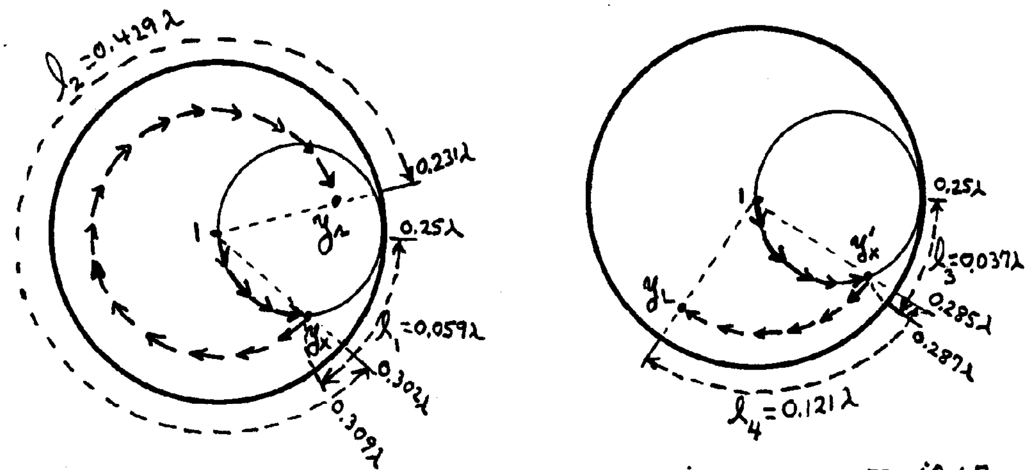
WHICH WILL BE $y_x=1$ ($Z_x=50\Omega$ OR $\Gamma_x=0$).

3.24) (a) SINCE $K=1.19$ AND $\Delta=0.399\angle 126.5^\circ$ (i.e., $|\Delta|<1$) THE BJT IS UNCONDITIONALLY STABLE AT 3.5 GHz. THEREFORE, IT CAN BE DESIGNED FOR A SIMULTANEOUS CONJUGATE MATCH.

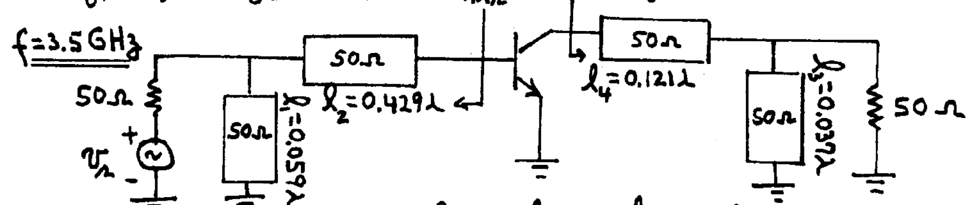
(b) FROM (3.6.5) AND (3.6.6): $\Gamma_{Ms}=0.798\angle -166.9^\circ$, $\Gamma_{ML}=0.904\angle 68^\circ$

FROM (3.6.10): $G_{T,max}=23.06$ OR 13.63 dB.

A DESIGN FOR THE AMPLIFIER AT 3.5 GHz IS:



$y_x=1-j2.6$, $y_s=4.4+j4.4$ $\quad \Gamma_{Ms}$ $\quad \Gamma_{ML}$ $\quad y_x'=1-j4.2$, $y_L=0.073-j0.67$



(c)

f(GHz)	λ		l_1	l_2	l_3	l_4
$f_1=3$	$\lambda_1=\frac{c}{f_1}$	$\lambda_2=\frac{f_1}{f_2}\lambda_1=0.857\lambda_1$	$0.051\lambda_1$	$0.368\lambda_1$	$0.032\lambda_1$	$0.104\lambda_1$
$f_2=3.5$	$\lambda_2=\frac{c}{f_2}$	λ_2	$0.059\lambda_2$	$0.429\lambda_2$	$0.037\lambda_2$	$0.121\lambda_2$
$f_3=4$	$\lambda_3=\frac{c}{f_3}$	$\lambda_2=\frac{f_3}{f_2}\lambda_3=1.143\lambda_3$	$0.067\lambda_3$	$0.49\lambda_3$	$0.042\lambda_3$	$0.138\lambda_3$

USING THE SMITH CHART IT IS SIMPLE TO FIND THE VALUES OF Γ_s AND Γ_L AT f_1 AND f_3. THE VALUES OF G_T ARE CALCULATED USING (3.2.1). THE RESULTS ARE:

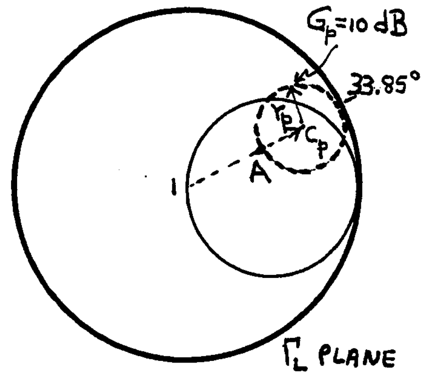
f(GHz)	Γ_s	Γ_L	G_T
3	$0.833\angle -118.5^\circ$	$0.934\angle 82.2^\circ$	0.944 OR −0.25 dB
3.5	$0.798\angle -166.9^\circ$	$0.904\angle 68^\circ$	23.06 OR 13.63 dB
4	$0.749\angle 145.6^\circ$	$0.878\angle 51.5^\circ$	2.257 OR 3.54 dB

3.25) (a) THE TRANSISTOR IS UNCONDITIONALLY STABLE ($K=1.033$, $\Delta=0.324\angle{-64.8^\circ}$)

WITH $g_p = \dfrac{G_p}{|S_{21}|^2} = \dfrac{10^1}{(1.92)^2} = 2.713$, WE OBTAIN FROM (3.7.4) AND (3.7.5):

$$C_p = 0.781\angle{33.85^\circ} \quad \text{AND} \quad r_p = 0.214$$

THE $G_p = 10\,dB$ GAIN CIRCLE IS DRAWN IN THE SMITH CHART. SELECTING Γ_L AT POINT "A": $\Gamma_L = 0.567\angle{33.85^\circ}$, GIVES



$$\Gamma_s = \Gamma_{IN}^* = 0.276\angle{93.33^\circ}.$$

AND

$$\Gamma_{OUT} = 0.86\angle{-33.85^\circ}$$

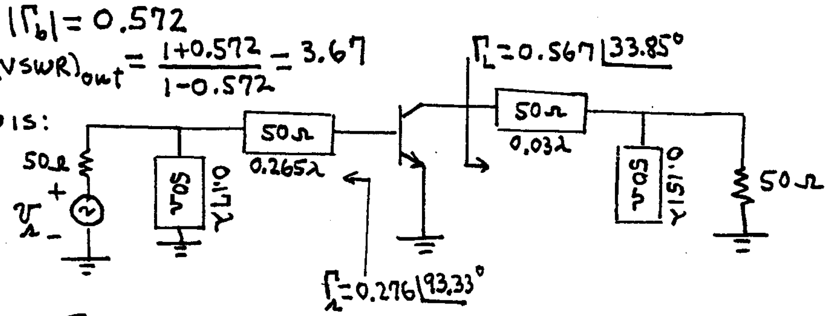
FROM (2.8.3): $|\Gamma_a| = 0$ (SINCE $\Gamma_s = \Gamma_{IN}^*$)

HENCE: $(VSWR)_{in} = 1$

FROM (2.8.6): $|\Gamma_b| = 0.572$

HENCE: $(VSWR)_{out} = \dfrac{1+0.572}{1-0.572} = 3.67$

A DESIGN IS:



(b) $G_{p,max} = G_{T,max} = 19.08$ OR $12.8\,dB$

THE $G_{p,max}$ GAIN CIRCLE (i.e., a point) OCCURS AT:

$$g_{p,max} = \frac{G_{p,max}}{|S_{21}|^2} = \frac{19.08}{(1.92)^2} = 5.176,\ C_{p,max} = 0.95\angle{33.8^\circ},\ r_{p,max} = 0.$$

OBSERVE (SEE PROBLEM 3.21) THAT: $\Gamma_{ML} = C_{p,max} = 0.95\angle{33.8^\circ}$

AND $\Gamma_s = \Gamma_{IN}^* = 0.73\angle{135^\circ}$ IS IDENTICAL TO Γ_{Ms}.

3.26) FOR THIS TRANSISTOR: $K = 1.053$ AND $\Delta = 0.576\angle{-85.4^\circ}$.
THEREFORE, IT IS UNCONDICIONALLY STABLE.

$G_{p,max} = G_{T,max} = 77.12$ OR 18.87 dB

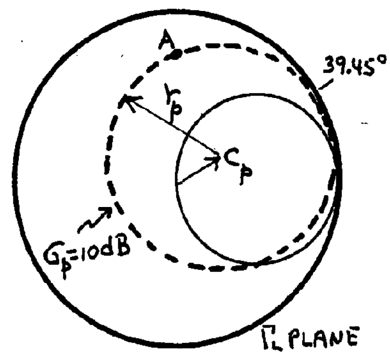
$G_p = 10\text{ dB}$ CIRCLE: $g_p = 0.977$, $C_p = 0.306\angle{39.45^\circ}$, $r_p = 0.693$

THE $G_p = 10\text{ dB}$ CONSTANT-GAIN CIRCLE IS SHOWN IN THE SMITH CHART. THE Γ_L SELECTED IS SHOWN AS "A": $\Gamma_L = 0.85\angle{89^\circ}$.

THEN: $\Gamma_s = \Gamma_{IN}^* = 0.793\angle{64.2^\circ}$, $\Gamma_{OUT} = 0.798\angle{-42.3^\circ}$

$|\Gamma_a| = 0$, $(VSWR)_{in} = 1$

$|\Gamma_b| = 0.9$, $(VSWR)_{out} = 18.9$



3.27) (a) $K = 0.53$, $\Delta = 0.524\angle{-142.9^\circ}$; IT IS POTENTIALLY UNSTABLE.

OUTPUT STABILITY CIRCLE [(3.3.7) AND (3.3.8)]:

$C_L = 1.47\angle{76.6^\circ}$ AND $r_L = 0.668$

$G_p = 10\text{ dB}$ CONSTANT-GAIN CIRCLE [(3.7.4) AND (3.7.5)]: $g_p = \dfrac{10^1}{(2.43)^2} = 1.694$,

$C_p = 0.41\angle{76.6^\circ}$ AND $r_p = 0.641$

(b) THE $G_p = 10\text{ dB}$ GAIN CIRCLE IS DRAWN ON THE SMITH CHART. THREE VALUES OF Γ_L ARE DENOTED BY "a", "b", AND "c". THEN,

	Γ_L	$\Gamma_s = \Gamma_{IN}^*$	Γ_{OUT}	$\lvert\Gamma_b\rvert$	$(VSWR)_{in}$	$(VSWR)_{out}$
"a"	$0.59\angle{0^\circ}$	$0.687\angle{106.11^\circ}$	$0.84\angle{-70.73^\circ}$	0.889	1	17
"b"	$0.24\angle{-90^\circ}$	$0.757\angle{100.35^\circ}$	$0.83\angle{-76.22^\circ}$	0.891	1	17.3
"c"	$0.67\angle{145^\circ}$	$0.851\angle{97.7^\circ}$	$0.84\angle{-83.74^\circ}$	0.889	1	17

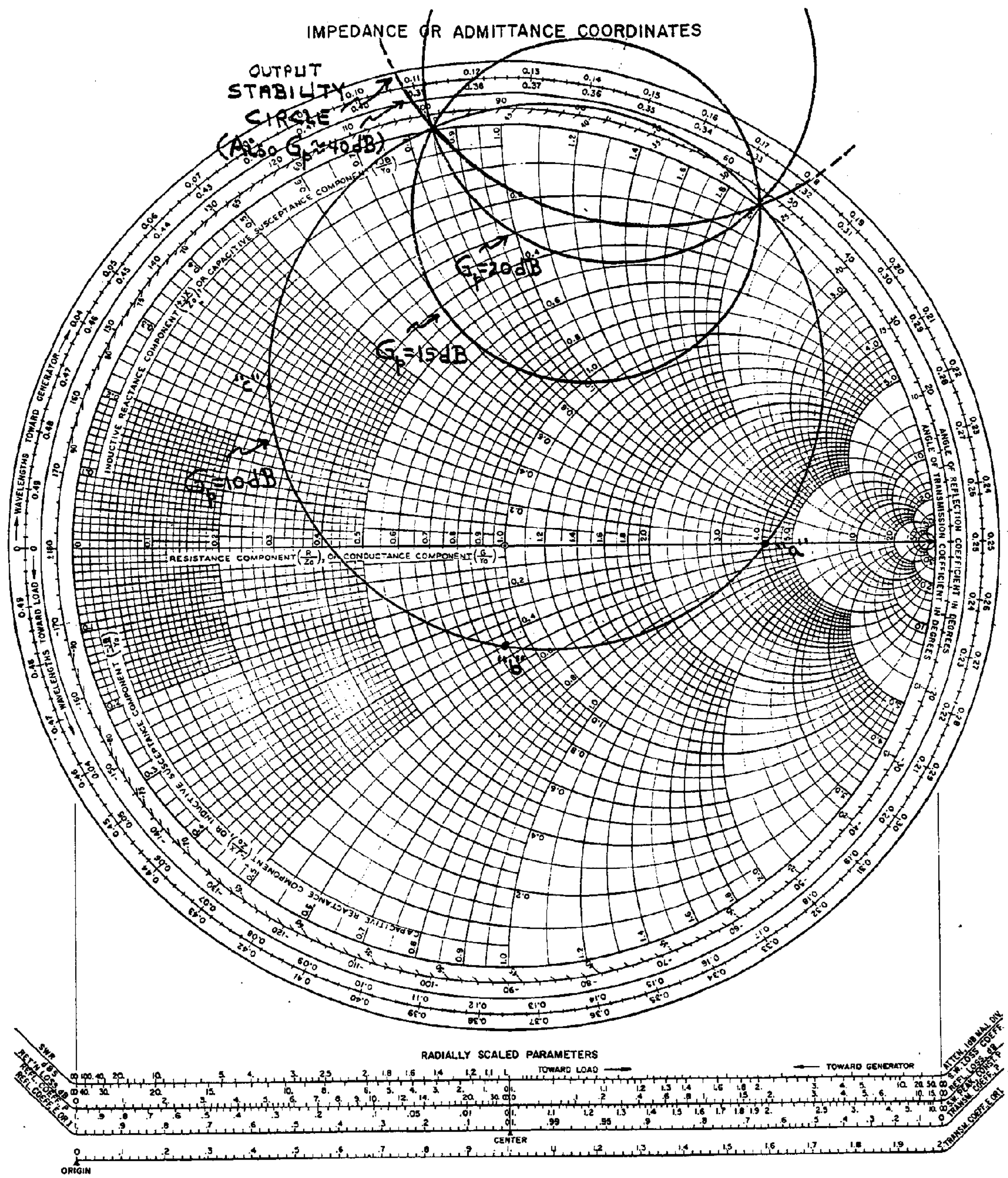
THE 3 VALUES OF Γ_s ARE IN THE STABLE REGION, SINCE $C_s = 1.3\angle{115.7^\circ}$ AND $r_s = 0.46$.

(c) FOR $G_p = 15\text{ dB}$: $g_p = \dfrac{10^{1.5}}{(2.43)^2} = 5.355$, $C_p = 0.81\angle{76.6^\circ}$, $r_p = 0.402$

FOR $G_p = 20\text{ dB}$: $g_p = \dfrac{10^2}{(2.43)^2} = 16.94$, $C_p = 1.17\angle{76.6^\circ}$, $r_p = 0.457$

FOR $G_p = 40\text{ dB}$: $g_p = \dfrac{10^4}{(2.43)^2} = 1,694$, $C_p = 1.46\angle{76.6^\circ}$, $r_p = 0.665$

THE $G_p = 15\text{ dB}$, 20 dB, AND 40 dB GAIN CIRCLES ARE ALSO DRAWN ON THE SMITH CHART. THE $G_p = 40\text{ dB}$ CIRCLE ALMOST COINCIDES WITH THE OUTPUT STABILITY CIRCLE.

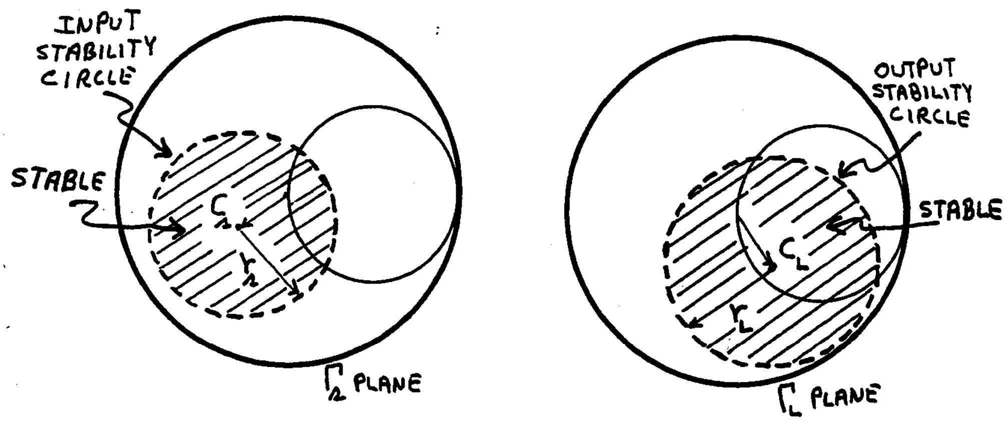


IMPEDANCE OR ADMITTANCE COORDINATES
OUTPUT STABILITY CIRCLE
(Also Gp = 40dB)
Gp=20dB
Gp=15dB
Gp=10dB
RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
INDUCTIVE REACTANCE COMPONENT (+jX/Zo), OR CAPACITIVE SUSCEPTANCE COMPONENT (+jB/Yo)
CAPACITIVE REACTANCE COMPONENT (-jX/Zo), OR INDUCTIVE SUSCEPTANCE COMPONENT (-jB/Yo)
WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
RADIALLY SCALED PARAMETERS
TOWARD LOAD
TOWARD GENERATOR
CENTER
ORIGIN

3,29) (a) $K = 1.032$, $\Delta = 1.65\angle 78.1^\circ$ ∴ POTENTIALLY UNSTABLE

FROM (3.3.7) TO (3.3.10):

INPUT STAB. CIRCLE $\begin{cases} C_s = 0.285\angle -161.1^\circ \\ r_s = 0.65 \end{cases}$ OUTPUT STAB. CIRCLE $\begin{cases} C_L = 0.315\angle -61.5^\circ \\ r_L = 0.627 \end{cases}$



(b) FROM (3.2.3) WITH $\Gamma_L = 0$: (AND $\Gamma_{IN} = S_{11}$ WHEN $\Gamma_L = 0$)

$$G_p = \frac{|S_{21}|^2}{1-|S_{11}|^2} = \frac{4^2}{1-(0.5)^2} = 21.33 \text{ OR } 13.3\,dB$$

(c) G_p CAN BE INFINITE, BECAUSE IT IS POTENTIALLY UNSTABLE. AS Γ_L APPROACHES THE STABILITY CIRCLE, $G_p \to \infty$.

3,30) FROM EXAMPLE 3.8.1: $G_{A,max} = 9.66\,dB$, $G_A = 9.66 - 2 = 7.66\,dB$.

FROM (3.7.15) AND (3.7.16), FOR THE $G_A = 7.66\,dB$ GAIN CIRCLE:

$$g_a = \frac{10^{0.766}}{(2.3)^2} = 1.103, \quad C_a = 0.503\angle -40.45^\circ, \quad r_a = 0.436$$

THE VALUES OF Γ_s ON THE 7.6 dB CIRCLE ARE GIVEN BY:

$$\Gamma_s = C_a + r_a e^{j\theta_1} = 0.503\angle -40.45^\circ + 0.436 e^{j\theta_1}$$

LETTING $\theta_1 = 0, \frac{\pi}{2}, \pi$, AND $\frac{3\pi}{2}$ WE OBTAIN THE VALUES OF Γ_s SHOWN IN THE TABLE. THE ASSOCIATED VALUES OF Γ_{OUT} ARE ALSO SHOWN.

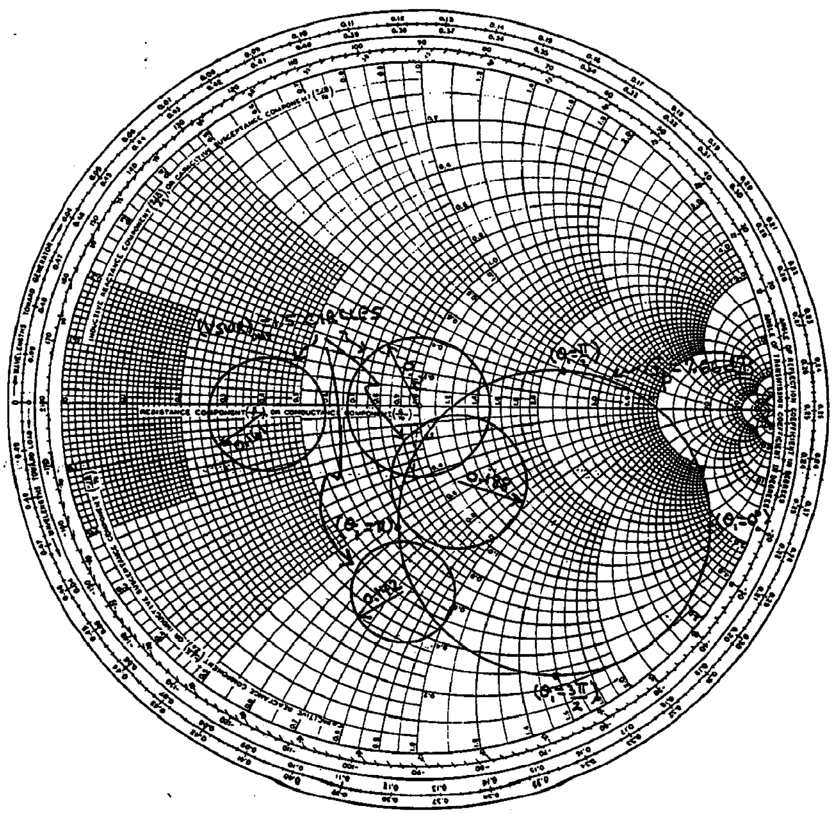
FOR $(VSWR)_{out} = 1.5$ (OR $|\Gamma_b| = 0.2$), USING (3.8.7) AND (3.8.8), THE CENTER AND RADIUS OF THE $(VSWR)_{out} = 1.5$ CIRCLE ARE CALCULATED.

THE VALUES OF Γ_L ON THE $(VSWR)_{out} = 1.5$ CIRCLE ARE GIVEN BY: $\Gamma_L = C_{V_0} + r_{V_0} e^{j\theta_2}$. LETTING $\theta_2 = 0, \frac{\pi}{2}, \pi$, AND $\frac{3\pi}{2}$, FOUR VALUES OF Γ_L ON THE $(VSWR)_{out} = 1.5$ CIRCLE ARE CALCULATED, AS SHOWN IN THE TABLE. THE ASSOCIATED VALUES OF Γ_{IN}, $|\Gamma_a|$, AND $(VSWR)_{in}$ ARE ALSO SHOWN.

Γ_s	Γ_{OUT}	$(VSWR)_{out}=1.5$ CIRCLE	Γ_L	Γ_{IN}	$\lvert\Gamma_a\rvert$	$(VSWR)_{in}$
$(\theta_1=0°)$ $0.881\angle -21.73°$	$0.451\angle 176.74°$	$C_{V_0}=0.437\angle -176.74°$	$0.276\angle -174.8°$ $(\theta_2=0)$	$0.683\angle 33.8$	0.596	3.95
		$r_{V_0}=0.161$	$0.457\angle 162.7°$ $(\theta_2=\frac{\pi}{2})$	$0.712\angle 28.8°$	0.507	3.05
			$0.598\angle -177.6°$ $(\theta_2=\pi)$	$0.771\angle 30.9°$	0.495	2.96
			$0.474\angle -156.9°$ $(\theta_2=\frac{3\pi}{2})$	$0.748\angle 35.7°$	0.604	4.05
$(\theta_1=\pi/2)$ $0.398\angle 15.99°$	$0.005\angle 95.36°$	$C_{V_0}=0.005\angle -95.36°$	$0.2\angle -1.4°$ $(\theta_2=0)$	$0.539\angle 38.5°$	0.501	3.00
		$r_{V_0}=0.2$	$0.195\angle 90.1°$ $(\theta_2=\frac{\pi}{2})$	$0.582\angle 30.3°$	0.491	2.93
			$0.2\angle -178.6°$ $(\theta_2=\pi)$	$0.659\angle 34°$	0.591	3.89
			$0.2\angle -90.1°$ $(\theta_2=\frac{3\pi}{2})$	$0.628\angle 41.5°$	0.598	3.98
$(\theta_1=\pi)$ $0.331\angle -99.26°$	$0.249\angle 62.12°$	$C_{V_0}=0.24\angle -62.12°$	$0.368\angle -35.2°$ $(\theta_2=0)$	$0.539\angle 47°$	0.473	2.79
		$r_{V_0}=0.188$	$0.115\angle -12.1°$ $(\theta_2=\frac{\pi}{2})$	$0.569\angle 38°$	0.543	3.38
			$0.225\angle -109.6°$ $(\theta_2=\pi)$	$0.652\angle 40.8°$	0.613	4.17
			$0.416\angle -74.3°$ $(\theta_2=\frac{3\pi}{2})$	$0.633\angle 48.8°$	0.56	3.54
$(\theta_1=3\pi/2)$ $0.853\angle -63.34°$	$0.547\angle 94.15°$	$C_{V_0}=0.531\angle -94.15°$	$0.54\angle -78.9°$ $(\theta_2=0)$	$0.666\angle 51.8°$	0.526	3.22
		$r_{V_0}=0.142$	$0.39\angle -95.6°$ $(\theta_2=\frac{\pi}{2})$	$0.673\angle 45.7°$	0.606	4.07
			$0.559\angle -108.8°$ $(\theta_2=\pi)$	$0.742\angle 46.3°$	0.597	3.97
			$0.673\angle -93.3°$ $(\theta_2=\frac{3\pi}{2})$	$0.74\angle 51.9°$	0.485	2.88

|0.613| (θ₂ = π/2) |0.74|51.1 |0.485| 2.88

FROM THESE CALCULATIONS IT IS SEEN THAT A DESIGN WITH $\Gamma_s = 0.331\angle{-99.26^\circ}$ AND $\Gamma_L = 0.368\angle{-35.2^\circ}$ RESULTS IN $(VSWR)_{in} = 2.79$ AND $(VSWR)_{out} = 1.5$.



3.31) (a) $K = 1.344$, $\Delta = 2.156\angle{-16.6^\circ}$ $\therefore$ POTENTIALLY UNSTABLE

(b) OUTPUT STABILITY CIRCLE: $C_L = 0.261\angle{-36.3^\circ}$, $r_L = 0.409$

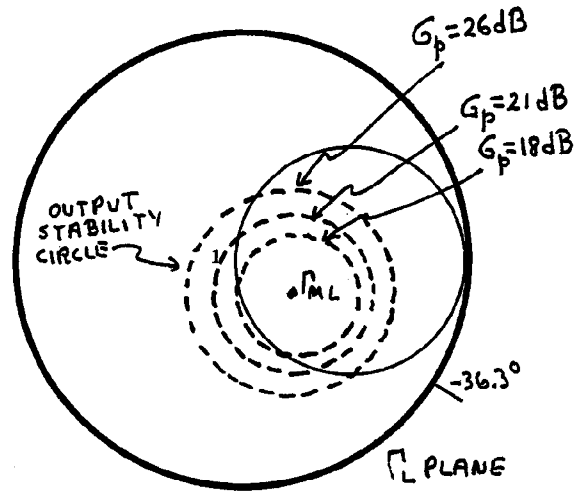
(c) FROM (3.6.6) (USING THE + SIGN): $\Gamma_{ML} = 0.319\angle{-36.3^\circ}$

(d) $G_{p,min} = G_{T,min} = 44.82$ OR $16.51\,dB$

(e)

G_p	CENTER AND RADIUS
18 dB	$C_p = 0.3\angle{-36.3^\circ}$, $r_p = 0.234$
21 dB	$C_p = 0.28\angle{-36.3^\circ}$, $r_p = 0.34$
26 dB	$C_p = 0.266\angle{-36.3^\circ}$, $r_p = 0.39$
36 dB	$C_p = 0.261\angle{-36.3^\circ}$, $r_p = 0.407$

THE 26 dB GAIN CIRCLE, THE 36 dB GAIN CIRCLE, AND THE OUTPUT STABILITY CIRCLE ALMOST COINCIDE.



(f) INPUT STABILITY CIRCLE: $C_s = 0.102\angle{107.4^\circ}$, $r_s = 0.44$

FROM (3.6.5) (USING THE + SIGN): $\Gamma_{Ms} = 0.127\angle{107.44^\circ}$

(g) $(VSWR)_{in} = (VSWR)_{out} = 1$.

3.32) (a) $K = 1.17$, $\Delta = 0.368\angle{27.91^\circ}$ UNCONDITIONALLY STABLE

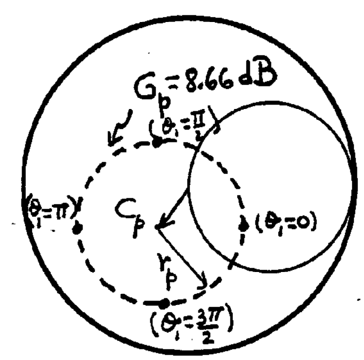
$G_{p,max} = 9.24$ OR $9.66\,dB$, $G_p = 9.66 - 1 = 8.66\,dB$

FOR THE $G_p = 8.66\,dB$ CIRCLE: $g_p = 1.388$, $C_p = 0.292\angle{-129.4^\circ}$, $r_p = 0.466$

(b) THE VALUES OF Γ_L ON THE 8.66 dB CIRCLE ARE:

$\Gamma_L = C_p + r_p e^{j\theta_1} = 0.292\angle{-129.4^\circ} + 0.466 e^{j\theta_1}$

LETTING $\theta_1 = 0, \frac{\pi}{2}, \pi$, AND $\frac{3\pi}{2}$ WE OBTAIN THE VALUES OF Γ_L SHOWN IN THE TABLE. THE ASSOCIATED VALUES OF Γ_{IN} ARE ALSO SHOWN.



FOR $(VSWR)_{in} = 1.5$ (OR $|\Gamma_a| = 0.2$), USING (3.8.3) AND (3.8.4), THE CENTER AND RADIUS OF THE $(VSWR)_{in} = 1.5$ CIRCLE ARE CALCULATED.

(c) THE VALUES OF Γ_s ON THE $(VSWR)_{in} = 1.5$ CIRCLE ARE GIVEN BY $\Gamma_s = C_{V_i} + r_i e^{j\theta_2}$. LETTING $\theta_2 = 0$ AND π, TWO VALUES OF Γ_s ON THE $(VSWR)_{in} = 1.5$ CIRCLE ARE CALCULATED (SEE THE TABLE). THE ASSOCIATED VALUES OF Γ_{OUT}, $|\Gamma_b|$, AND $(VSWR)_{OUT}$ ARE ALSO SHOWN

Γ_L	Γ_{IN}	$(VSWR)_{in}=1.5$ CIRCLE	Γ_s	Γ_{OUT}	$\lvert\Gamma_b\rvert$	$(VSWR)_{out}$
$(\theta_1=0)$ 0.36 $\angle -38.8^\circ$	0.548 $\angle 47.1^\circ$	$C_{V_i}=0.532\angle -47.1^\circ$	0.637 $\angle -37.7^\circ$ $(\theta_2=0)$	0.311 $\angle 129.5^\circ$	0.475	2.8
		$r_{V_i}=0.142$	0.448 $\angle -60.5^\circ$ $(\theta_2=\pi)$	0.259 $\angle 91.2^\circ$	0.304	1.875
$(\theta_1=\pi/2)$ 0.304 $\angle 127.6^\circ$	0.634 $\angle 27.9^\circ$	$C_{V_i}=0.619\angle -27.9^\circ$	0.729 $\angle -23.4^\circ$ $(\theta_2=0)$	0.314 $\angle 161.7^\circ$	0.368	2.16
		$r_{V_i}=0.122$	0.514 $\angle -34.3^\circ$ $(\theta_2=\pi)$	0.219 $\angle 123.5^\circ$	0.419	2.44
$(\theta_1=\pi)$ 0.689 $\angle -160.9^\circ$	0.81 $\angle 34.2^\circ$	$C_{V_i}=0.799\angle -34.2^\circ$	0.859 $\angle -31.5^\circ$ $(\theta_2=0)$	0.501 $\angle 153.7^\circ$	0.306	1.88
		$r_{V_i}=0.071$	0.741 $\angle -37.3^\circ$ $(\theta_2=\pi)$	0.399 $\angle 136.2^\circ$	0.483	2.87
$(\theta_1=3\pi/2)$ 0.716 $\angle -105^\circ$	0.782 $\angle 49.4^\circ$	$C_{V_i}=0.77\angle -49.4^\circ$	0.824 $\angle -45.2^\circ$ $(\theta_2=0)$	0.518 $\angle 124.3^\circ$	0.430	2.51
		$r_{V_i}=0.08$	0.721 $\angle -54.2^\circ$ $(\theta_2=\pi)$	0.429 $\angle 107.5^\circ$	0.415	2.42

FROM THESE CALCULATIONS IT IS SEEN THAT A DESIGN WITH $\Gamma_L = 0.689\angle -160.9^\circ$ AND $\Gamma_s = 0.859\angle -31.5^\circ$ GIVES: $G_p = 8.66\,dB$, $(VSWR)_{in} = 1.88$, $(VSWR)_{out} = 1.5$.

3.33) (a) FROM EXAMPLE 3.7.2, FOR THE $G_p = 10\,dB$ CIRCLE: $C_p = 0.572\angle 97.2^\circ$, $r_p = 0.473$

FROM (3.8.9) AND (3.8.10), WITH $C_{oo} = C_p$ AND $r_{oo} = r_p$, WE OBTAIN:

$$C_i = 1.131\angle 170.6^\circ \quad \text{AND} \quad r_i = 0.622$$

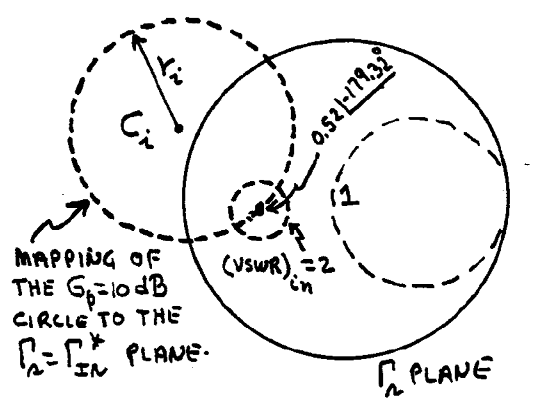
(b) FOR $\Gamma_L = 0.1\angle 97^\circ$, $\Gamma_{IN} = 0.52\angle 179.32^\circ$,

$\Gamma_s = \Gamma_{IN}^* = 0.52\angle -179.32^\circ$

THEN $(VSWR)_{in} = 1$

FOR $(VSWR)_{in} = 2$ (OR $|\Gamma_a| = 0.333$), WE OBTAIN FROM (3.8.3) AND (3.8.4):

$C_{V_i} = 0.477\angle 179.32^\circ$, $r_{V_i} = 0.251$



3.34) $K = 0.924$, $\Delta = 0.137\angle{-139^\circ}$ $\therefore$ POTENTIALLY UNSTABLE

$$G_{MSG} = \frac{|S_{21}|}{|S_{12}|} = \frac{8}{0.03} = 266.6 \text{ OR } 24.3\,dB$$

DESIGN FOR $G_p = 20\,dB$ (i.e., 4.3 dB LESS THAN G_{MSG}).

OUTPUT STABILITY CIRCLE:

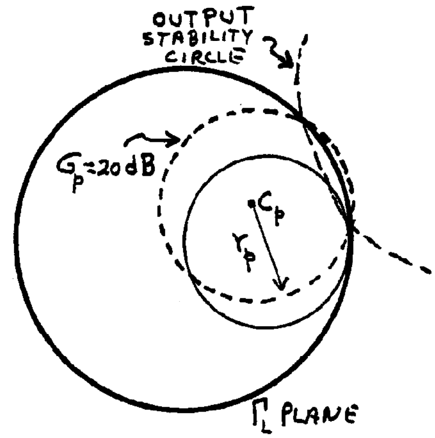
$C_L = 2.26\angle 40.1^\circ$, $r_L = 1.307$

$G_p = 20\,dB$ CONSTANT-GAIN CIRCLE: ($g_p = 1.563$)

$C_p = 0.505\angle 40.1^\circ$, $r_p = 0.519$

VALUES OF Γ_L ON $G_p = 20\,dB$ CIRCLE:

$\Gamma_L = C_p + r_p e^{j\theta_1} = 0.505\angle 40.1 + 0.519 e^{j\theta_1}$



THE TABLE SHOWS TWO VALUES OF Γ_L (i.e, for $\theta_1 = \pi$ AND $\theta_1 = \frac{3\pi}{2}$), THE ASSOCIATED VALUES OF $\Gamma_s = \Gamma_{IN}^*$, Γ_{OUT}, $|\Gamma_b|$, AND $(VSWR)_{OUT}$.

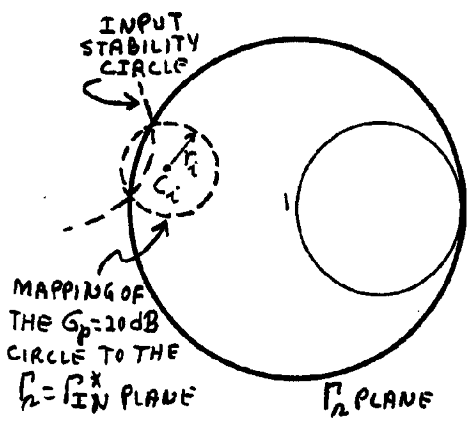
Γ_L	$\Gamma_s = \Gamma_{IN}^*$	$(VSWR)_{in}$	Γ_{OUT}	$\lvert\Gamma_b\rvert$	$(VSWR)_{OUT}$
($\theta_1 = \pi$) $0.352\angle 112.2^\circ$	$0.655\angle 163.4^\circ$	1	$0.668\angle{-44.8^\circ}$	0.667	30.25
($\theta_1 = 3\pi/2$) $0.432\angle{-26.6^\circ}$	$0.607\angle{-179.2^\circ}$	1	$0.674\angle{-34.3^\circ}$	0.668	30.25

MAPPING OF THE $G_p = 20\,dB$ CIRCLE TO THE $\Gamma_s = \Gamma_{IN}^*$ PLANE:

$C_i = 0.823\angle 175.3^\circ$, $r_i = 0.227$

INPUT STABILITY CIRCLE: $C_s = 1.65\angle 175.3^\circ$, $r_s = 0.679$

THE VALUES OF $(VSWR)_{OUT} = 30.25$ SHOW THAT THE OUTPUT HAS TO BE MISMATCHED IN ORDER TO REDUCE THE GAIN TO 20 dB. THE DESIGNER CAN TRY TO REDUCE $(VSWR)_{OUT}$ BY RELAXING THE INPUT VSWR VALUE (SAY, LET $(VSWR)_{in} \le 1.5$), AS DISCUSSED IN EXAMPLE 3.8.2.



3.35) $K = 0.875$, $\Delta = 0.445\angle 160.4^\circ$ $\therefore$ POTENTIALLY UNSTABLE

$$G_{MSG} = \frac{|S_{21}|}{|S_{12}|} = \frac{3.1}{0.125} = 24.8 \quad \text{OR} \quad 13.9\,\text{dB}$$

DESIGN FOR $G_A = 10\,\text{dB}$ (i.e, 3.9 dB LESS THAN G_{MSG})

INPUT STABILITY CIRCLE:

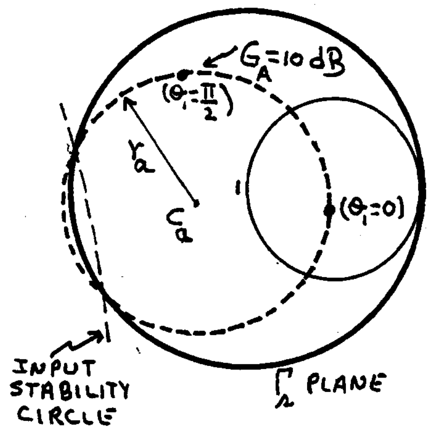
$C_s = 3.303\angle -173.2^\circ$, $r_s = 2.392$

$G_A = 10\,\text{dB}$ CONSTANT-GAIN CIRCLE: ($g_a = 1.041$)

$C_a = 0.296\angle -173.2^\circ$, $r_a = 0.73$

VALUES OF Γ_s ON THE $G_A = 10\,\text{dB}$ CIRCLE:

$$\Gamma_s = C_a + r_a e^{j\theta_1} = 0.296\angle -173.2^\circ + 0.73\,e^{j\theta_1}$$



THE TABLE SHOWS TWO VALUES OF Γ_s (i.e, FOR $\theta_1 = 0$ AND $\theta_1 = \frac{\pi}{2}$), THE ASSOCIATED VALUES OF $\Gamma_L = \Gamma_{OUT}^*$, Γ_{IN}, $|\Gamma_a|$, AND $(VSWR)_{in}$.

Γ_s	$\Gamma_L = \Gamma_{OUT}^*$	$(VSWR)_{OUT}$	Γ_{IN}	$\lvert\Gamma_a\rvert$	$(VSWR)_{in}$
$(\theta_1 = 0)$ $0.437\angle -4.6^\circ$	$0.405\angle 70.8^\circ$	1	$0.565\angle 172^\circ$	0.802	9.1
$(\theta_1 = \pi/2)$ $0.755\angle 112.9^\circ$	$0.08\angle 133.5^\circ$	1	$0.624\angle -171.9^\circ$	0.802	9.1

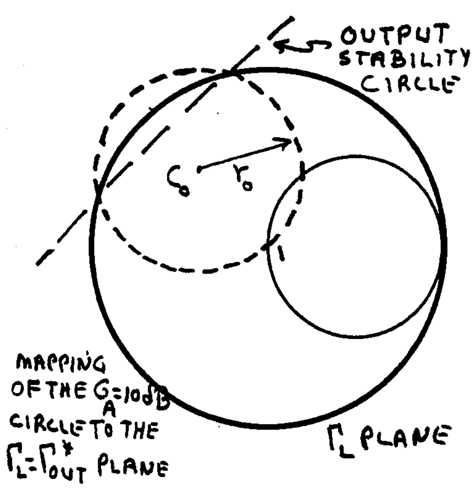
MAPPING OF THE $G_A = 10\,\text{dB}$ CIRCLE TO THE $\Gamma_L = \Gamma_{OUT}^*$ PLANE:

$C_o = 0.646\angle 130.9^\circ$ AND $r_o = 0.566$

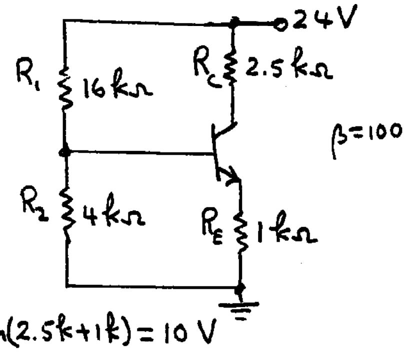
OUTPUT STABILITY CIRCLE:

$C_L = 9.33\angle -49.1^\circ$, $r_L = 10.19$

THE VALUES OF $(VSWR)_{in} = 9.1$ SHOW THAT THE INPUT HAS TO BE MISMATCHED IN ORDER TO REDUCE THE GAIN TO 10 dB. (i.e, $G_A = 10\,\text{dB}$). THE DESIGNER CAN TRY TO REDUCE $(VSWR)_{in}$ BY RELAXING THE OUTPUT VSWR.



3.36) (a) dc MODEL



(b) $V_{TH} = \dfrac{24(4k)}{4k+16k} = 4.8\ V$

$R_{TH} = 4k \| 16k = 3.2\ k\Omega$

$V_{TH} = I_B R_{TH} + 0.7 + I_C R_E \quad (I_C \approx I_E)$

$\therefore\ I_B = \dfrac{V_{TH} - 0.7}{R_{TH} + \beta R_E} = 40\,\mu A$

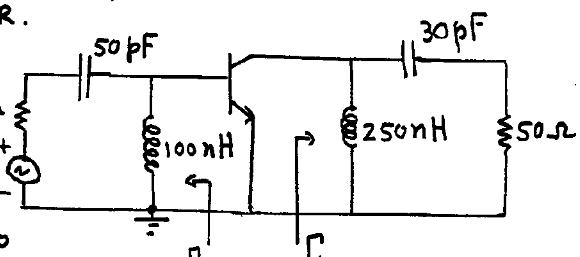
$I_C = \beta I_B = 4\ mA$

$V_{CE} = V_{CC} - I_C(R_C + R_E) = 24 - 4m(2.5k + 1k) = 10\ V$

(c) AT 500 MHz THE 0.1μF ($Z_c = -j0.003\Omega$) ACT AS SHORT CIRCUITS TO THE AC SIGNAL. THUS, RFCs ARE NOT NEEDED IN SERIES WITH THE 16kΩ AND 2.5kΩ RESISTORS.

THE 100 nH INDUCTOR ($Z_L = j314\Omega$) IMPEDANCE IS ABOUT 10% OF THE RESISTANCE OF $R_2 = 4k\Omega$. THUS, A RFC SHOULD BE USED IN SERIES WITH THE 4kΩ RESISTOR.

(d) ac MODEL



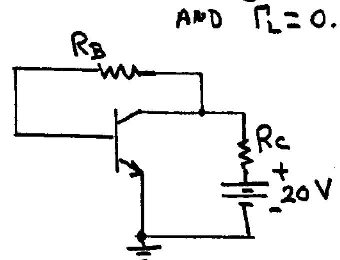
(e) $Z_{50pF} = \dfrac{1}{j2\pi 500 10^6 50 10^{-12}} = -j6.37\Omega$

$Z_{100nH} = j2\pi 500 10^6 100 10^{-9} = j314.2\Omega$

USING THE ZY CHART IT IS SIMPLE TO CALCULATE: $z_s = 1.015 + j0.035$ AND $\Gamma_s = 0.02\angle 65.8^\circ$

SIMILARLY: $z_L = 1.05 - j0.11$ AND $\Gamma_L = 0.06\angle -61^\circ$

3.37) (a) dc MODEL



(b) $20 = I_C R_C + V_{CE}$

OR $R_C = \dfrac{20-10}{5m} = 2\ k\Omega$

$V_{CE} = I_B R_B + 0.7$

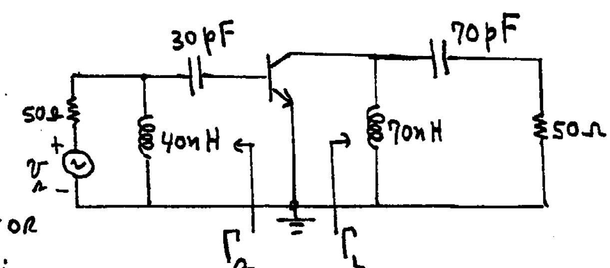
$R_B = \dfrac{10 - 0.7}{\left(\frac{5m}{100}\right)} = 186\ k\Omega$

THIS TYPE OF DC BIAS RESULTS IN A LARGE VALUE FOR R_B.

(c) ac MODEL

AT f=300MHz: $Z_{30pF} = -j17.68\Omega$, $Z_{70pF} = -j7.58\Omega$, $Z_{40nH} = j75.4\Omega$

$Z_{70nH} = j131.9\Omega$



USING THE ZY SMITH CHART OR SIMPLE CALCULATIONS, WE OBTAIN:

$Z_s = 35.1 + j5.2\Omega$ OR $\Gamma_s = 0.185\angle 157.3^\circ$; $Z_L = 49.9 + j1.25\Omega$ OR $\Gamma_L = 0.96\angle 0^\circ$.

3.38) LET $V_{cc} = 20\,V$, $R_E = \frac{10\%\,V_{cc}}{I_c} = \frac{0.1(20)}{10m} = 200\,\Omega$

$$V_{cc} = V_{CE} + I_c(R_c + R_E) \Rightarrow R_c + 200 = \frac{20-10}{4m} = 2.5k, \text{ OR } R_c = 2.3\,k\Omega$$

FOR GOOD β STABILITY LET $R_{TH} = \frac{\beta R_E}{10} = \frac{100(200)}{10} = 2\,k\Omega$

$$V_{TH} = I_B R_{TH} + 0.75 + I_c R_E = \frac{4m}{100}(2k) + 0.75 + 4m(200) = 1.63\,V$$

$$R_1 = R_{TH}\frac{V_{cc}}{V_{TH}} = 2.3k\,\frac{20}{1.63} = 28.22\,k\Omega$$

$$R_2 = \frac{R_{TH}}{1 - V_{TH}/V_{cc}} = \frac{2.3k}{1 - \left(\frac{1.63}{20}\right)} = 2.5\,k\Omega$$

3.39) $I_{c2} = 10\,mA$. LET $I_3 = 20\,mA$, THEN $I_{c1} = I_3 - I_{c2} = 20m - 10m = 10\,mA$

$$\therefore\ R_4 = \frac{0.75}{I_{c1}} = \frac{0.75}{10m} = 75\,\Omega \quad . \text{ LET } V_{cc} = 20\,V$$

$$R_3 = \frac{V_{cc} - V_{CE,2}}{I_3} = \frac{20-10}{20m} = 500\,\Omega$$

FOR GOOD β STABILITY LET $I_{R_1} \approx I_{R_2} = 20\,I_{B1} = 20\,\frac{10m}{100} = 2\,mA$,

$$V_{B,1} = V_{CE,2} - 0.75 = 9.25\,V$$

$$R_1 = \frac{V_{cc} - V_{B,1}}{I_{R_1}} = \frac{20-9.25}{2m} = 5.37\,k\Omega$$

$$R_2 = \frac{V_{B,1}}{I_{R_2}} = \frac{9.25}{2m} = 4.63\,k\Omega$$