UNIVERSITI SAINS MALAYSIA

Semester I Examination
Academic Session 2004/2005

October 2004

EEE 532 – MICROWAVE CIRCUIT DESIGN

Time : 2 hours

INSTRUCTION TO CANDIDATE:

Please ensure that this examination paper contains **SIX (6)** printed pages including Appendices (6 pages) and **SIX (6)** questions before answering.

This question paper has two sections, **Section A** and **Section B**.

Answer **TWO (2)** questions in **Section A** and **TWO (2)** questions in **Section B.**

Use two answer booklets which is provided where the answer for questions in **Section A** are in one answer booklet and for **Section B** in another answer booklet.

Answer **FOUR (4)** questions.

Distribution of marks for each question is given accordingly.

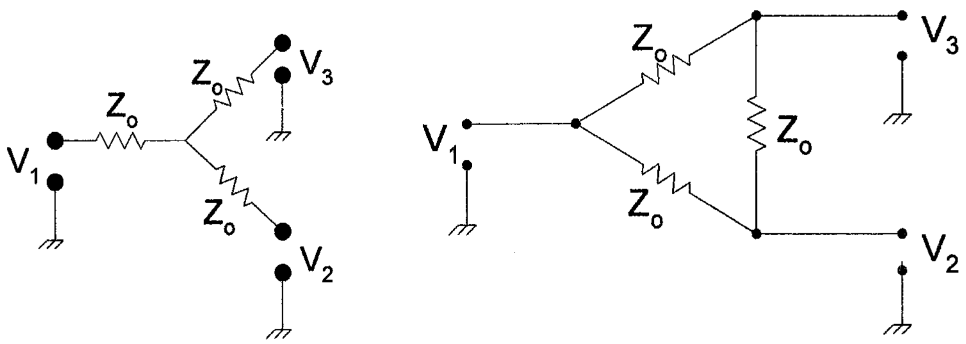
All questions must be answered in English.

SECTION A
INSTRUCTION: Answer **TWO** questions in this section.

1. Design a two sections of L-network to match a load of Z_L= 200 – j25ohm to a 50 ohm line using lumped components at frequency of 1GHz.

(25 marks)

2. Determine the S-parameter of the 3-ports network as in Figure 1 and give your comment.



(a) Star 3 port network (b) Delta 3 port network

Figure 1

(25 marks)

SECTION B
INSTRUCTION: Answer **TWO** questions in this section.

4. Design a third order microstrip low pass filter having the cutoff frequency of 6 GHz, 0.5 dB equal-ripple characteristic and to be used in 50Ω system. Use the Kuroda's identities in your design. The element values are given in Table 2. Use an approximate formula in the calculation of the microstrip width. The Duroid microwave laminate have a dielectric constant of 2.5, the thickness of 0.78 mm and the copper thickness is 35 μm.

(25 Marks)

5. An ATF transistor 35143 has S parameters tabulated in Table 1. The S parameter was measured on 50Ω systems.

S_{11}		S_{21}		S_{12}		S_{22}	
Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
0.60	145.61	2.53	12.43	0.157	-41.00	0.31	-138.01

Table 1: ATF 35413 transistor S parameters measured at 7 GHz.

If the source impedance, Z_S is 30Ω and the load impedance, Z_L is 40Ω. Calculates the transistor's:

(i) Power Gain. (5 Marks)

(ii) Available Gain. (5 Marks)

(iii) Transducer power gain. (5 Marks)

(iv) Determine the transistor stability. (10 Marks)

6. (a) Referring to Figure 2, prove that the reflection coefficients Γ_L and Γ_{in} are related as $\Gamma_L \Gamma_{in} = 1$ for steady-state oscillation of the negative resistance oscillator.

(10 Marks)

(b) Explain what is the phase noise in the oscillator. (5 Marks)

(c) Explain what is the resonator and name three type of resonators that are typically used in oscillator design.

(5 Marks)

(d) Briefly describe the feedback type oscillator topology and explain what are the important criterion in the design of the oscillator.

(5 Marks)

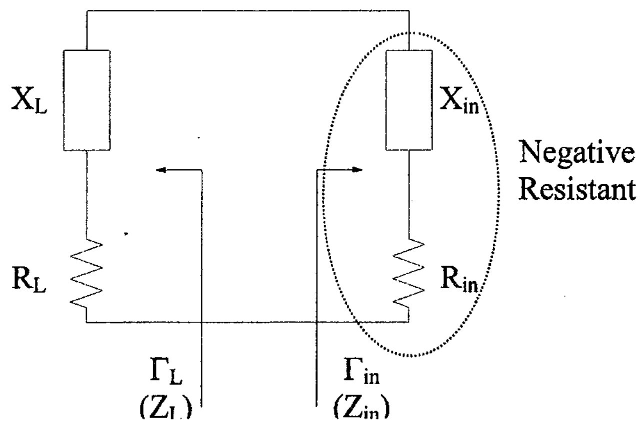


Figure 2

N	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9	g_{10}	g_{11}
1	0.6986	1.000									
2	1.4029	0.7071	1.9841								
3	1.5963	1.0967	1.5963	1.000							
4	1.6703	1.1926	2.3661	0.8419	1.9841						
5	1.7058	1.2296	2.5408	1.2296	1.7058	1.000					
6	1.7254	1.2479	2.6064	1.3137	2.4758	0.8696	1.9841				
7	1.7372	1.2583	2.6381	1.3444	2.6381	1.2583	1.7372	1.000			
8	1.7451	1.2647	2.6564	1.3590	2.6964	1.3389	2.5093	0.8796	1.9841		
9	1.7504	1.2690	2.6678	1.3673	2.7239	1.3673	2.6679	1.2690	1.000		
10	1.7543	1.2721	2.6754	1.3725	2.7392	1.3806	2.7231	1.3485	2.5239	0.8842	1.9841

Table 2: Element values for Equal-Ripple Low-Pass Filter Prototypes 0.5 dB ripple.

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APPENDIX

Important Formulas:

Network parameters

S=parameter

$$S_{11} = \left.\frac{V_{r1}}{V_{i1}}\right|_{V_{r2}=0} \qquad S_{12} = \left.\frac{V_{t2}}{V_{i2}}\right|_{V_{r2}=0} \qquad S_{21} = \left.\frac{V_{t1}}{V_{i1}}\right|_{V_{r1}=0} \qquad S_{22} = \left.\frac{V_{rt2}}{V_{i2}}\right|_{V_{r1}=0}$$

ABCD parameter

$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} \qquad B = \left.\frac{V_1}{-I_2}\right|_{V_2=0} \qquad C = \left.\frac{I_1}{V_2}\right|_{I_2=0} \qquad D = \left.\frac{I_1}{-I_2}\right|_{V_2=0}$$

Conversion

$$\begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} = \frac{1}{Z_oA + B + Z_o^2C + Z_oD}\begin{bmatrix} Z_oA + B - Z_o^2C - Z_oD & 2Z_o(AD - BC) \\ 2Z_o & -Z_oA + B - Z_o^2C + Z_oD \end{bmatrix}$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \frac{1}{2S_{21}}\begin{bmatrix} (1+S_{11})(1-S_{22}) + S_{12}S_{21} & Z_o((1+S_{11})(1+S_{22}) - S_{12}S_{21}) \\ \frac{1}{Z_o}((1-S_{11})(1-S_{22}) - S_{12}S_{21}) & (1-S_{11})(1+S_{22}) + S_{12}S_{21} \end{bmatrix}$$

Butterworth lowpass filter

$g_k = 2\sin(2k-1)\frac{\pi}{2n}$ where k=1,………., n

$$g_0 = g_{n+1} = 1$$

$$n = \frac{\log_{10}\left(10^{A/10} - 1\right)}{2\log_{10}(\omega/\omega_c)}$$

$$C_k = \frac{g_k}{Z_o\omega_c}$$

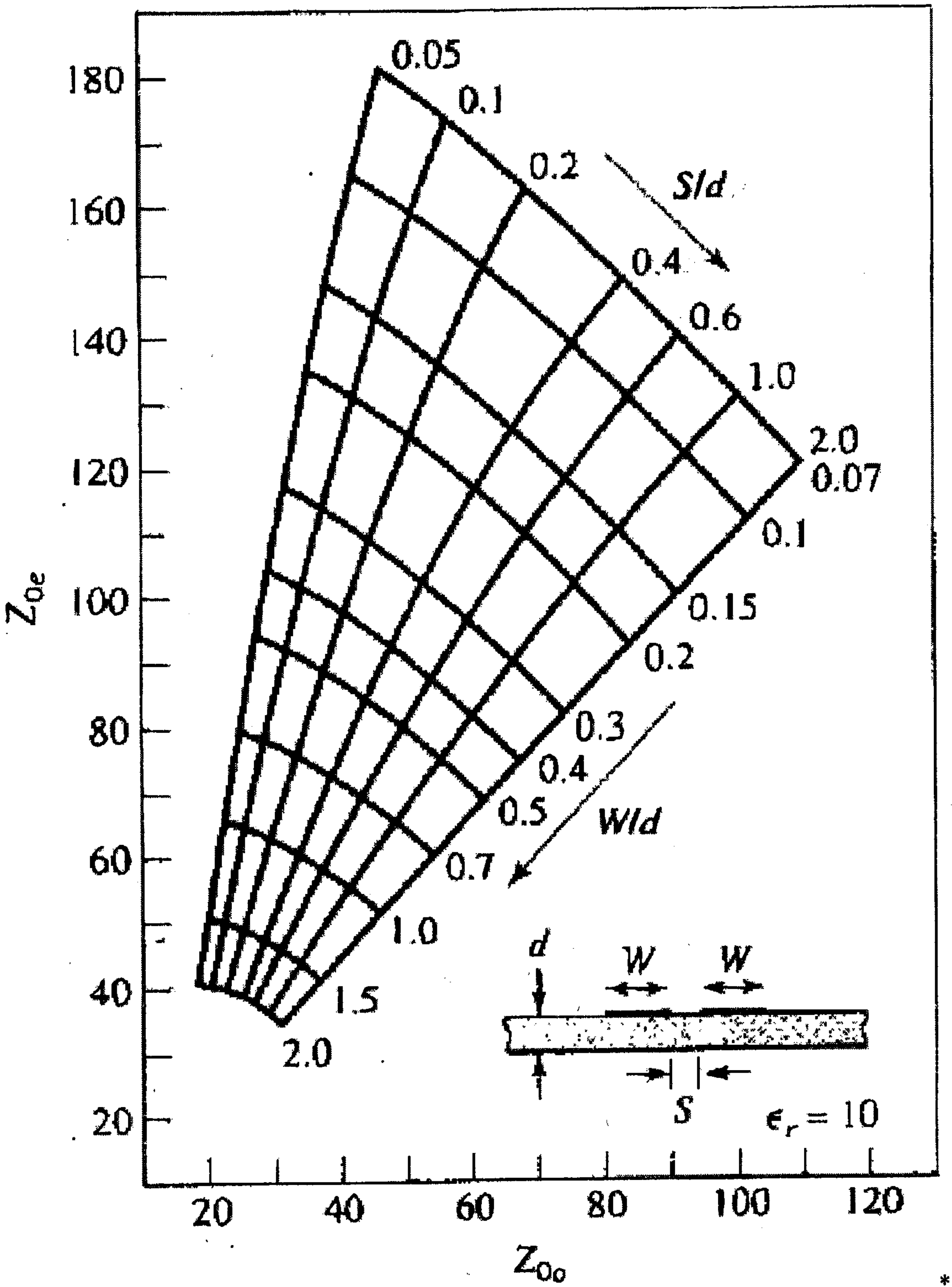
$$L_k = \frac{Z_o g_k}{\omega_c}$$

Bandpass filter

$$J_{01} = \left(\frac{\pi\,\Omega}{2g_0g_1}\right)^{\frac{1}{2}}$$

$J_{k,k+1} = \left(\frac{\pi\,\Omega}{2}\right)\frac{1}{\sqrt{g_k \cdot g_{k-1}}}$ where k=1,………., n

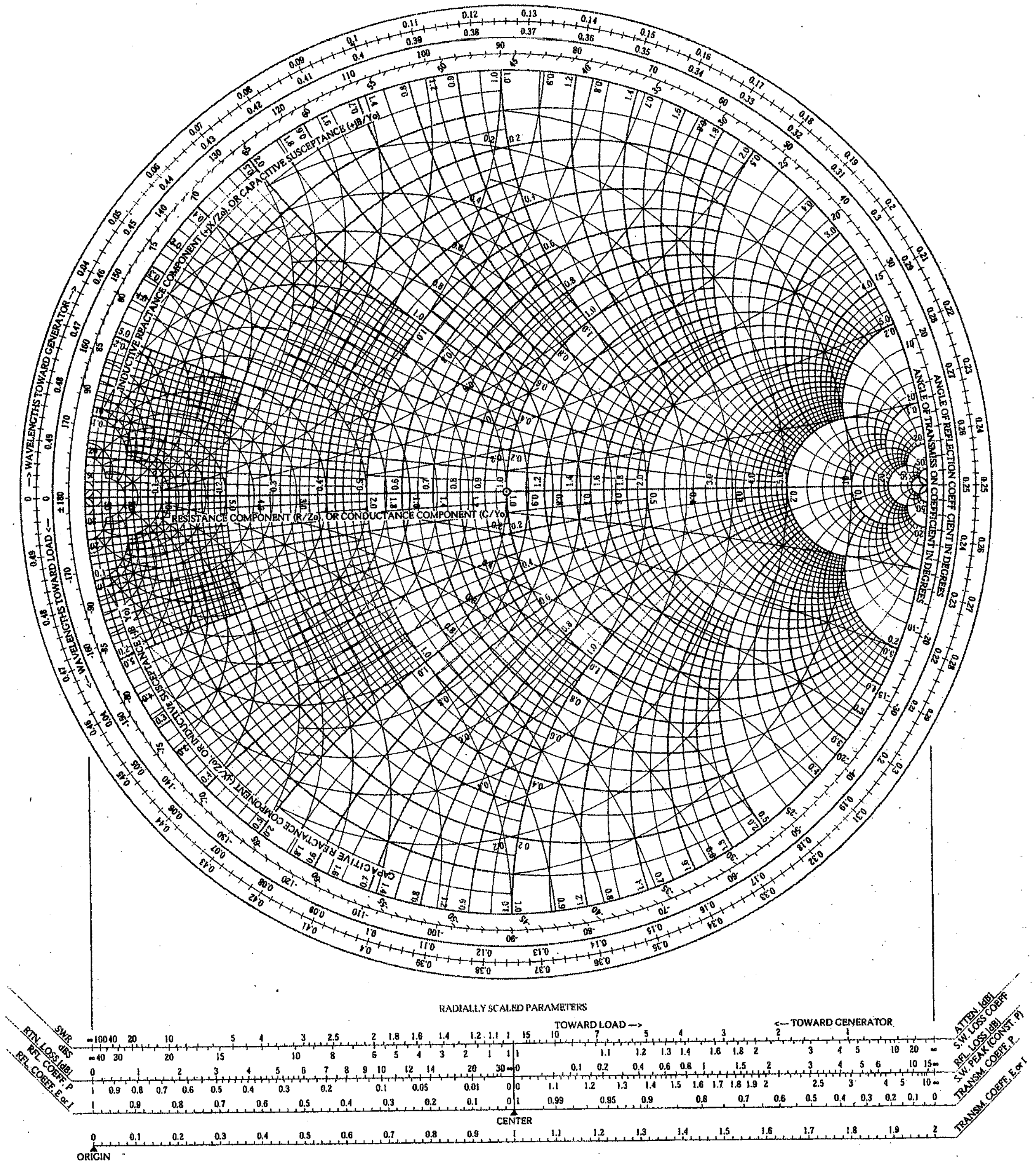
$$J_{n,n+1} = \left(\frac{\pi\,\Omega}{2 \cdot g_n \cdot g_{n+1}}\right)$$



Even and odd-mode characteristic impedances design data for coupled microstrip lines

NAME	TITLE	DWG. NO.
		DATE
SMITH CHART FORM ZY-01-N	Microwave Circuit Design - EE523 - Fall 2000	

NORMALIZED IMPEDANCE AND ADMITTANCE COORDINATES



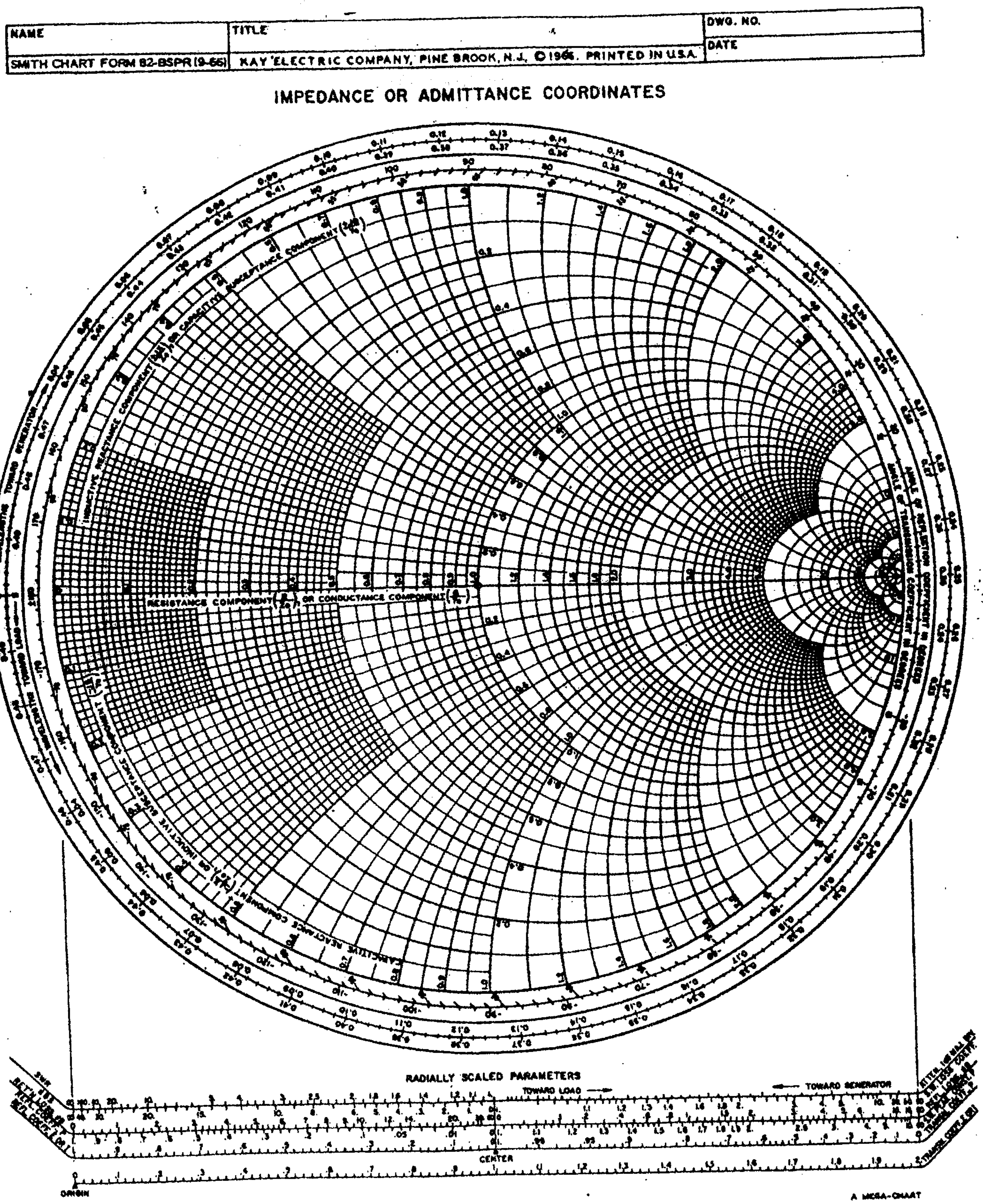


Figure 4.8 Smith chart, reprinted by permission of P. H. Smith, renewal copyright, 1976.