 = 16.5dB$; $G(2,3) = G_2 + G_3 = 10.5 + 5.6 = 16.1dB$; $G(2,4) = G_2 + G_4 = 10.5 + 8.4 = 18.9dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
$F_1 = 0.95dB=1.245$, $F_2 = 1.11dB=1.291$, $F_3 = 0.64dB=1.159$, $F_4 = 0.70dB=1.175$, $G_3 = 5.6dB=3.631$, $G_4 = 8.4dB=6.918$;
$F(4,1) = 1.175 + (1.245-1)/6.918 = 1.210 = 0.83dB$; $F(3,2) = 1.159 + (1.291-1)/3.631 = 1.239 = 0.93dB$;
$F(4,1) < F(3,2) \rightarrow$ minimum noise is when we use devices **4,1** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

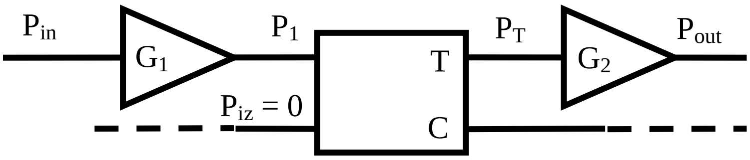
f [GHz]	Δ	|Δ|	K	μ'
0.3	0.357+ j·(0.082)	0.366	0.206	0.585
5.1	-0.177+ j·(-0.418)	0.454	0.528	0.804

b) μ' (0.3GHz) < μ' (5.1 GHz) so the transistor has better stability at 5.1 GHz
c) we use S parameters for f = 5.1 GHz and assume $S12 = 0\angle 0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 109.67 = 20.40dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.446$, U_minus = -3.206dB, U_plus = 5.137dB (L8/2021, S142)

Subject no. 47

1. z = 1.090 + j·1.290; Y = 1 / 50Ω / (1.090 + j·1.290) = 0.0076S + j·(-0.0090)S ; Γ = (z-1)/(z+1) = (1.090 + j·1.290-1)/(1.090 + j·1.290+1) = 0.307+j·(0.428) = 0.527∠54.3°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.15mW = 3.32dBm ; P_1 = Pin + G_1 = 3.32dBm + 9.1dB = 12.42dBm = 17.48mW ; Pc = P_1 – C = 12.42dBm - 5.70dB = 6.72dBm = 4.70mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 17.48mW - 4.70mW = 12.77mW= 11.06dBm ; Pout = P_T + G_2 = 11.06dBm + 8.7dB = 19.76dBm = 94.68**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.470 + j·0.539 + 1)/[1 − (0.470 + j·0.539)] = 42.75Ω + j·94.33Ω
b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 21.38Ω + j·47.16Ω;
Γ = (Z/2−50Ω)/(Z/2+50Ω) = 0.025+j·0.644 = 0.645∠87.8°;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.645, arg(Γ) = 87.8°
θ_{S1} = 21.2° ; Im(y_S) = -1.688 ; θ_{P1} = 120.6° **and** θ_{S2} = 71.0° ; Im(y_S) = 1.688 ; θ_{P2} = 59.4°, all lines with Z_0 = 50Ω
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.40dB): G(1,2) = G_1 + G_2 = 8.8 + 11.0 = 19.8dB; G(1,4) = G_1 + G_4 = 8.8 + 7.9 = 16.7dB; G(2,3) = G_2 + G_3 = 11.0 + 6.5 = 17.5dB; G(2,4) = G_2 + G_4 = 11.0 + 7.9 = 18.9dB
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.07dB=1.279, F_2 = 1.14dB=1.300, F_3 = 0.58dB=1.143, F_4 = 0.79dB=1.199, G_3 = 6.5dB=4.467, G_4 = 7.9dB=6.166;
F(4,1) = 1.199 + (1.279−1)/6.166 = 1.245 = 0.95dB; F(3,2) = 1.143 + (1.300−1)/4.467 = 1.210 = 0.83dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

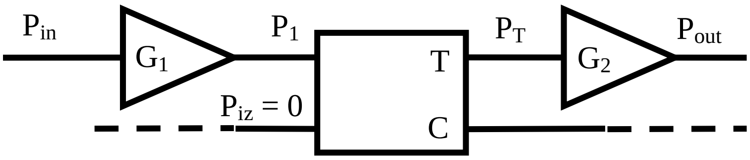
f [GHz]	Δ	|Δ|	K	μ
2.9	0.042+ j·(-0.569)	0.571	0.941	0.879
4.2	-0.043+ j·(-0.484)	0.486	0.409	0.439

b) μ (2.9GHz) > μ (4.2 GHz) so the transistor has better stability at 2.9 GHz
c) we use S parameters for f = 2.9 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 41.09 = 16.14dB
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2)$ = 0.151, U_minus = -1.223dB, U_plus = 1.424dB (L8/2021, S142)

Subject no. 48

1. $z = 0.820 + j\cdot 0.720$; $Y = 1 / 50\Omega / (0.820 + j\cdot 0.720) = 0.0138S + j\cdot(-0.0121)S$; $\Gamma = (z-1)/(z+1) = (0.820 + j\cdot 0.720-1)/(0.820 + j\cdot 0.720+1) = 0.050+j\cdot(0.376) = 0.379\angle 82.5°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 2.10mW = 3.22dBm ; P_1 = Pin + G_1 = 3.22dBm + 9.6dB = 12.82dBm = 19.15mW ; Pc = P_1 – C = 12.82dBm - 5.80dB = 7.02dBm = 5.04mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 19.15mW - 5.04mW = 14.11mW= 11.50dBm ; Pout = $P_T + G_2$ = 11.50dBm + 9.3dB = 20.80dBm = 120.14**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.116 + j\cdot 0.117 + 1)/[1 - (0.116 + j\cdot 0.117)] = 61.17\Omega + j\cdot 14.71\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 30.59\Omega + j\cdot 7.36\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.231+j\cdot 0.112 = 0.257\angle 154.0°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.257$, $\arg(\Gamma) = 154.0°$
$\theta_{S1} = 155.4°$; $Im(y_S) = -0.531$; $\theta_{P1} = 152.0°$ **and** $\theta_{S2} = 50.6°$; $Im(y_S) = 0.531$; $\theta_{P2} = 28.0°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.80dB): $G(1,2) = G_1 + G_2 = 9.2 + 11.8 = 21.0dB$; $G(1,4) = G_1 + G_4 = 9.2 + 7.1 = 16.3dB$; $G(2,3) = G_2 + G_3 = 11.8 + 6.5 = 18.3dB$; $G(2,4) = G_2 + G_4 = 11.8 + 7.1 = 18.9dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 0.95dB=1.245, F_2 = 1.12dB=1.294, F_3 = 0.69dB=1.172, F_4 = 0.79dB=1.199, G_3 = 6.5dB=4.467, G_4 = 7.1dB=5.129;
F(4,1) = 1.199 + (1.245−1)/5.129 = 1.247 = 0.96dB; F(3,2) = 1.172 + (1.294−1)/4.467 = 1.238 = 0.93dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

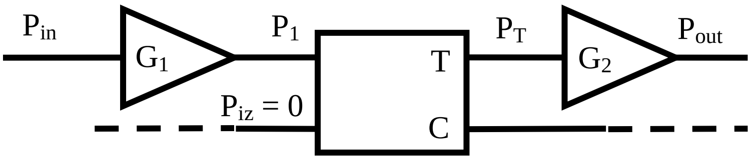
f [GHz]	Δ	|Δ|	K	μ'
2.4	0.061+ j·(-0.344)	0.349	0.844	0.900
3.9	0.013+ j·(-0.489)	0.490	0.390	0.785

b) μ' (2.4GHz) > μ' (3.9 GHz) so the transistor has better stability at 2.4 GHz
c) we use S parameters for f = 2.4 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 59.76 = 17.76dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2) = 0.067$, U_minus = -0.566dB, U_plus = 0.606dB (L8/2021, S142)

Subject no. 49

1. z = 1.005 + j·0.725; Y = 1 / 50Ω / (1.005 + j·0.725) = 0.0131S + j·(-0.0094)S ; Γ = (z-1)/(z+1) = (1.005 + j·0.725-1)/(1.005 + j·0.725+1) = 0.118+j·(0.319) = 0.340∠69.7°, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.30mW = 5.19dBm ; P_1 = Pin + G_1 = 5.19dBm + 9.3dB = 14.49dBm = 28.09mW ; Pc = P_1 – C = 14.49dBm - 6.95dB = 7.54dBm = 5.67mW ; Lossless coupler: P_T = P_1 – Pc – Piz = 28.09mW - 5.67mW = 22.42mW= 13.51dBm ; Pout = P_T + G_2 = 13.51dBm + 11.6dB = 25.11dBm = 324.05**mW**



3. a) Γ = (Z−50Ω)/(Z+50Ω); Z = 50Ω·(1+Γ)/(1−Γ) = 50Ω·(0.448 + j·0.484 + 1)/[1 − (0.448 + j·0.484)] = 52.42Ω + j·89.80Ω

b) 2 identical loads from a) in parallel connection will have an impedance Z/2 = 26.21Ω + j·44.90Ω; Γ = (Z/2−50Ω)/(Z/2+50Ω) = 0.026+j·0.574 = 0.574∠87.4°;

c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, |Γ| = 0.574, arg(Γ) = 87.4°
θ_{S1} = 18.8° ; Im(y_S) = -1.404 ; θ_{P1} = 125.5° **and** θ_{S2} = 73.8° ; Im(y_S) = 1.404 ; θ_{P2} = 54.5°, all lines with Z_0 = 50Ω

d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 15.55dB): G(1,2) = G_1 + G_2 = 9.2 + 11.4 = 20.6dB; G(1,4) = G_1 + G_4 = 9.2 + 7.1 = 16.3dB; G(2,3) = G_2 + G_3 = 11.4 + 5.8 = 17.2dB; G(2,4) = G_2 + G_4 = 11.4 + 7.1 = 18.5dB

b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise

F_1 = 1.02dB=1.265, F_2 = 1.10dB=1.288, F_3 = 0.52dB=1.127, F_4 = 0.85dB=1.216, G_3 = 5.8dB=3.802, G_4 = 7.1dB=5.129;

F(4,1) = 1.216 + (1.265−1)/5.129 = 1.268 = 1.03dB; F(3,2) = 1.127 + (1.288−1)/3.802 = 1.203 = 0.80dB;
F(4,1) > F(3,2) → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ
2.1	0.109+ j·(-0.331)	0.349	0.787	0.742
1.4	0.444+ j·(-0.292)	0.531	0.170	0.190

b) μ (2.1GHz) > μ (1.4 GHz) so the transistor has better stability at 2.1 GHz

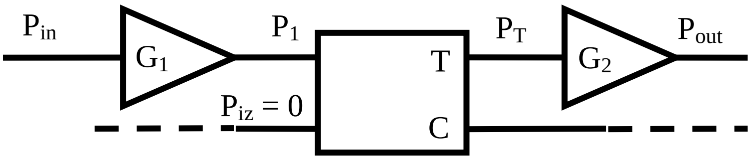
c) we use S parameters for f = 2.1 GHz and assume S12 = 0∠0° (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2)$ = 77.40 = 18.89dB

d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2) /(1-|S_{22}|^2)$ = 0.084, U_minus = -0.699dB, U_plus = 0.760dB (L8/2021, S142)

Subject no. 50

1. $z = 1.060 - j\cdot1.105$; $Y = 1 / 50\Omega / (1.060 - j\cdot1.105) = 0.0090S + j\cdot(0.0094)S$; $\Gamma = (z-1)/(z+1) = (1.060 - j\cdot1.105-1)/(1.060 - j\cdot1.105+1) = 0.246+j\cdot(-0.404) = 0.473\angle-58.7°$, plot point in complex plane either with rectangular coordinates or polar coordinates

2. Pin = 3.40mW = 5.31dBm ; P_1 = Pin + G_1 = 5.31dBm + 9.9dB = 15.21dBm = 33.23mW ; Pc = P_1 – C = 15.21dBm - 4.45dB = 10.76dBm = 11.93mW ; Lossless coupler: $P_T = P_1$ – Pc – Piz = 33.23mW - 11.93mW = 21.30mW= 13.28dBm ; Pout = $P_T + G_2$ = 13.28dBm + 11.0dB = 24.28dBm = 268.16**mW**



3. a) $\Gamma = (Z-50\Omega)/(Z+50\Omega)$; $Z = 50\Omega\cdot(1+\Gamma)/(1-\Gamma) = 50\Omega\cdot(0.036 + j\cdot0.484 + 1)/[1 - (0.036 + j\cdot0.484)] = 32.85\Omega + j\cdot41.60\Omega$
b) 2 identical loads from a) in parallel connection will have an impedance $Z/2 = 16.42\Omega + j\cdot20.80\Omega$;
$\Gamma = (Z/2-50\Omega)/(Z/2+50\Omega) = -0.371+j\cdot0.429 = 0.567\angle130.8°$;
c) Complex calculus from L7/2021, S165÷169, 2 solutions for the match, $|\Gamma| = 0.567$, $\arg(\Gamma) = 130.8°$
$\theta_{S1} = 176.9°$; $Im(y_S) = -1.378$; $\theta_{P1} = 126.0°$ **and** $\theta_{S2} = 52.3°$; $Im(y_S) = 1.378$; $\theta_{P2} = 54.0°$, all lines with $Z_0 = 50\Omega$
d) The shunt stub θ_{P1}/θ_{P2} must be in parallel with the 50Ω source

4. a) From the 6 possible combinations, 2 don't offer the required gain (1,3 ; 3,4).
The 4 possible combinations (G > 16.90dB): $G(1,2) = G_1 + G_2 = 9.9 + 11.0 = 20.9dB$; $G(1,4) = G_1 + G_4 = 9.9 + 7.2 = 17.1dB$; $G(2,3) = G_2 + G_3 = 11.0 + 6.0 = 17.0dB$; $G(2,4) = G_2 + G_4 = 11.0 + 7.2 = 18.2dB$
b) Friis formula (L8/2021, S177), $F = F_a + (F_b-1)/G_a$; We note that $F_3 < F_4 < F_1 < F_2$;
For every one of the 4 combinations of 2 devices, minimum noise factor is obtained if the first device in cascade is the one with lower noise. From the 4 possible combinations with required gain, we only have to compare (4,1) and (2,3) because always $F_4 + (F_1-1)/G_4 < F_4 + (F_2-1)/G_4 < F_1 + (F_2-1)/G_1$ so (4,2) and (1,2) will always have higher noise
F_1 = 1.03dB=1.268, F_2 = 1.11dB=1.291, F_3 = 0.53dB=1.130, F_4 = 0.75dB=1.189, G_3 = 6.0dB=3.981, G_4 = 7.2dB=5.248;
$F(4,1) = 1.189 + (1.268-1)/5.248 = 1.240 = 0.93dB$; $F(3,2) = 1.130 + (1.291-1)/3.981 = 1.203 = 0.80dB$;
$F(4,1) > F(3,2)$ → minimum noise is when we use devices **3,2** , in that order

5. a) Must compute either μ or μ' (**as requested!**) (L8/2021, S82 or 83);

f [GHz]	Δ	|Δ|	K	μ'
2.4	0.213+ j·(-0.521)	0.562	0.890	0.907
5.2	-0.191+ j·(-0.406)	0.449	0.541	0.809

b) μ' (2.4GHz) > μ' (5.2 GHz) so the transistor has better stability at 2.4 GHz
c) we use S parameters for f = 2.4 GHz and assume $S12 = 0\angle0°$ (unilateral - L8/2021, S141)
$G_{TUmax} = 1 / (1 - |S_{11}|^2) \cdot |S_{21}|^2 / (1 - |S_{22}|^2) = 57.78 = 17.62dB$
d) $U = |S_{11}|\cdot|S_{12}|\cdot|S_{21}|\cdot|S_{22}|/(1-|S_{11}|^2)/(1-|S_{22}|^2) = 0.154$, U_minus = -1.247dB, U_plus = 1.457dB (L8/2021, S142)