GLOBAL MARKETS, GLOBAL TECHNOLOGY, AND GLOBAL STUDENS?

A COMMUNICATIONS CONTRIBUTION TO THE WORKSHOP, "THE FUTURE OF & TECHNOLOGY" UNIVERSITY OF FLORIDA @ GAINESVILLE

UPDATED 2022

Ulrich L. Rohde, Prof. Dr. Ing. habil.
Chairman Synergy Microwave Corp.
Cottbus University of Technology, Germany
University of the Armed Forces, Munich, Germany
Partner Rohde & Schwarz

UF UNIVERSITY of FLORIDA

University of Florida

THE

DEPARTMENT OF ELECTRICAL ENGINEERING

With the approval of the Faculty

hereby recognizes the permanent appointment of

ULRICH L. ROHDE

as

Professor of Electrical Engineering

March 15, 1977

Wayne H. Chen
Dean, College of Engineering

Donald L. Childers
Chairman, Department of

The George Washington University

THE

DEPARTMENT OF ELECTRICAL ENGINEERING

With the approval of the Faculty
hereby recognizes the permanent appointment of

Ulrich L. Rohde

as

Adjunct Professor of Electrical Engineering

Arthur D. Friedman

May 4, 1982

Arthur D. Friedman
Chairman, Department of Electrical

GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Using the example of the cell phone industry

International communications market

- The technologies involved are a combination of analog and digital applications as well as passive and active components.
- The globally/universally useful RF engineering additionally understands
  - A/D converters
  - DSP, digital signal processing (DSP),
  - Micro processor coding in C++
  - Business education (MBA)
  - Innovative design with an eye for quality and reliability of the product.

Analog Technology, Examples

- RF front ends consists of
  - Analog low noise preamplifiers
  - “Linear mixers”
  - PLL based synthesizers with low power consumption
- Design parameters may be:
  - Noise figure, i.e.: < 1dB
  - Intermodulation distortion IP3>1dBm
  - Input selectivity,
  - Phase noise (-145dBc/Hz @ 200KHz)
  - Settling speed, less than 1mS

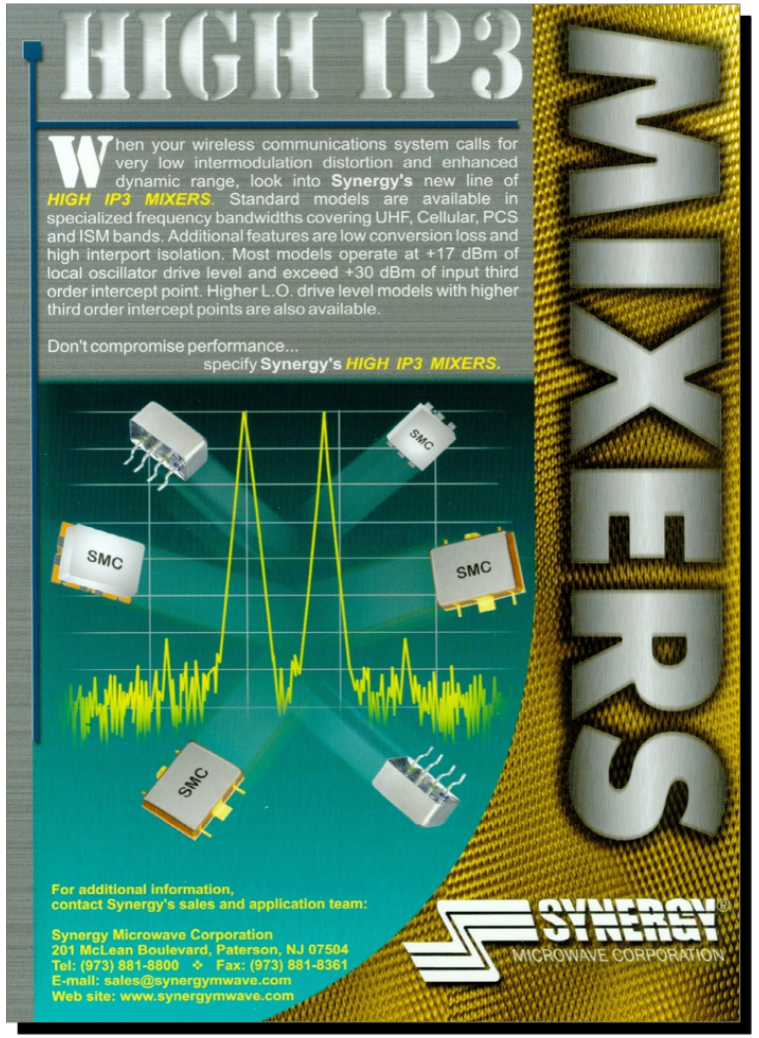
Digital Technology Example

- Analog to digital converters (A/D)
  - Optimized IF frequencies
  - impedance matching
  - Overload vs. noise figure
- Design decisons may be:
  - IF selectivity
  - Coding scheme
  - Composite filters implementation in DSP
  - Automatic gain routines
  - Computational delay time

ANALOG AND DIGITAL TECHNIQUES

HIGH PERFORMANCE ANALOG TECHNIQUES

AN EXAMPLE



GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Using the example of the cell phone industry

Evolution of the cellular technologies

EVOLUTION OF DIGITAL CELLULAR TECHNOLOGIES

2G

Mainly GSM

Narrowband 270 kHz

Few frequencies
900/1800/1900 MHz
No global frequencies

Low datarates, initaly 9.6 kbps evolving up to 384 kbps

Very high latency

1991

3G

Mainly WCMDA

Bandwith 5 MHz

Initially 2.1 GHz almost global availability
Evolved to a global standard

Data rates 384 kBit/s evolving to 42 Mbit/s

Medium latency
Suffered from IPR fights

2002

4G

LTE

Flexible bandwidth up to 20MHz

Deployed from 400 MHz to 3.7 GHz

Data rates from 40 Mbit/s to todays 1.2 Gbit/s

Low latency

2010

5G

5G NR

Scalable bandwidth up to 400 MHz

Frequencies up to 53 GHz

Very high data rates

Ultra low latency possible

2019

GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Winners and others: Some examples

Winners

Apple

- Entered the mobile world 2007
- Most profitable since manufacturer 2009

Samsung

- Scale of economy
- In house touch screen expertise
- Worlds largest manufacturer

Google

- Android has 85% market share as mobile OS
- 38% of all devices connected to the internet are using Android
- 2021 – 3 billion active devices

Others

Nokia

- 2009 the largest cellphone maker in the world
- Too proud to adopt Android
- Strong innovation culture – failed to bring innovations to the market – sold to Microsoft – Name sold to HMD
- Most profitable since manufacturer 2009

Motorola

- Sold to Google – sold to Lenovo

Ericsson

- Cellphones was a mean to sell infrastructure - when 3G matured – not able to compete.
- Sold to Sony

Blackberry

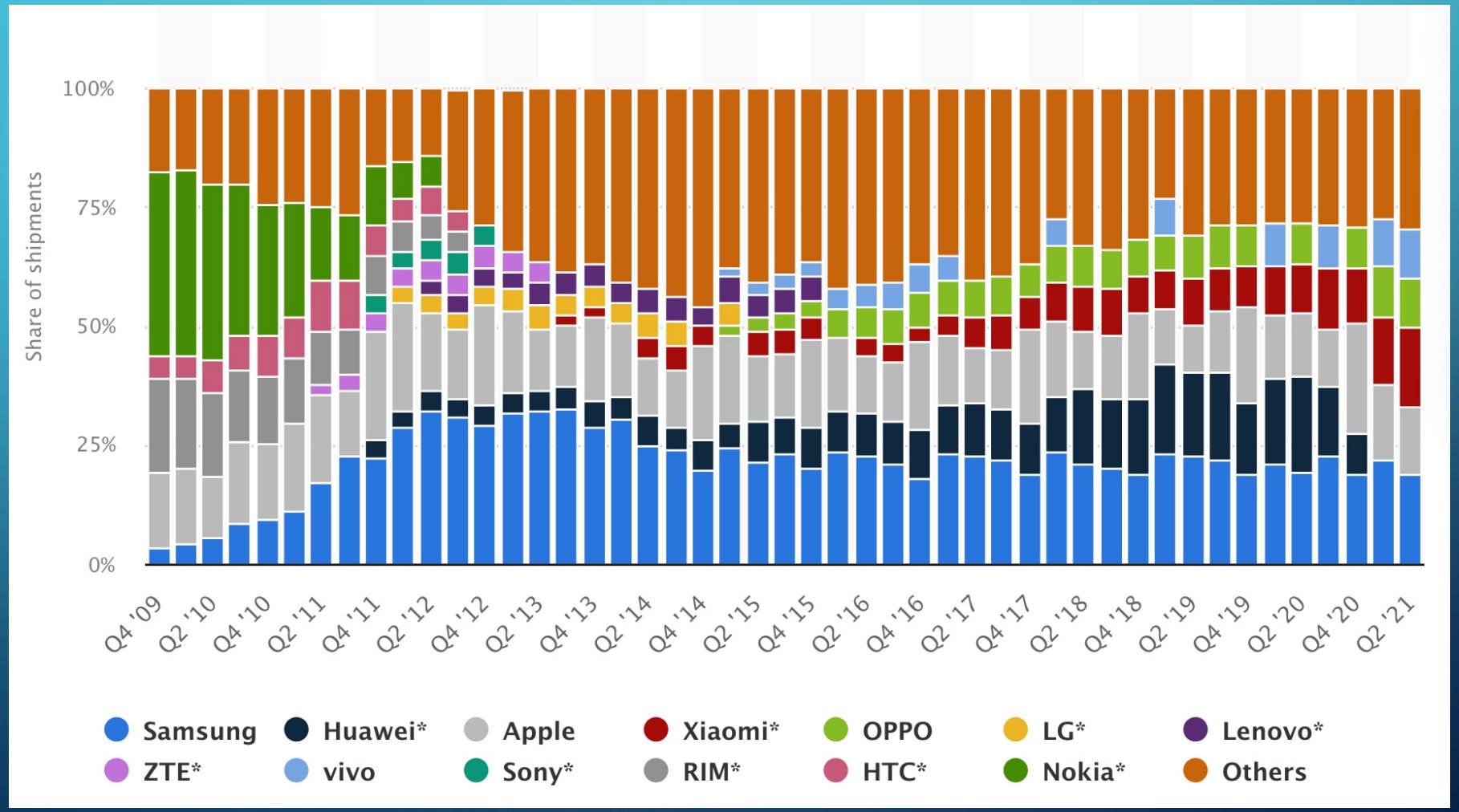
- Focused on messaging
- Missed the touch screen revolution

Huawei

- First cellphones 2003
- 2019 worlds second largest supplier of smartphones
- "Killed" by US trade sanctions

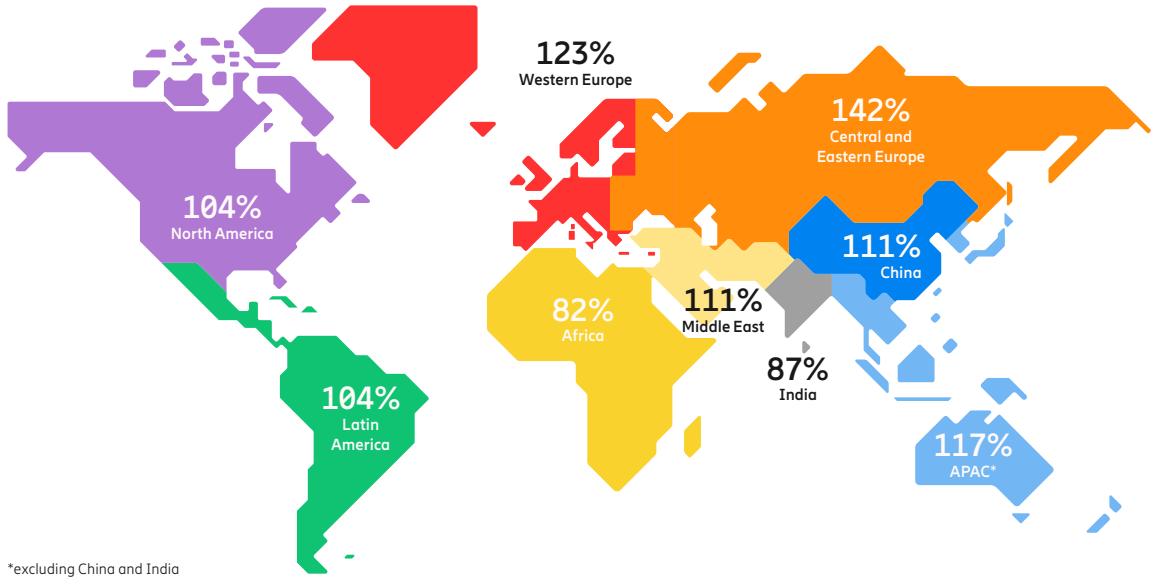
CELLPHONE SHIPMENTS UNTIL 2021

SOURCE: WWW.STATISTA.COM

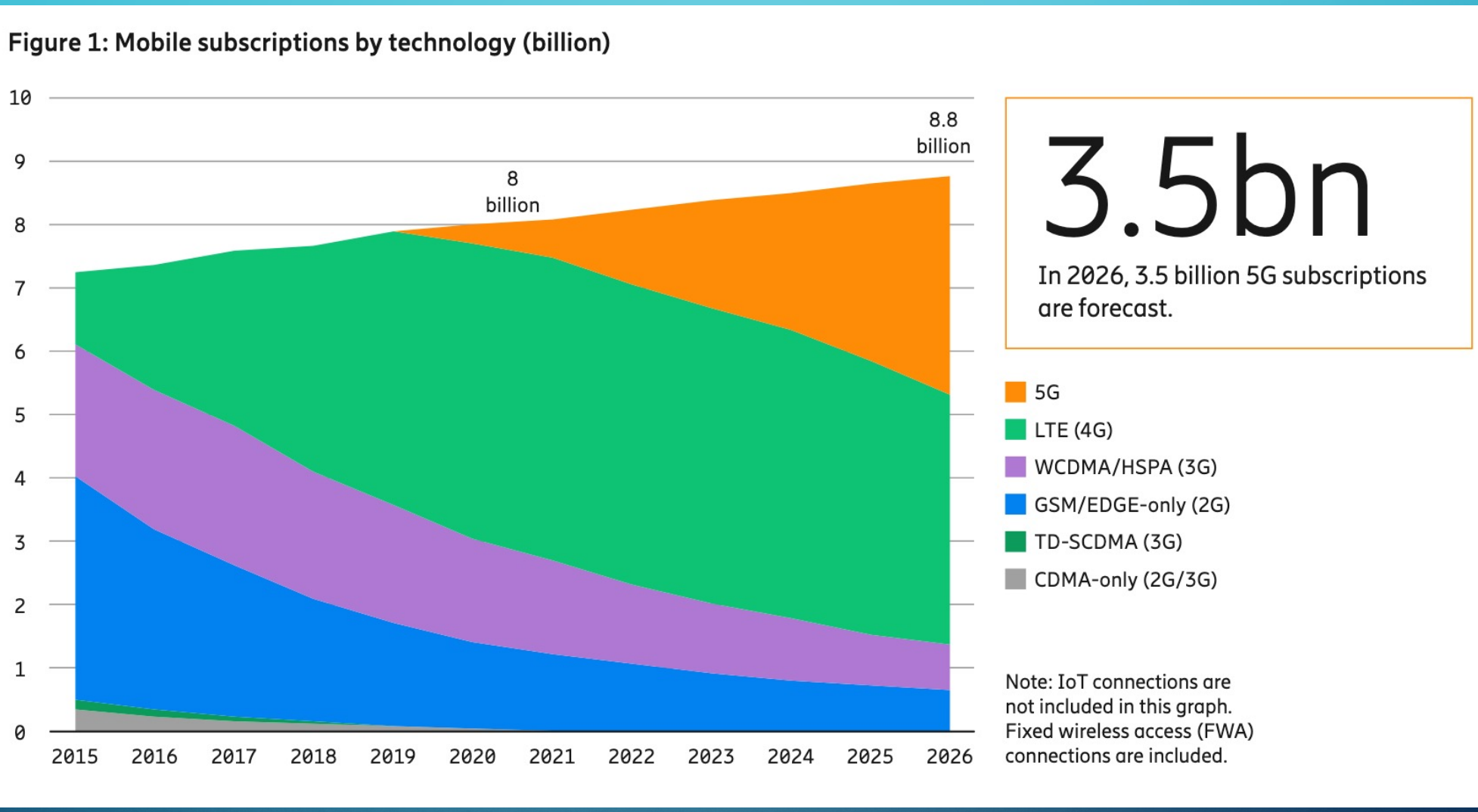


GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Looking Forward: What will drive the technological development?

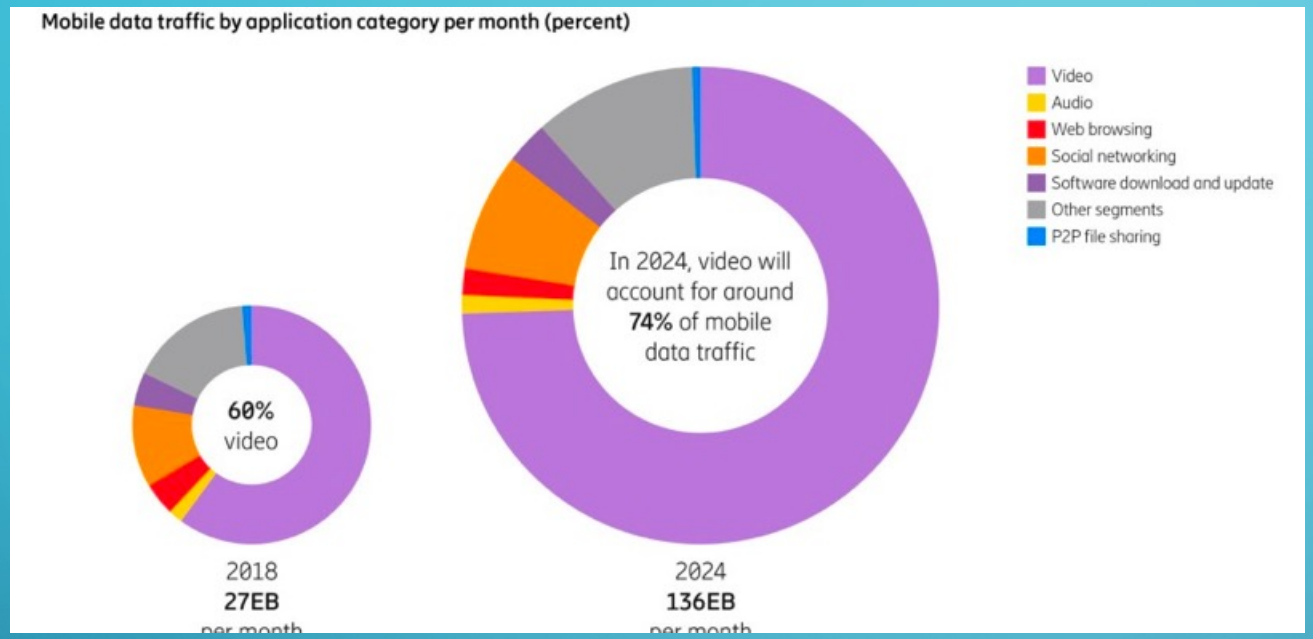


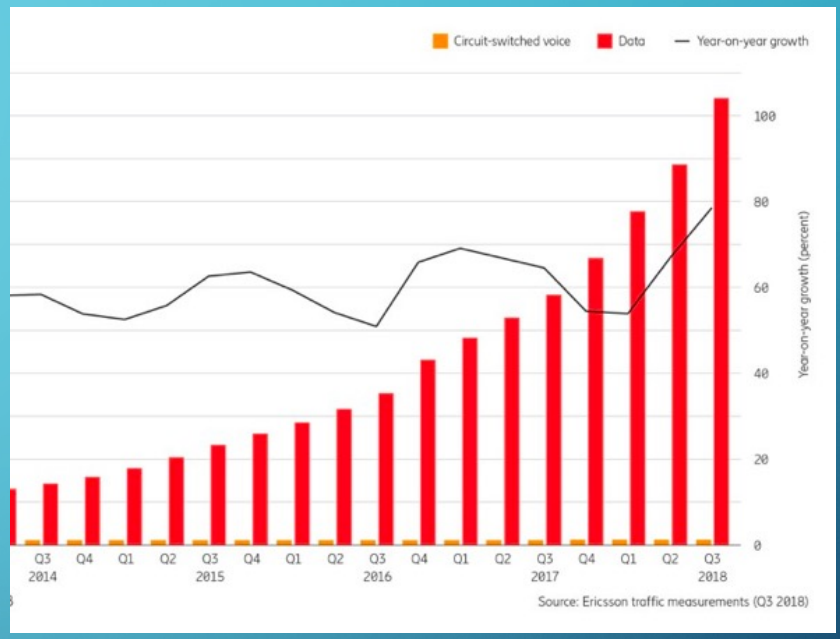
LTE A TRUELY GLOBAL TECHNOLOGY
SUBSCRIPTION PENETRATION 2018
SOURCE: ERICSSON MOBILITY REPORT



THE FUTURE OF WIRELESS TECHNOLOGIES

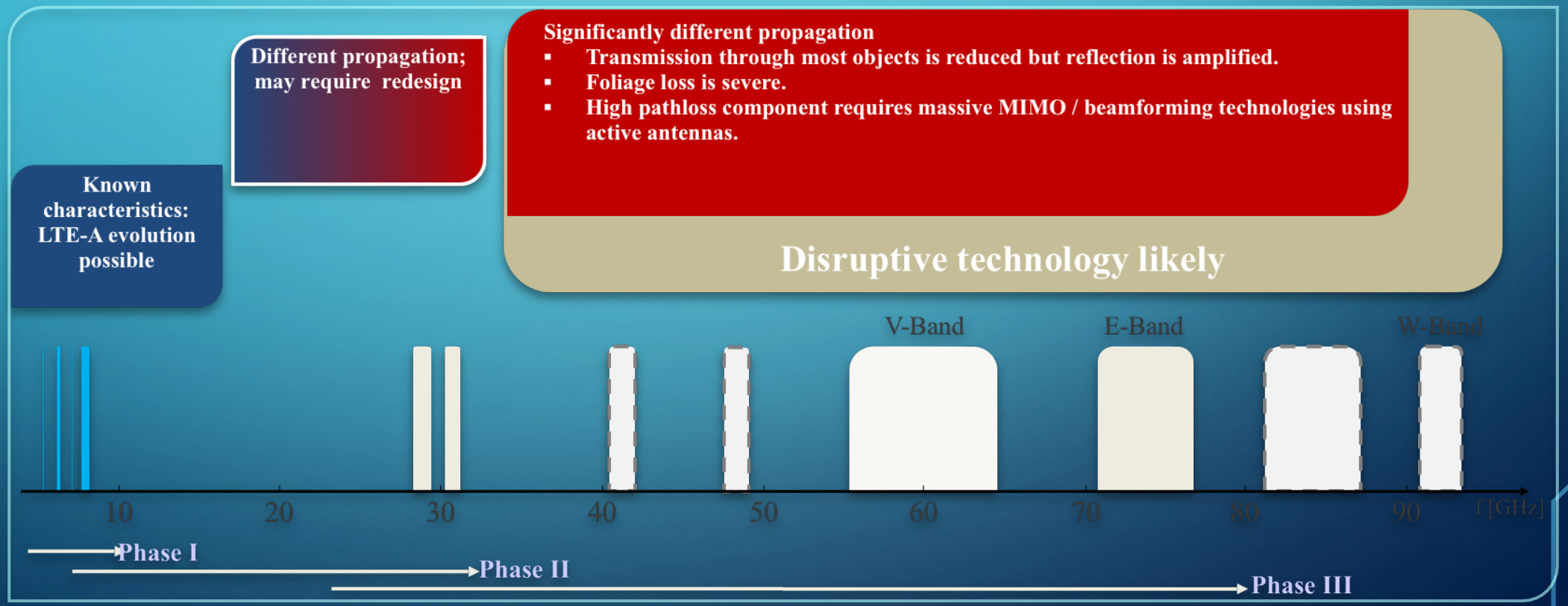
SOURCE: ERICSSON MOBILITY REPORT



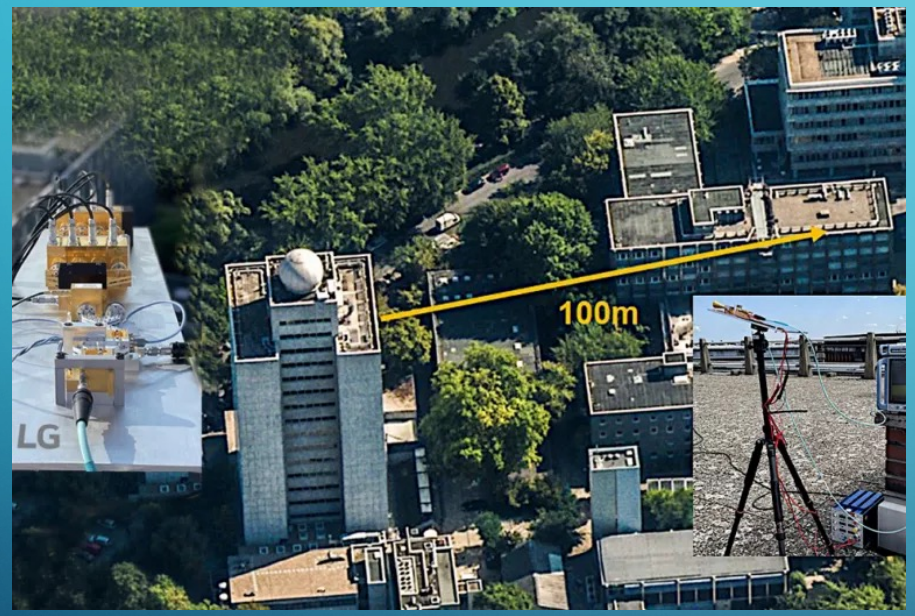


DATA WILL BE DRIVING THE FUTURE OF THE CELLULAR INDUSTRY

HIGHER DATA RATES REQUIRES BANDWIDTH ONLY AVAILABLE AT HIGHER FREQUENCIES



FIRST 6G DEMOSTRATORS USING D-BAND AIMING FOR COMMERCIALIZATION 2029

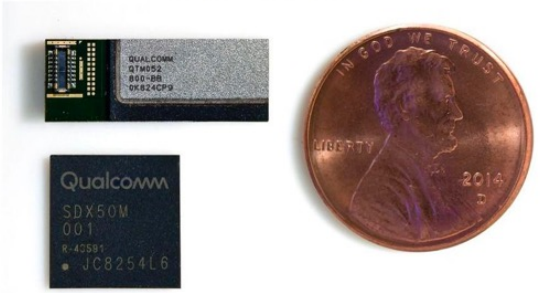


https://www.lgnewsroom.com/2021/08/lg-records-6g-thz-band-milestone/

GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

How has the cellphone antenna developed over the years ?

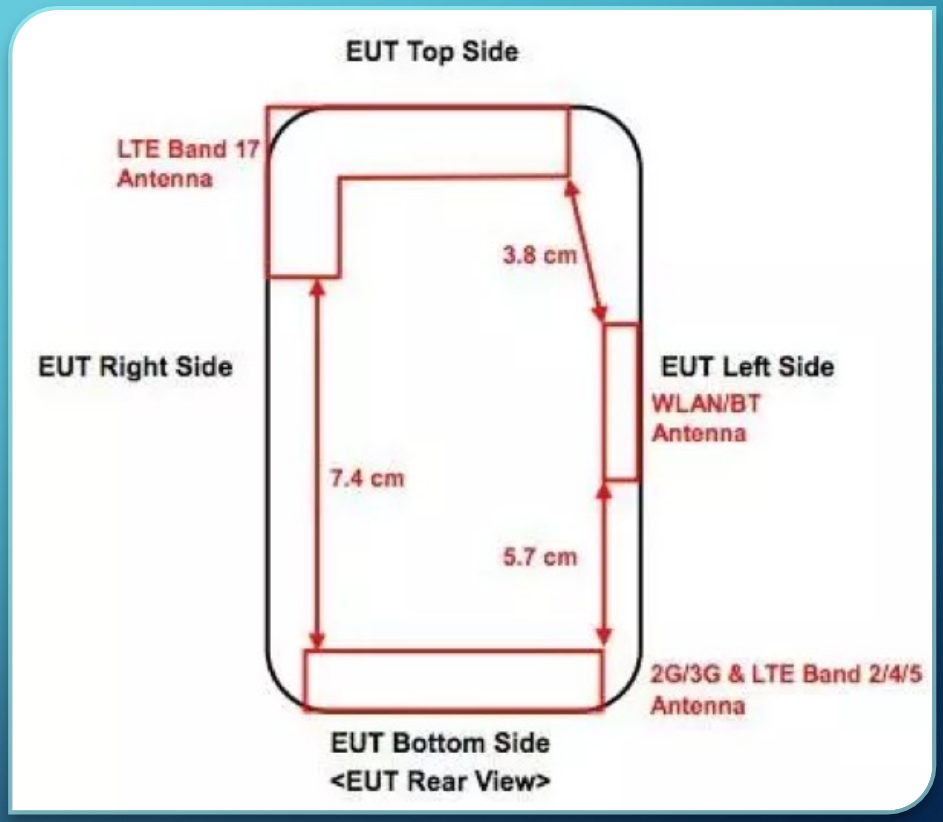
Qualcomm QTM052 mmWave Antenna Module & Snapdragon X50 5G modem



Antennas in a modern cellphone

Not just one antenna

- Up to 10 different frequency bands
- Multiple cellular technologies:
  GSM, UMTS,LTE, TD-SCDMA
- Non cellular technologies: WiFi, Bluetooth, GPS, Glonass, Galileo, Baidu, NFC
- Receive diversity antennas



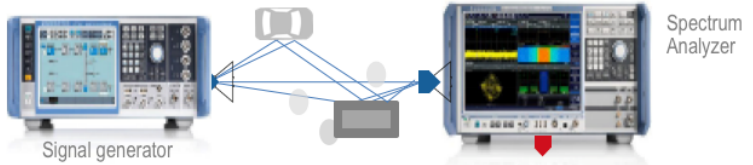
GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

What tools are available for the RF engineers ?

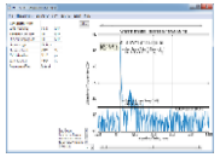
Wideband Signal Testing

DUT

Channel Sounding Solution



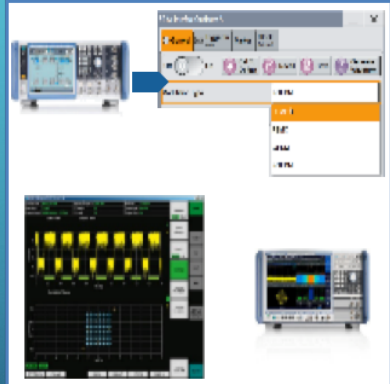
- fast measurement in time domain
- support for in- and outdoor sounding
- very high dynamic range



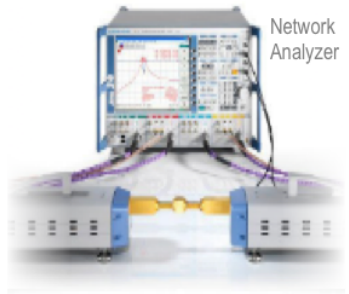
Massive MIMO - Beamforming

- Phase-coherent RF generation
- Multi-port VNA

New 5G PHY Candidates

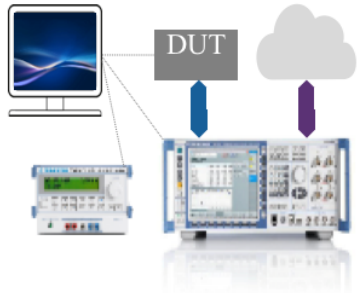


Component Characterization



Direct measurements up to 110 GHz

E2e Application Testing



Analyze application behavior like signaling load, delay, power etc.

GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Requirements For Modern Adaptive Students

Requirements For Modern Adaptive Students

Fewer young people nowadays choose engineering education, and what is even more worrisome is the fact that the most gifted students decide to study at the faculties of computer science and engineering, choosing zeros and ones over microwaves or curl and divergence. The said zeros and ones are significantly easier to comprehend than the area of curl and divergence.

Requirements For Modern Adaptive Students

Therefore, as a consequence, the computer students score higher than those who study the microwaves area, while putting, in fact, less effort into their learning. Difficult curriculum and fewer opportunities to obtain high grades cause the students to lose interest in microwaves.

Requirements For Modern Adaptive Students

“The only person who is educated is the one who has learned how to learn and change”

The general demand to master new skills results from constantly modernizing technologies.

“The world does not pay for what a person knows. But it pays for what a person does with what he knows.”

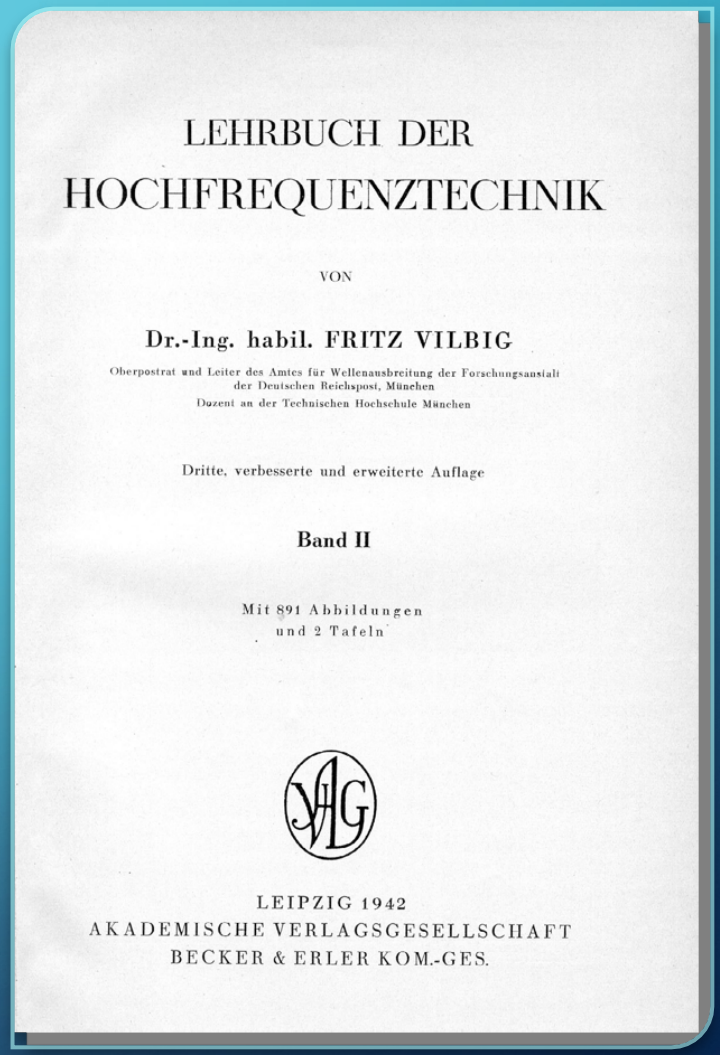
Reference: Josef W. Modelski, MTT-S Microwave Magazine, August 2008

GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Literature

From 1942

- RF/Microwave Education (in German)
- Focus mostly on theory
- No international conferences
- No technology exchange or transfer due to language problems
- No digital technology (did not exist at that time)



LEHRBUCH DER
HOCHFREQUENZTECHNIK

VON

Dr.-Ing. habil. FRITZ VILBIG

Oberpostrat und Leiter des Amtes für Wellenausbreitung der Forschungsanstalt der Deutschen Reichspost, München
Dozent an der Technischen Hochschule München

Dritte, verbesserte und erweiterte Auflage

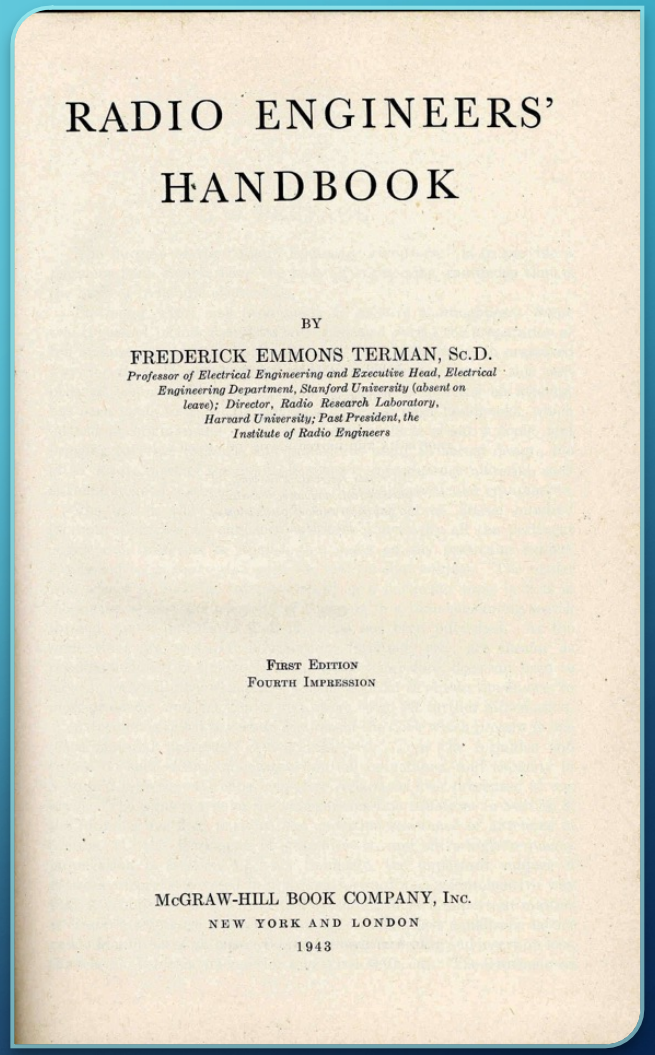
Band II

Mit 891 Abbildungen
und 2 Tafeln

LEIPZIG 1942
AKADEMISCHE VERLAGSGESELLSCHAFT
BECKER & ERLER KOM.-GES.

From 1943

- The State of the Art text book for radio engineering
- Probably the best comprehensive US radio electrical engineering book ever written. Used in all English speaking countries.
- Contains only analog circuitry (Digital technology did not exist at that time)



RADIO ENGINEERS' HANDBOOK

BY

FREDERICK EMMONS TERMAN, Sc.D.

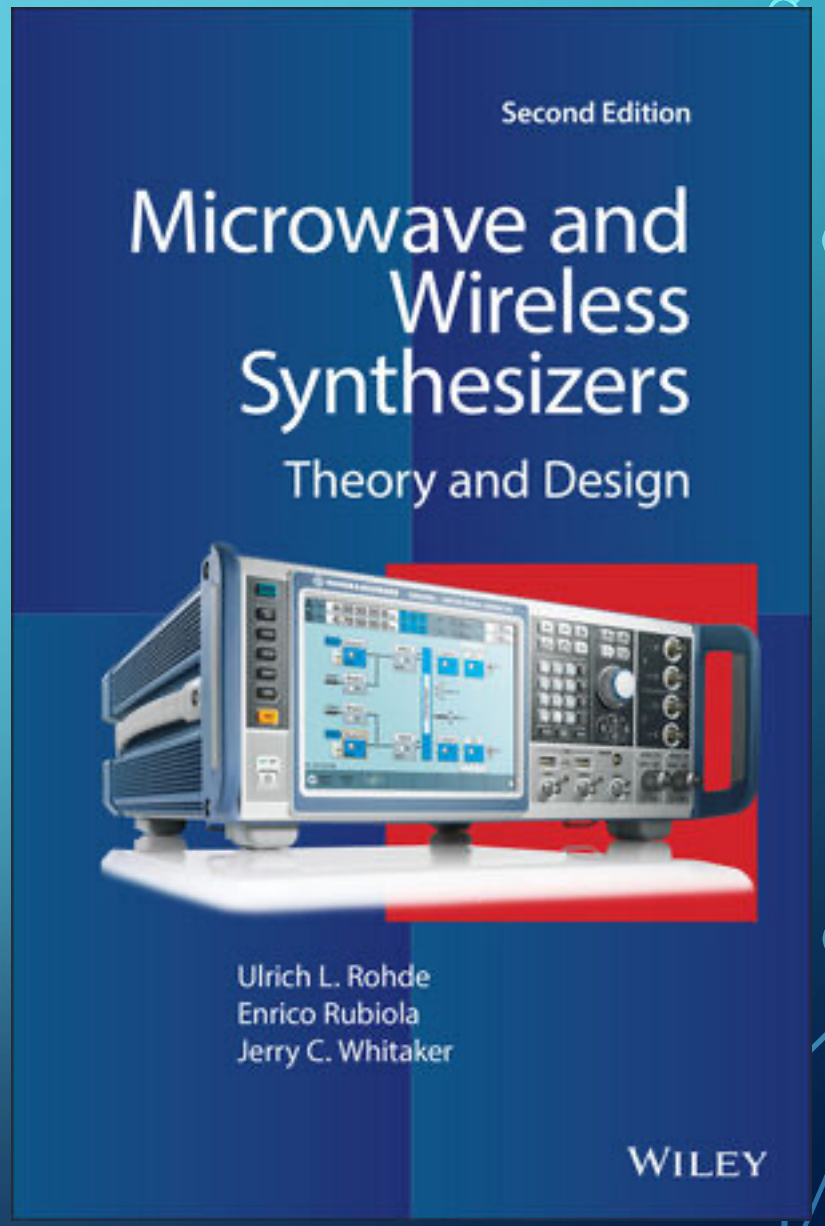
Professor of Electrical Engineering and Executive Head, Electrical Engineering Department, Stanford University (absent on leave); Director, Radio Research Laboratory, Harvard University; Past President, the Institute of Radio Engineers

First Edition
Fourth Impression

McGRAW-HILL BOOK COMPANY, Inc.
NEW YORK AND LONDON
1943

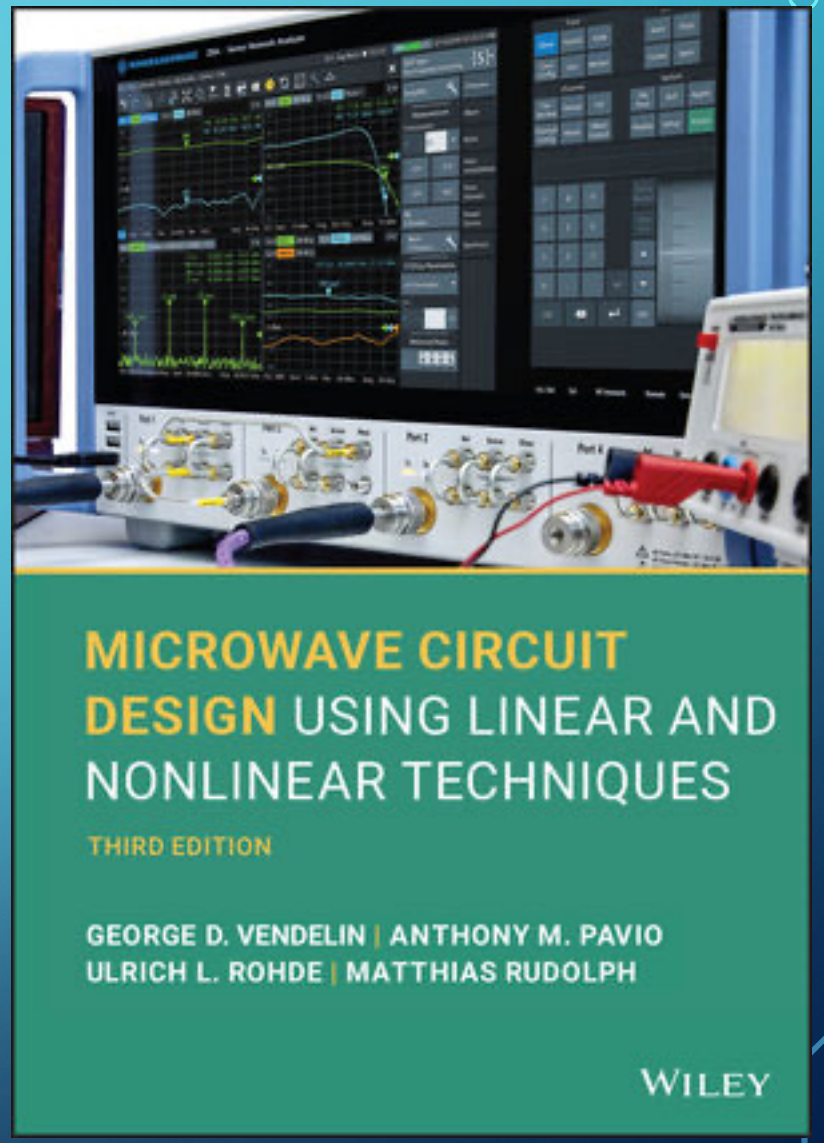
From 1997

- Microwave and Wireless Synthesizers-the first book to emphasize both practical circuit information from RF to millimeter-wave frequencies and up-to-date theory.
- In-depth look at the practical side of the phase-lock loop (PLL) in synthesizers-including special loops, loop components, and practical circuits-material
- Second edition 2021



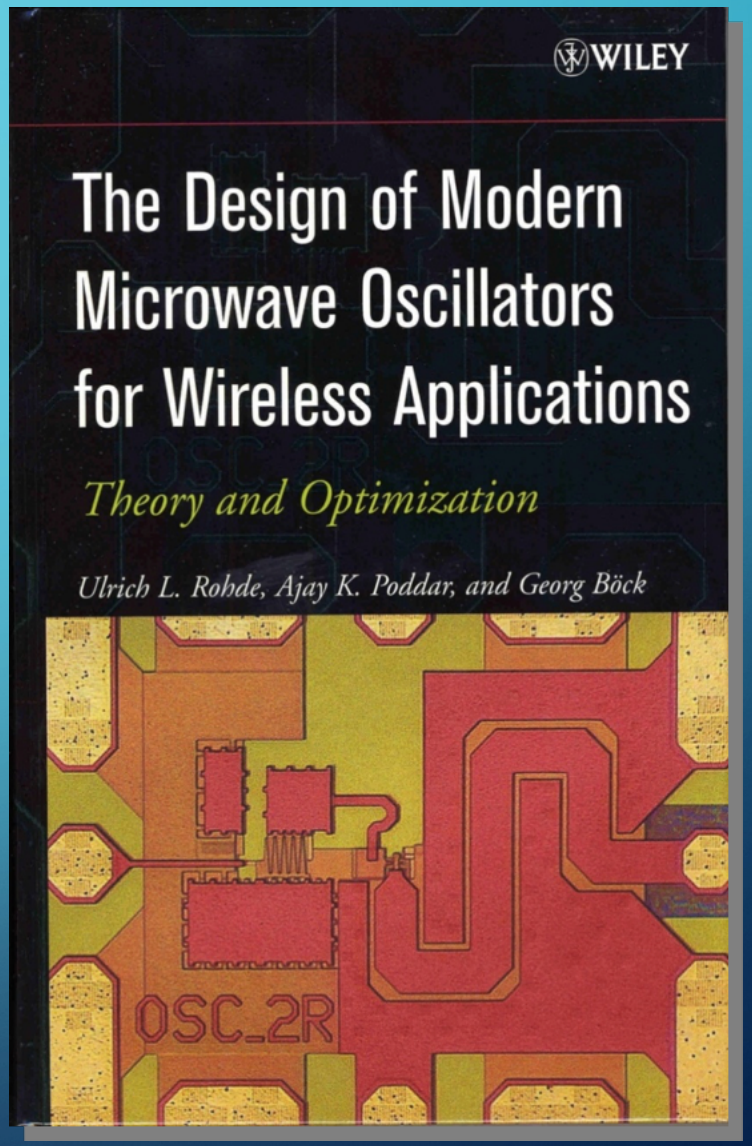
From 2005

- Linear and nonlinear circuit analysis treatment 3rd edition 2021
- Best in class
- Covers all relevant material
- Ideal reference material



From 2005

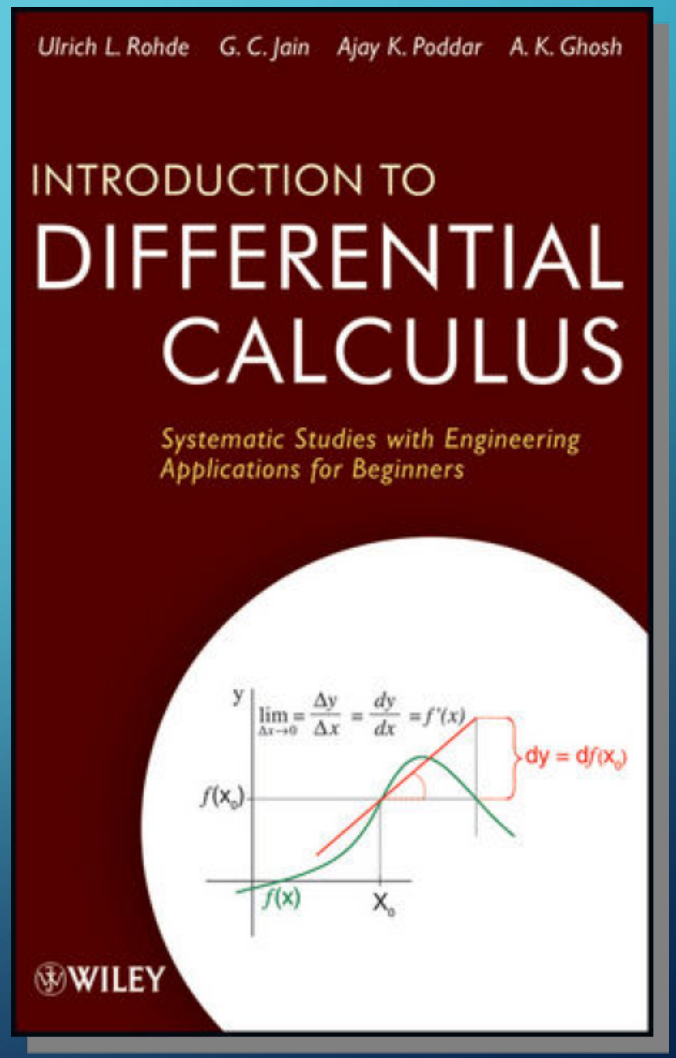
- Oscillator performance can make or break a system performance
- Covers RF to millimeter wave circuits
- Most advanced text book on this topic
- Ideal reference material



From 2012

Introduction to Differential Calculus fully engages readers by presenting the fundamental theories and methods of differential calculus and then showcasing how the discussed concepts can be applied to real-world problems in engineering and the physical sciences.

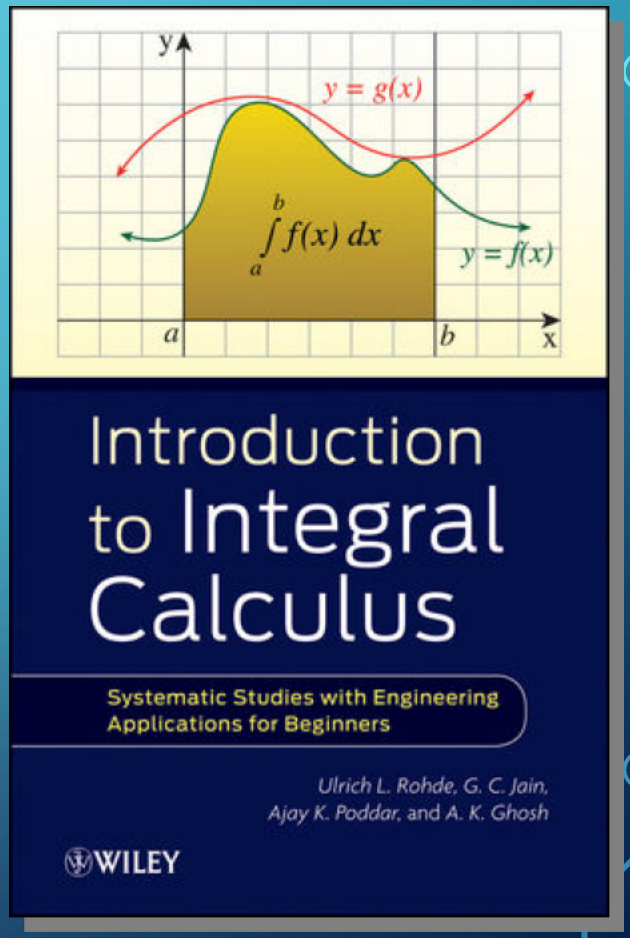
- Concepts of function, continuity, and derivative
- Properties of exponential and logarithmic function
- Inverse trigonometric functions and their properties
- Derivatives of higher order
- Methods to find maximum and minimum values of a function
- Hyperbolic functions and their properties



From 2012

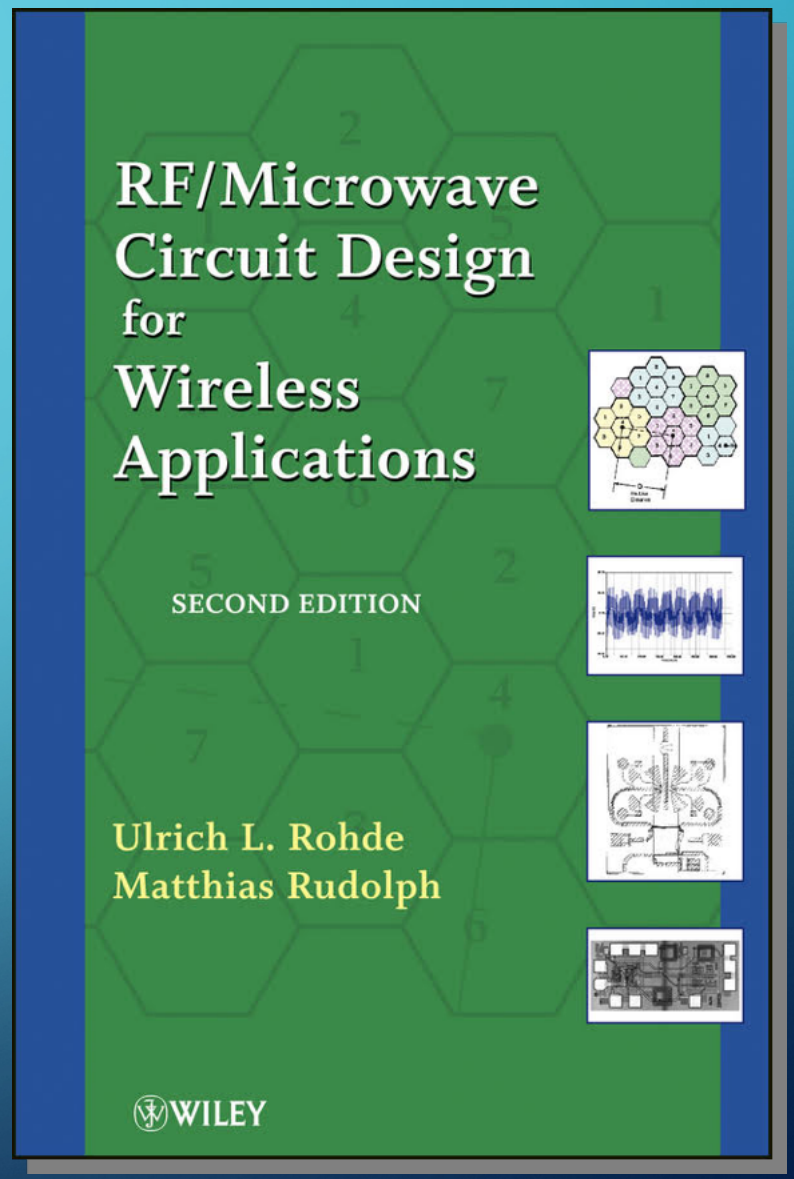
Integration is an important function of calculus, and Introduction to Integral Calculus combines fundamental concepts with scientific problems to develop intuition and skills for solving mathematical problems related to engineering and the physical sciences

- Mastering and applying the first and second fundamental theorems of calculus to compute definite integrals
- Defining the natural logarithmic function using calculus
- Evaluating definite integrals
- Calculating plane areas bounded by curves
- Applying basic concepts of differential equations to solve ordinary differential equations



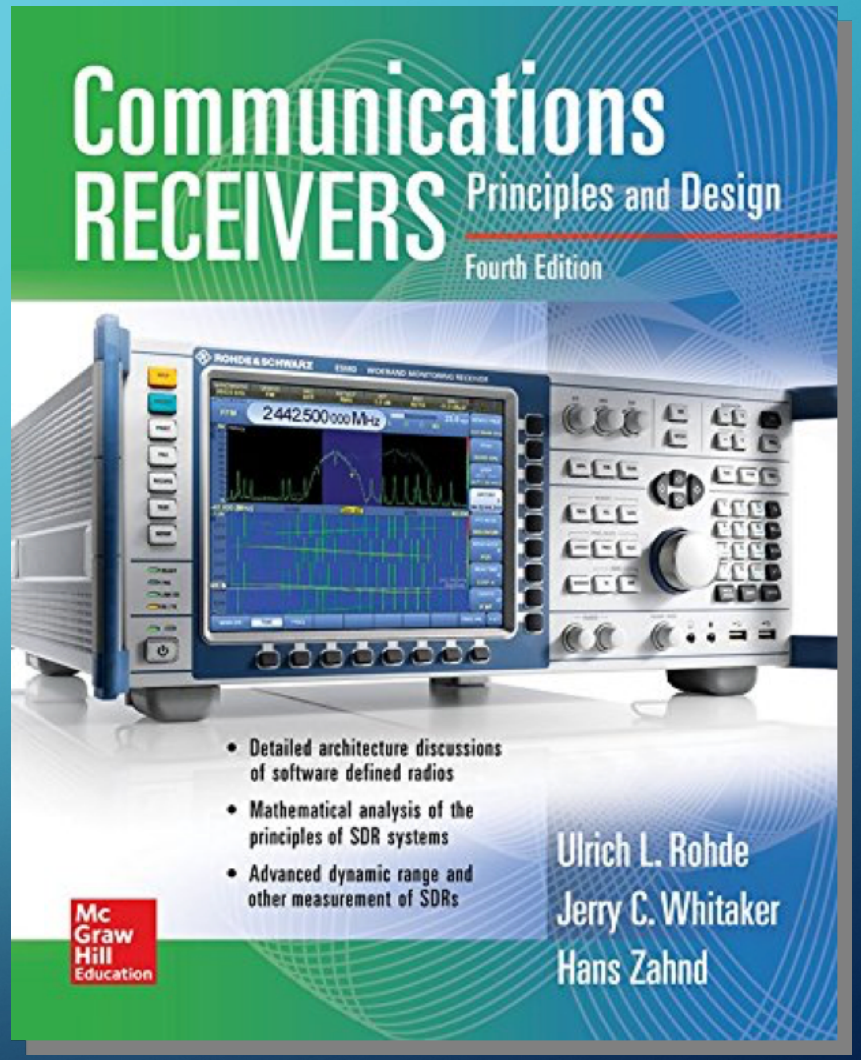
From 2013

- Education in English international technology language
- Focus on theory and real life application
- Material presented at international conferences
- Result of technology exchange or transfer
- Covers modern cellular radio technology, analog and digital



From 2017

- State of the art communication technology
- Covers high performance application
- Good reference for past and modern design

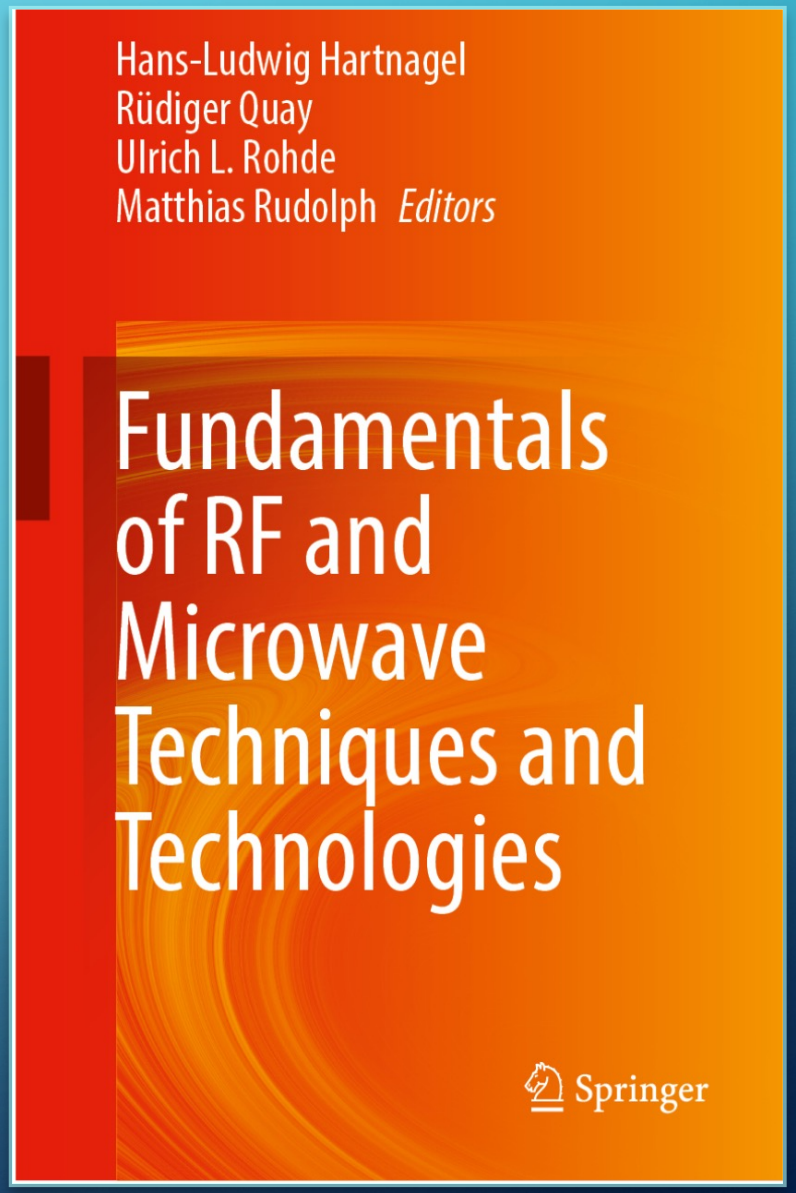


From 2022

Starting with the fundamentals it provides state-of-the-art theory, design, and applications of all RF and Microwave Techniques and Technologies

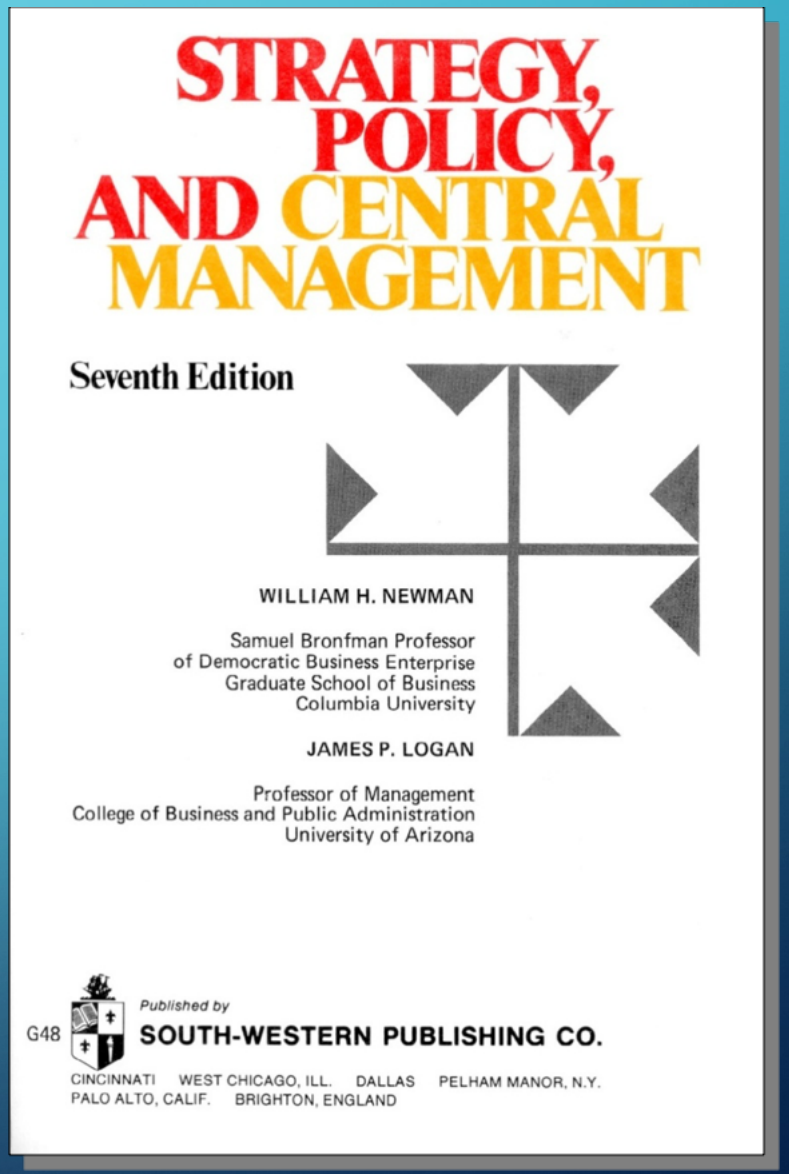
Covers:

- RLC circuits, transmission-line theory, antenna theory and noise statistics and physics
- Active microwave semiconductors, amplifier, mixer and oscillator circuits and SDR based systems
- Digital signal modulation schemes.



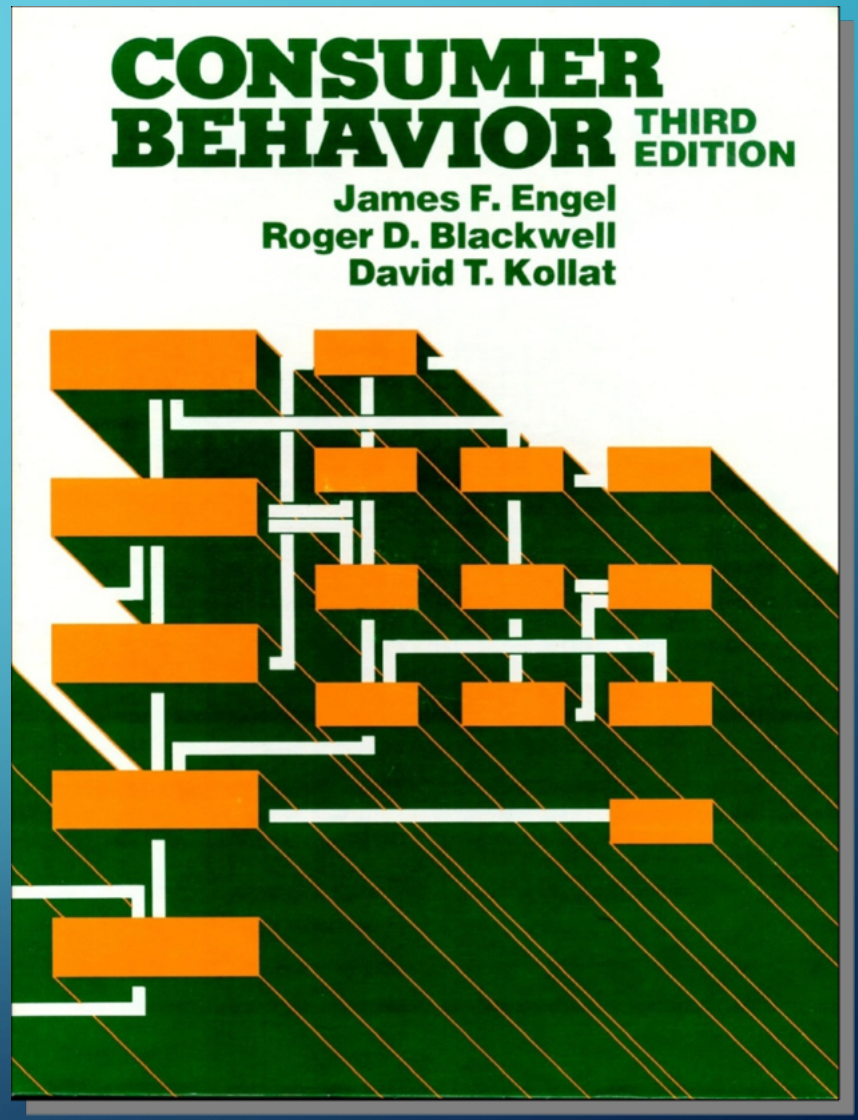
From 2009

- Success by implementing strategy, policies and central management
- Focus on market needs and cost effective manufacturing
- Watch your competitors at international conferences and adapt products
- Learn from technology exchange



From 2009

- Success by watching consumer behavior
- Listen to the customers needs
- Decisions are made on perceptions more often than reality
- Compatibility with existing technologies or products is key to success



Thank You

- You need a good mix between tradition and society demands
- Students come from all countries and become global professionals
- Country barriers are disappearing
- Success lies in education and commitment to excellency
- Good luck with all the Pomp and Circumstances !