Comparative analysis of T and I Shaped Rectangular Mircostrip Patch Antenna for Wireless communication Applications

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Abstract: The following is an abstract of the paper, the mirror image design parameters and effective results for an antenna with a rectangular microstrip overlay using IE3D software is described that outcomes of the simulations and designs are displayed. The probe feed approach was used to generate the microstrip patch pattern. Such patch antennas have been investigated due to their large bandwidth and gain. This antenna is fabricated on a FR-4 epoxy substrate. This antenna's performance and results are also matched to a standard rectangular patch antenna. Variables are utilised to improve the antenna's simulation results are as position, space, length and width of different mirror images T and I shaped antenna slots. The measured results from the simulated design show that the designed construction resonates at various closely separated frequencies that are within the frequency band allotment for wireless applications. At resonance frequencies of 2GHz to 3GHz, the bandwidth and return loss are significantly enhanced.

***Keywords*—Rectangular Microstrip patch Antenna (RMPA), Bandwidth, VSWR, Return Loss, Ground Plane, FR4, Resonant frequency.**

1. Introduction

In recent years of antenna area of Communications network growth necessitates the development of very low cost, minimum weight as possable, antennas with a low profile that can retain a high signal Effective performance across a broad frequency spectrum. The goal and goal of future private communication device development will be to offer image, voice, and digital information communications at every time and from anywhere on planet. It means that antennas for future communication will have to meet all of requirements for wideband or multi-band operating in order to cover all of the available operating bands sufficiently and effectively. The microstrip antenna's performance and characteristics were measured and compared to modelling findings. Furthermore, we have suggested which FR4 is best suited for various applications such as antenna size diminution and alternative mode improvement alteration-related tasks. The efficiency of rectangular patch microstrip antennas built utilizing FR4 substrate was compared to that of similar array built on a standard FR4 substrate. Microstrip patch antennas are extensively utilized for wireless devices in modern wireless communication networks. As a result, antenna shrinking has become a critical challenge in lowering the overall size of the communication network. Micro strip patch antenna are extensively used wireless networks in modern wireless communication networks. Because of the abilities of planned satellite communication systems, there is a demand in corporate, army, and wireless systems. Antennas having characteristics such as low profile, low weight, low price, ease of designing and technical integration, and relatively easy and easy fabrication. All of these antennas can be constructed with the help of the IE3D simulation programme, resulting in sharp and effective results. The proposed RMPA (rectangular microstrip patch antenna) may be employed in variety of wireless applications due of their low profile and small weight, connectivity systems are popular. A Microstrip Patch antenna, in its most basic form, comprises of a radiating patch on one part of a dielectric platform with a ground plane on the opposite side patch. The route of an antenna is usually made of conductive material such as copper or gold; we prefer copper since it is less expensive and can be bent into any form. Patch and feed line radiation is normally done using a photo etched method on a dielectric material. The impedance bandwidth and transmission loss of any telescope are critical characteristics. The bandwidth impedance is determined by the specifications of patch antenna element as well as the feed line. The capacity is restricted to a small percentage of the total. As a result, basic microstrip patch antennas have this disadvantage. The FR4 rectangular microstrip patch antenna significantly enhances bandwidth, back loss and VSWR. The FR4-based rectangle monopole patch antenna was designed using IE3D, a software tool for electromagnetic analysis and antenna.

In this work, we look at two different types of single-frequency antennas. Some types of ground structure are also used to enhance the findings analysis by limiting return loss and boosting the antennas' bandwidth. the antenna's back loss and expanding the antenna's bandwidth

[2]. SIMULATION OF SUGGESTED ANTENNA STRUCTURE

Figure 1 depicts the proposed antenna's geometry (a). A rectangular microstrip patch with dimensions of L x W was isolated from its ground plane by a foam substrate (r1) with a thickness of h1. In the centre of the different patch is a different shape. The W option can be used to specify the placement of the slots on the patches. W and L are the width and length of the slots, respectively. A 50 output feed probe is used to feed the square patch.

- Length(L): The two sides were chosen to be 45.64mm in length each.
- Width(W): The two sides were chosen to be 35.14mm in length each.
- Frequency of operation(fo): The transmitters' frequency response must be chosen carefully. For our design, we chose a resonance frequency of 2 GHz.
- Substrate low dielectric (r): The dielectric material that we used for our design has a refractive index of 4.43. Because it decreases the size of the transmitters, a high dielectric constant substrate was used.
- Height of dielectric material (h): It is critical that the microstrip patch antennas used in cellular phones are not too bulky. As a result, the dielectric substrate has a height of 1.6mm.
- Length (L) and Cutting Width (w): 5 mm and 10 mm were chosen as the length and width, respectively.

Zeland Inc's IE3D was used to design and simulate the Micro strip antennas. The method of moments is used to create IE3D, a full-wave electromagnetic simulator. It examines general shape 3D dimension and layered constructions. Wire transmitters, patch antennas, and other wireless and RF antennas have all been designed with it. It may be utilized to figure the band width, back loss and VSWR.

[2.1]. Microstrip Patch Antenna Design

Step 01: Calculation of Width (*W*)

The Microstrip patch antenna's width is specified as:

$$\frac{1}{2Fr\sqrt{(\mu\varepsilon)}}\sqrt{\left(\frac{2}{(\varepsilon r+1)}\right)}=\frac{C}{2Fr}\sqrt{\left(\frac{2}{(\varepsilon r+1)}\right)} \qquad (1)$$

Replacing c = 3.00e+008 m/s, ε_r = 4.40 and fo = 2.0 GHz

Step 02: Computation of Effective dielectric constant (εreff):

The effective dielectric constant is:

$$\varepsilon\, ff = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left(\frac{1}{\sqrt{1 + \frac{12h}{w}}}\right) \quad (2)$$

Step 03: Computation of the Effective length (*Leff*)

The effective length is:

$$L_{eff} = \frac{C}{2 f_0 \sqrt{\varepsilon_{reff}}} \quad (3)$$

Replacing Eeff = 4.40, c = 3.00e+008 m/s and fo = 2.0 GHz

Step 04: Computation of the length extension (Δ*L*):

$$\Delta L = 0.412h \frac{(\varepsilon_{ref}\, f + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

Step 05: Computation of actual length of patch (*L*):

The actual length is obtained by:

$$L = Leff - 2\Delta L \quad (5)$$

Step 06: Computation of VSWR

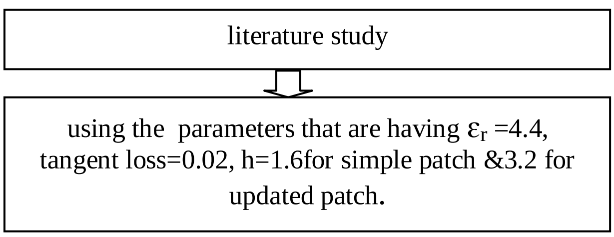
$$VSWR = \left(\frac{1 + |\Gamma|}{1 - |\Gamma|}\right) \quad (6)$$

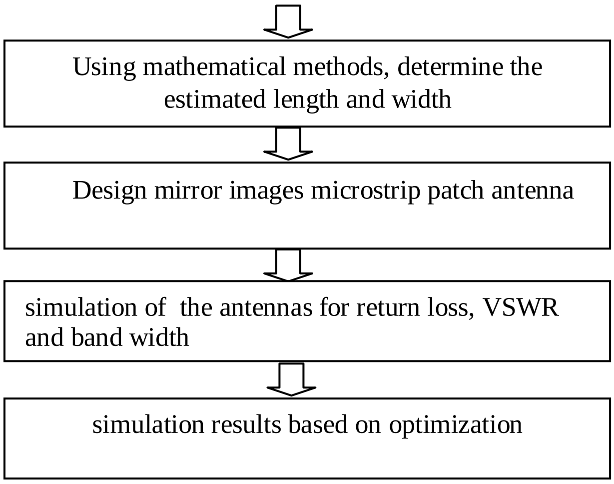
Step 07: Computation of Return Loss

Once an electromagnetic wave passes through a transmission radiating patch and strikes a mismatched load or a feed line discontinuity, some of incidence power is returned back down line. The return loss is calculated as follows,

$$RL = 10 \log_{10}(\Gamma)\, dB \quad (7)$$

[2.2]. Methodology BASED DISIGN





[3]. Designing of T-shape Rectangular microstrip patch antenna Topology

Figure 1 depicts the proposed RMPA transmitter arrangement (a). The suggested L&W dimension is printed on a substrate with a height of h=1.6 and a comparative capacitance of 4.4. On a base substrate, the print is scratched. A 50-microstrip line feeds the slot. Figure 1 shows the basic square microstrip line fed printing transmitter layout (a). The working frequency for exciting is around 2 GHz, and the size is determined by Figure 1 depicts a Square Microstrip Patch Antenna fed by Microstrip Line, wherein c is velocity of sound in air, is efficient relative capacitance and L is length of the Rectangular Microstrip Patch Antenna. The resonance frequency of a microstrip patch transmitter is 2 GHz. The patch is 35.443mm in length and 45.656mm in width. The microstrip line has a length of 32.822mm and is used for feeding. We used a double-sided copper PCB to design this transmitter. The bottom layer for this transmitter is a copper field on the lower side of the PCB, and we constructed a perfect mirror T- patch with the given size on the upper side of the PCB. Using a dielectric with a thickness of 1.6mm and a dipole constant of 4.4mm, the entire geometry is modeled and increased effectively. The material's loss tangent is 0.02. The feed to the transmitter is provided via the microstrip feeding method

[3]. Design parameters of T shape Microstrip Patch Antenna

Co-ordinates 1st:
The slot size of
ws1, ws2, ws3, ws4 ,ws5, ws6, ws7, w8, ws9, ls1, ls2, ls3, ls4, ls5, ls6, ls7, ls8, ls9 are 2.5, 2.5, 7.5, 7.5, -7.5, -7.5, -2.8, -2.8, 2.5, 12.8, 17.8, 17.8, 22.8, 22.8, 17.8, 17.8, 12.8 and 12.8mm respectively.

Co-ordinates 2nd
The slot size of
ws1, ws2, ws3, ws4, ws5, ws6, ws7, w8, ws9, ls1, ls2, ls3, ls4, ls5, ls6, ls7, ls8, ls9 are 2.5, 2.5, 7.5, 7.5, -7.5, -7.5, -2.8, -2.8, 2.5, -12.8, -17.8, -17.8, -22.8, -22.8, -17.8, -17.8, -12.8 and -.8.0mm respectively.

Co-ordinates 3rd:

A circle
X=0 ; Y=0
R=5, single ploygen
No. of segments = 50

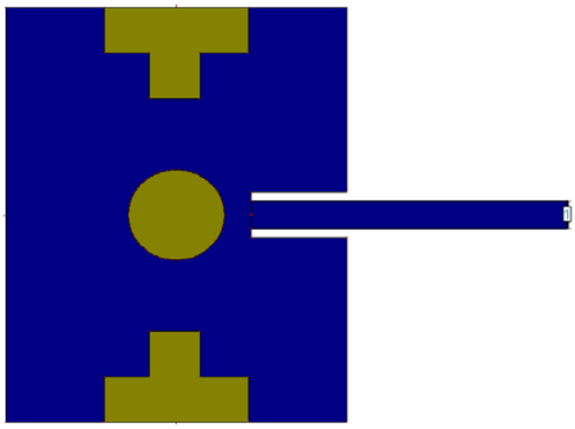


Figure 1(a): T Shape Rectangular Microstrip Patch Antenna

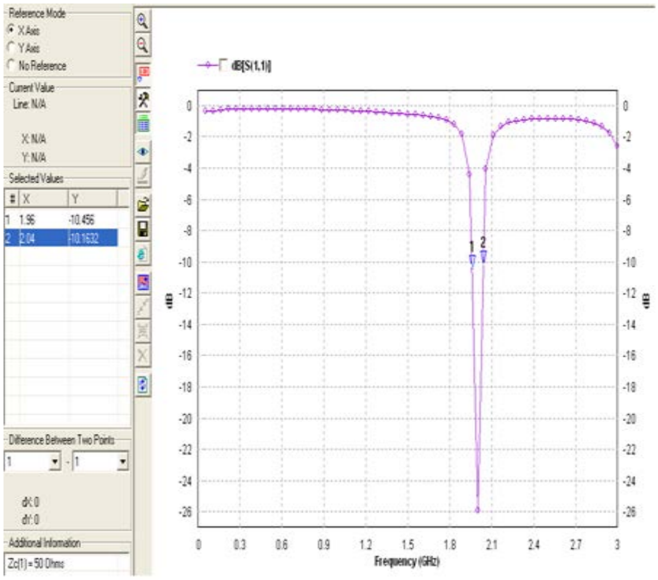


Figure1(b): Simulation Results of Return Loss of T Shape Rectangular Microstrip Patch Antenna

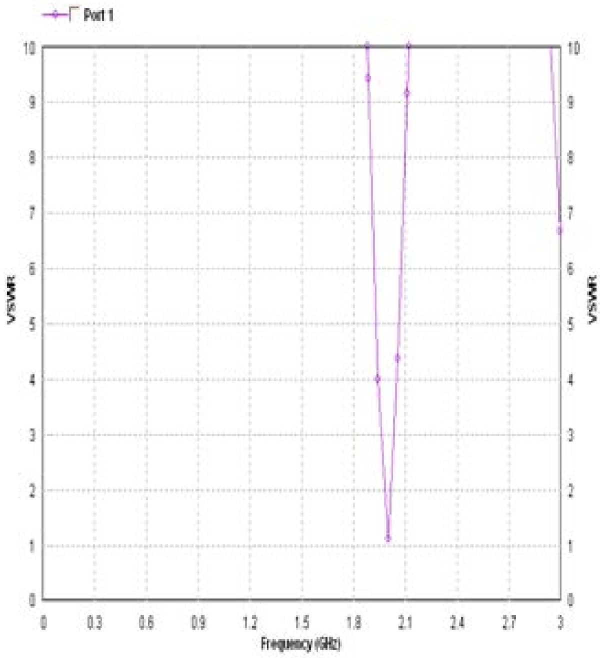


Figure 1(C): VSWR forT Shape microstirp Patch Antenna

[3.1]. Geometry & Designing

A little compact T form and I shape microstrip patch transmitter is presented in this study. We used mirror image designs to improve the performance of this T-and I shaped microstrip patch transmitter The efficiency of a simple patch cannot be influenced by any single structure that lacks a mirror reflection. In this study, the two structures in the shape of T and I have been utilized, and outcomes are very similar. The T and I forms can help with impedance matching. Figures 1 and 2 depict the suggested microstrip patch satellite's design. The patch antenna is small in size of 45.644mm x 35.142mm (W x L) and is built on a FR4 substrate with a depth of 3.2mm and an absolute dielectric constant (r) of 4.4, as illustrated in Figs. 1 and 2.

A microstrip line with a cut length of 5 mm and a cut length of 10 mm feeds the burner. A 50 microstrip line with such a frequency of 2GHz is printed on the partially grounded substrate as the excitation.

The redesigned first and second ground planes serve as an impedance matching component in square microstrip patch antennas, controlling the resistance bandwidth Where ws stands for antenna width and ls stands for antenna length.

The suggested transmitter may be configured to function at 2.0GHz frequency by selecting these variables. The findings of both simulations and experiments are also discussed. The Zeland IE3D model yielded the simulation results in this research.

[3.2] Design parameters of I Shape Microstrip Patch Antenna

Co-ordinates 1^{st}:

The slot size of

ws1, ws2, ws3, ws4, ws5, ws6, ws7, w8, ws9, ws10, ws11, ws12, ws13, ls1, ls2, ls3, ls4, ls5, ls6, ls7, ls8, ls9, ls10, ls11, ls12, ls13, 9, 11, 11, -11, -11, -9, -9, -11, -11, 11, 11, 9, 9, 17.8, 17.8, 22.8, 22.8, 17.8, 17.8, 8.8, 8.8, 3.8, 3.8, 8.8, 8.8, 17.8 respectively.

Co-ordinates 2nd

The slot size of

ws1, ws2, ws3, ws4, ws5, ws6, ws7, ws8, ws9, ws10, ws11, ws12, ws13, ls1, ls2, ls3, ls4, ls5, ls6, ls7, ls8, ls9, ls10, ls11, ls12, ls13, 9, 11, 11, -11, -11, -9, -9, -11, -11, 11, 11, 9, 9, -17.8, -17.8,-22.8, -22.8, -17.8, -17.8, -8.8, -8.8, -3.8, -3.8, -8.8, -8.8, -17.8 respectively.

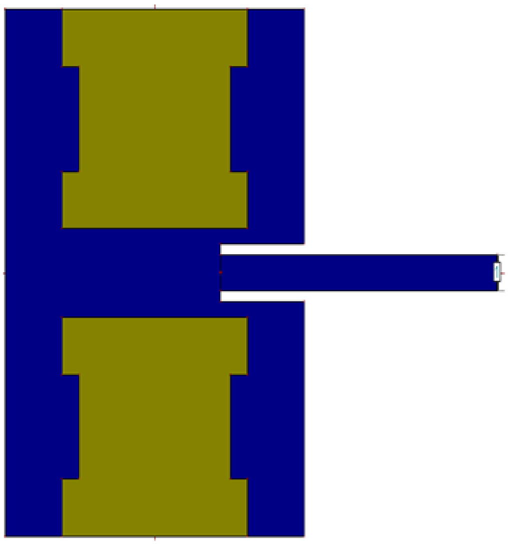


Fig2 I shape microstrip patch antenna

[3.3]. Return Loss & VSWR

The inset feed utilized is design to have inset depth of 10.0mm, feed-line width of 5.0mm as well as feed path length of 32.0mm. A frequency span of 2.0GHz is chosen and 151frequency points are chosen over this span to acquire precise and effective results.

The centre frequency is chosen to have return loss minimal. The span of frequencies during which the RL is higher than -10 dB is referred to as the antenna's bandwidth (A VSWR of 1 yields 10 dB, which would be a good value). The best feed depth, as determined by IE3D, is Yo = 13.2mm, with an RL of -38.01dB, The achieved centre frequency of 2.0GHz is quite near to the required design frequency of 1.998 GHz.

The numerical simulation in Figures 1 and 2 support this approach. T slots and I slots have an impact on antenna effectiveness. The S11 hits -39.12 dB and 40 dB at 2 GHz, respectively, and the VSWR is 1.0212 and 1.012. The increased bandwidth is attributed to the T shape and I shape achieving even more vertically electrical current throughout the patch, resulting in an even more consistent supply of magnetic current in digits. The suggested antenna's predicted current distribution around 2.0GHz frequencies is shown in Fig.

An antenna model was built and evaluated to verify the simulation results. Measurements are taken in this prototype using a coaxial port connected to underside edge of both the microstrip feed line. Several disparities between simulated and observed results, however, can be easily detected.

[3.4]. Simulated Results and Discussions

The suggested antenna is simulated using the IE3D simulation tool in determining its performance. By altering one of several physical model parameters while leaving the others constant, the antenna was analysed for various physical model parameters. This research is being done to see how flexible design of a two layer patch antenna may be.

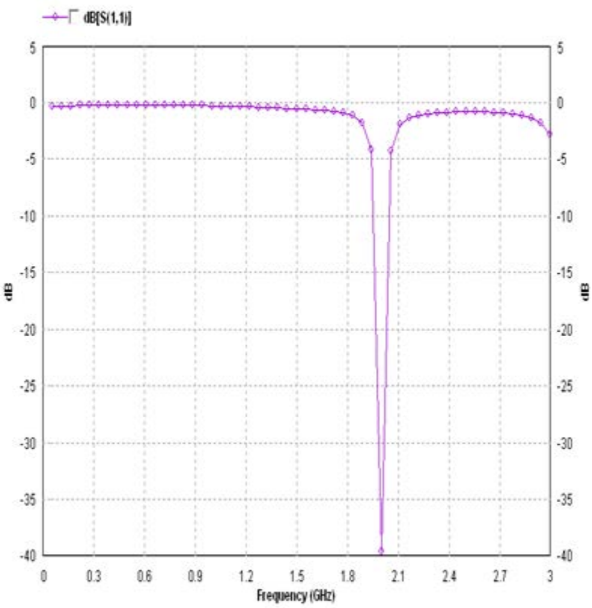


Fig2(a) simulation results of return loss of I shape microstrip antenna

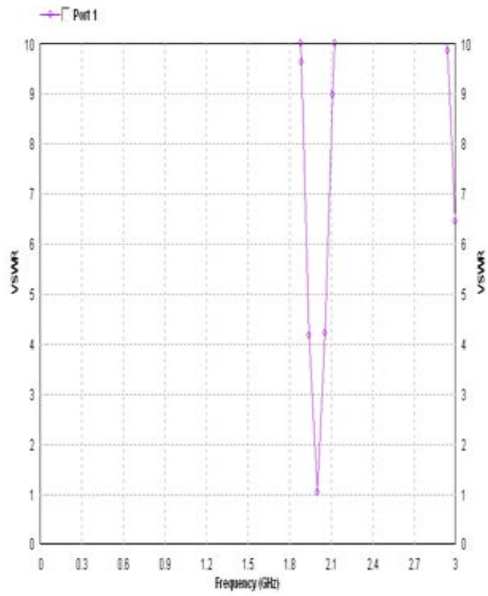


Fig2(b) simulation results of VSWR I shape microstrip antenna

[4].Conclusion

This Paper describes the result of proposed design of different shapes modified Rectangular A mathematical model of a microstrip patch antenna made of FR4 has been developed. IE3D software was used to simulate and design the project. The insertions of FR4 Structure are discovered in this paper on 1.6mm or Finally, 3.2mm Covering on Rectangular Microstrip Patch Transmitter Reduces comparative analysis of T and I shape the Return Loss and Enhances Bandwidth significantly, It is occur in modified by RMPA 1 is -38dB and RMPA 2 is -40db . It was also established that the focused effective The effect of FR4 is that it minimises their Return Loss, improves bandwidth, and improves VSWR. This proposed RMPA typically can be used for satellite and wireless communication.

[5].References

[1]Dheeraj Bhardwaj, Komal Sharma'' Dual band and Broadband Rectangular Patch Mircostrip Antenna with T Shaped Slot for WiMax Application'' International Journal of Engineering Research and Development ,Volume 3, Issue 12,September 2012.

[2] Bimal garg, Himanshu Srivastava, Prem Kumar, "Micro-strip Patch Antenna with Parameters Improvement Using "Symmetric Cylinder Shapes of Zero & Four Segments" Meta-material Structure", International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501, Vol.2, No.3, June 2012.

[3] Ravishankar Tiwari,'' 't' shape microstrip patch antenna at 2.45ghz'' Journal of Research in Electrical and Electronics Engineering (ISTP-JREEE),2013.

[4] F. Zhao, K. Xiao, W.-J. Feng, S.-L. Chai, and J.-J. Mao, "Design and Manufacture of the Wide-Band Aperture-Coupled Stacked Microstrip Antenna", Progress in Electromagnetics Research C, Vol.7, Pg No. 37-50, 2009.

[5] Yoshiaki Kamiya,Wataru CHUJO and Masayuki FUJISE "Design for Dual Frequency Microstrip Antenna using Annular Slot Aperture Coupling." Antenna and Propagation Society International Symposium, 1991.

[6] S.M.Duffy and D.M.Pozar "Circularly Polarized Aperture Coupled Antenna" electronics letters Vol. 31 No. 16, 3rd August 2002.

[7] Rashid. A Saeed, S.Khatun, Borhauddin, M.A. Khazani, Raina A Mokhtar "Design of Single Fed Aperture coupled Microstrip antenna for WLAN".IEEE Transaction on Antenna and Propagation, 2005.

[8] Manoj Singh, Ananjun Basu and S.K.Koul "Design of Aperture Coupled Fed Microstrip Antenna for Wireless Communication"/ IEEE , Indian Conference, Pg No: 1-5, 2006.

[9] M.S.R. Mohd Shah, M.K.Suaidi, M.Z.A.Abdul Aziz, M.F.Abd Kadir, M.K.A. Rahim "Dual Polarization Microstrip Patch Array Antenna for WLAN Applications"/ Antennas and Propagation, 2009. EuCAP 2009. 3rd European Conference, 2009.

[10] V.G.Veselago"The electrodynamics of substances with simultaneously negative value ε and μ" Sov. Phys. Uspekekhy.10 (4), pp 509-514, 1968.

[11] W.L. Stutzman, G.A. Thiele, Antenna Theory and design, John Wiley & Sons, 2nd Ed., New York, 1998.