

# GLOBAL MARKETS, GLOBAL TECHNOLOGY, AND GLOBAL STUDENTS?

17<sup>TH</sup> INTERNATIONAL CONFERENCE ON  
ENGINEERING OF MODERN ELECTRIC  
SYSTEMS  
MAY 26-27, 2023

*Ulrich L. Rohde, Prof. Dr. Ing. habil.*

*<https://www.rohde-stiftung.de/en/rohde-foundation/ulrich-l-rohde.html>*

*University of Oradea, Romania*





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 T. 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**

A handwritten signature in dark ink, appearing to read "Arthur D. Friedman".

Arthur D. Friedman  
Chairman, Department of Electrical

May 4, 1982

**ROMANIA**  
**MINISTERUL INVATAMANTULUI**  
**UNIVERSITATEA DIN ORADEA**



**DIPLOMA**

The University of Oradea, with the recommendation of the  
Senate and the Faculty hereby appoints permanently

**Ulrich L. Rohde**

as Professor of Electrical Engineering and Microwave Technology.



Rector  
prof. dr. ing. TEODOR MAGHIAR  
May 30, 1997



Im Namen der  
**Bundesrepublik Deutschland**

bestelle ich

Herrn

Prof. Dr.-Ing. habil. Dr. h.c. mult. ULRICH L. ROHDE

zum

Honorarprofessor

an der Universität der Bundeswehr München

Bonn, den 12. Juli 2017

Die Bundesministerin der Verteidigung



Translation

In the name of the Federal Republic of Germany  
I appoint

Prof. Dr.-Ing. habil. Dr. h.c. mult. ULRICH L. ROHDE  
as

Honorary Professor  
At the Universität der Bundeswehr München  
(University of the federal armed forces in Munich  
Germany)

Bonn, 12 July 2017

Secretary of Defense

*Ursula von der Leyen*



## **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++
- Data science in Python
- 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.:  $< 1\text{dB}$
- Intermodulation distortion  $\text{IP3} > 1\text{dBm}$
- Input selectivity
- Phase noise ( $-145\text{dBc/Hz}$  @  $200\text{KHz}$ )
- Settling speed, less than  $1\text{mS}$



# Digital Technology Example

Analog to digital converters (A/D)

- Optimized IF frequencies
- Impedance matching
- Overload and saturation vs. noise figure

Design decisions may be:

- IF selectivity
- Coding scheme
- Composite filters implementation in DSP
- Automatic gain routines
- Computational delay time

# ANALOG AND DIGITAL TECHNIQUES



**Broadband Wireless Solutions...**

**...from 1 to 60 GHz**

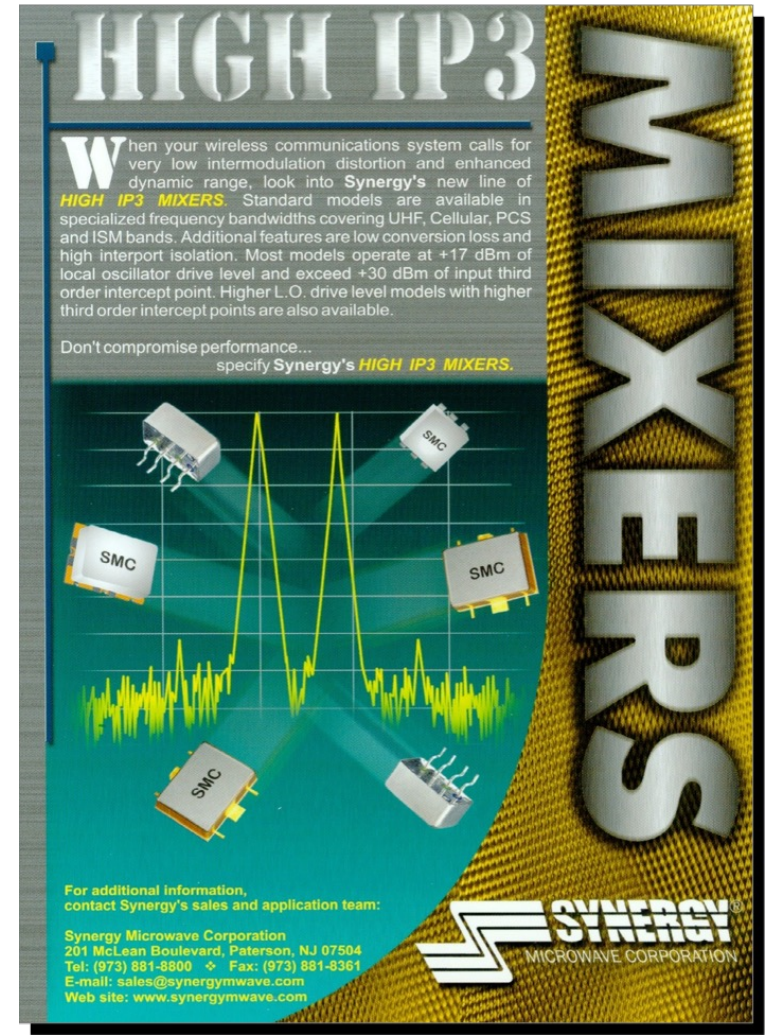
**UNBEATABLE MMIC SOURCE**

UMS is the "one stop" supplier of integrated circuits covering the broadband wireless requirements from very low noise to high power, using PHEMT technologies up to 94GHz.

The advertisement features a large parabolic antenna in the foreground, a radio tower in the background, and a circuit diagram showing various components like amplifiers, mixers, and filters. The background is a field of sunflowers under a blue sky.

# HIGH PERFORMANCE ANALOG TECHNIQUES

## AN EXAMPLE



### HIGH IP3 MIXERS

When your wireless communications system calls for very low intermodulation distortion and enhanced dynamic range, look into Synergy's new line of **HIGH IP3 MIXERS**. Standard models are available in specialized frequency bandwidths covering UHF, Cellular, PCS and ISM bands. Additional features are low conversion loss and high interport isolation. Most models operate at +17 dBm of local oscillator drive level and exceed +30 dBm of input third order intercept point. Higher L.O. drive level models with higher third order intercept points are also available.

Don't compromise performance...  
specify Synergy's **HIGH IP3 MIXERS**.

For additional information,  
contact Synergy's sales and application team:

Synergy Microwave Corporation  
201 McLean Boulevard, Paterson, NJ 07504  
Tel: (973) 881-8800 ♦ Fax: (973) 881-8361  
E-mail: [sales@synergymwave.com](mailto:sales@synergymwave.com)  
Web site: [www.synergymwave.com](http://www.synergymwave.com)

**SYNERGY**  
MICROWAVE CORPORATION





# 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 data rates, initially  
9.6 kbps evolving up to  
384 kbps

Very high latency

1991

## 3G

### Mainly WCDMA

Bandwidth 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 today's 1.2  
Gbit/s

Low latency

2010

## 5G

### 5G NR (New Radio)

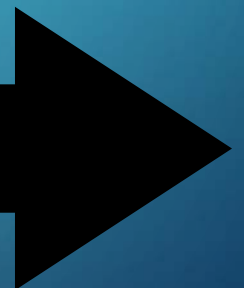
Scalable bandwidth up  
to 2000 MHz

Frequencies up to 71  
GHz

Very high data rates

Ultra low latency  
possible

2019



# HAS 5G DELIVERED ON ITS PROMISES?

## YES AND NO

- ✓ Download speeds are up, latency is down
- ✓ Is the “playground” where new features are being developed
  - ✓ Non terrestrial networks
  - ✓ Reduced capabilities devices
- Current 5G networks are more 4.9G networks maintaining legacy 4G functionality
  - Increased user equipment complexity, cost and power consumption
- Slow take up on low latency and Internet of Things (IoT) applications



# GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL EDUCATORS & STUDENTS

Winners and others: Some examples



# Winners

## Apple

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

## Samsung

- Scale of economy
- In house touch screen expertise
- World's 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

## Motorola

- Sold to Google – sold to Lenovo

## Ericsson

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

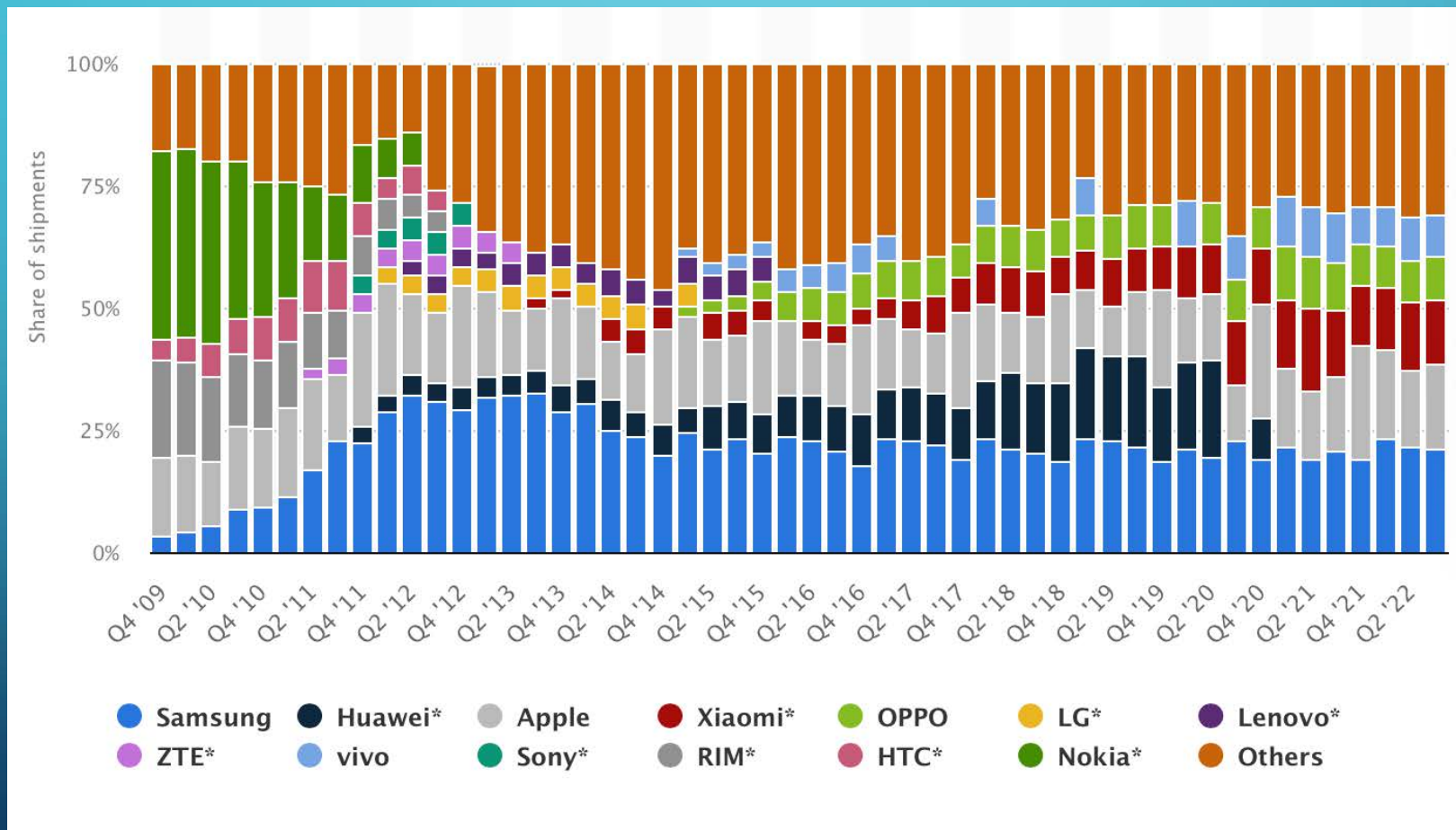
## Blackberry

- Focused on messaging
- Missed the touch screen revolution

## Huawei

- First cellphones 2003
- 2019 worlds second largest supplier of smartphones
- "Killed" by US trade sanctions –Renamed to Honor -sold

SOURCE: WWW.STATISTA.COM

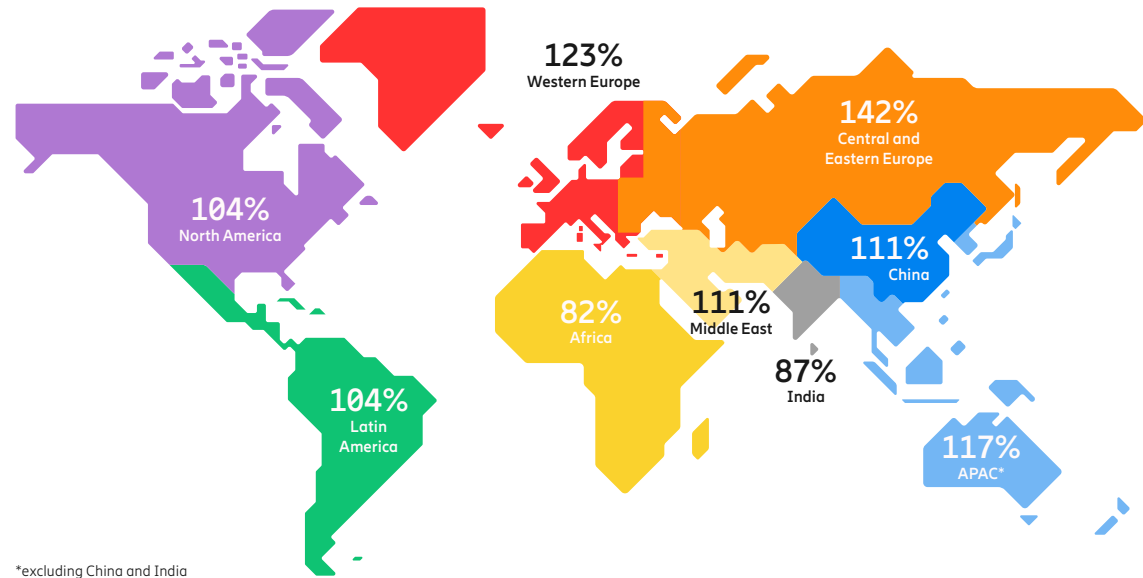




## GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

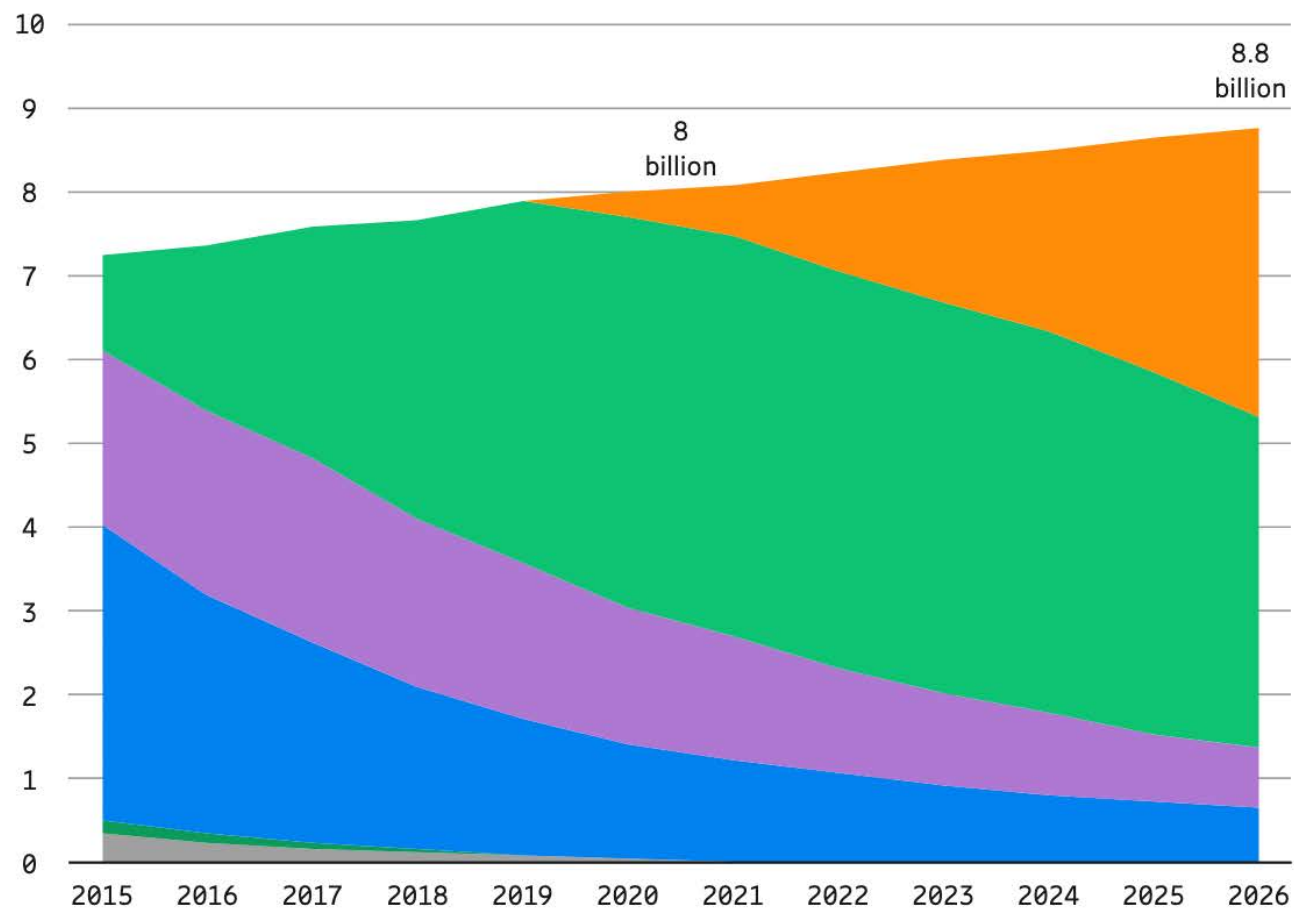
Looking Forward: What will drive the technological  
development?





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

Figure 1: Mobile subscriptions by technology (billion)



3.5bn

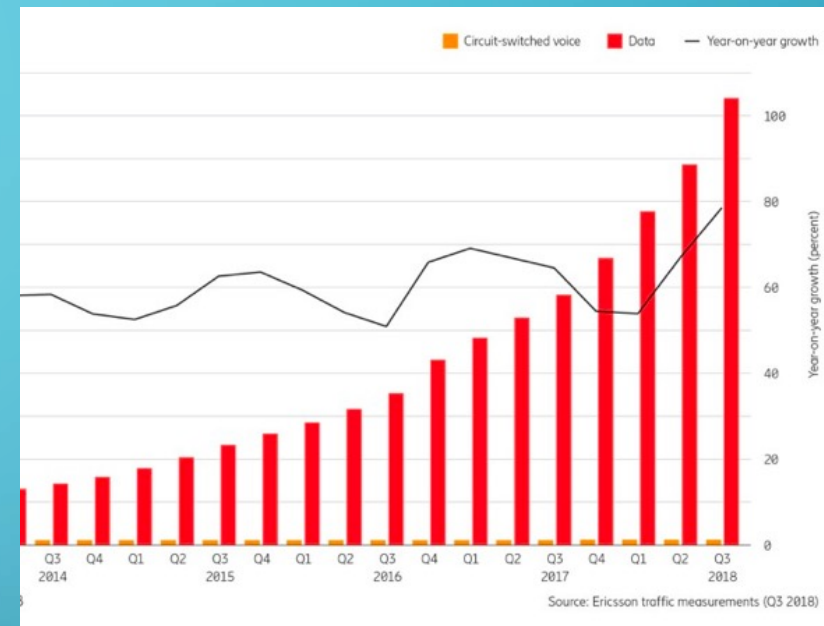
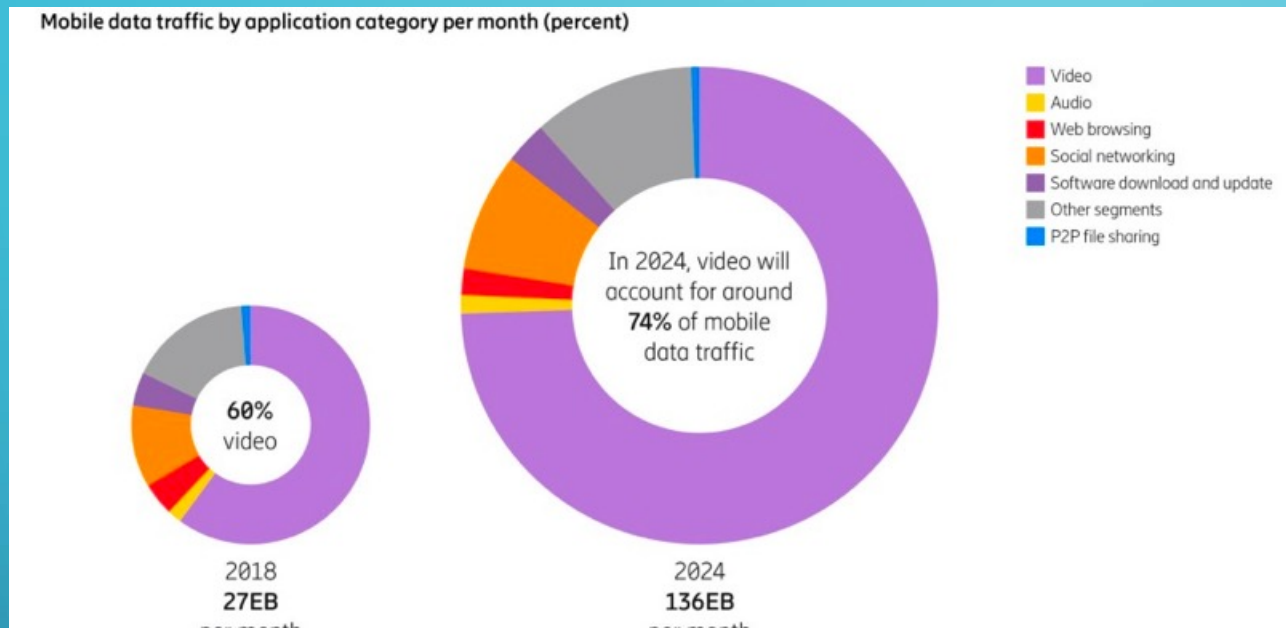
In 2026, 3.5 billion 5G subscriptions are forecast.

- 5G
- LTE (4G)
- WCDMA/HSPA (3G)
- GSM/EDGE-only (2G)
- TD-SCDMA (3G)
- CDMA-only (2G/3G)

Note: IoT connections are not included in this graph. Fixed wireless access (FWA) connections are included.

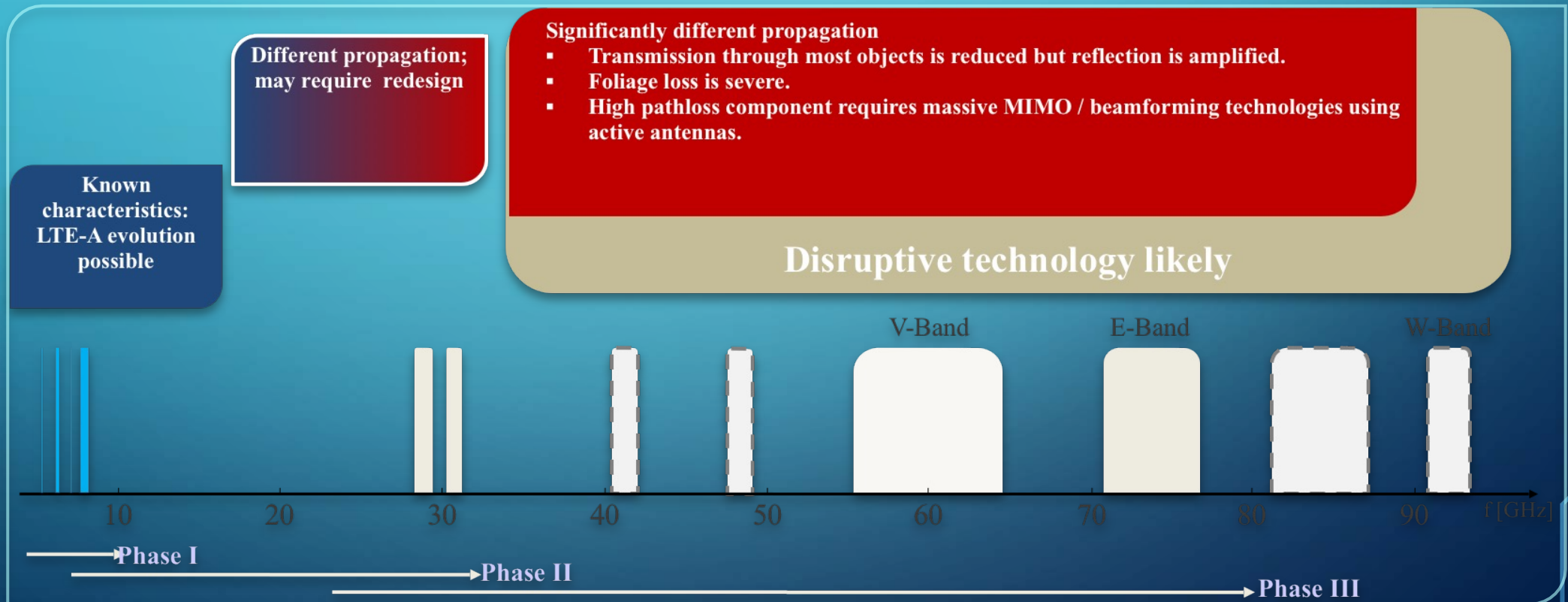
## THE FUTURE OF WIRELESS TECHNOLOGIES

SOURCE: ERICSSON MOBILITY REPORT



# DATA WILL BE DRIVING THE FUTURE OF THE CELLULAR INDUSTRY

# HIGHER DATA RATES REQUIRES BANDWIDTH ONLY AVAILABLE AT HIGHER FREQUENCIES





# WHERE ARE WE WITH 6G STANDARDIZATION?

- 3GPP has not started yet – First 5G advanced work will be started in release 18, with planned completion in 2024
- ITU-R is working on “IMT for 2030 and beyond” (aka “6G”)
  - Targeting commercialization around 2030
- Currently inputs are collected around use cases to find suitable technologies

# WHAT ARE THE USE CASES FOR 6G ?

## A FEW EXAMPLES FROM THE NGMN ALLIANCE

- Enhanced Human Communication – Metaverse, digital twin and holographic telepresence
- Enhanced Machine Communication -Robots, interactive collaborative robots and autonomous machines
- Enabling Services - high accuracy location, mapping, environmental, or body sensing data
- Network Evolution – AI and energy efficiency
- Social needs – environmental sustainability, security and privacy

[HTTPS://WWW.NGMN.ORG/WP-CONTENT/UPLOADS/220222-NGMN-6G-USE-CASES-AND-ANALYSIS-1.PDF](https://www.ngmn.org/wp-content/uploads/220222-NGMN-6G-USE-CASES-AND-ANALYSIS-1.PDF)

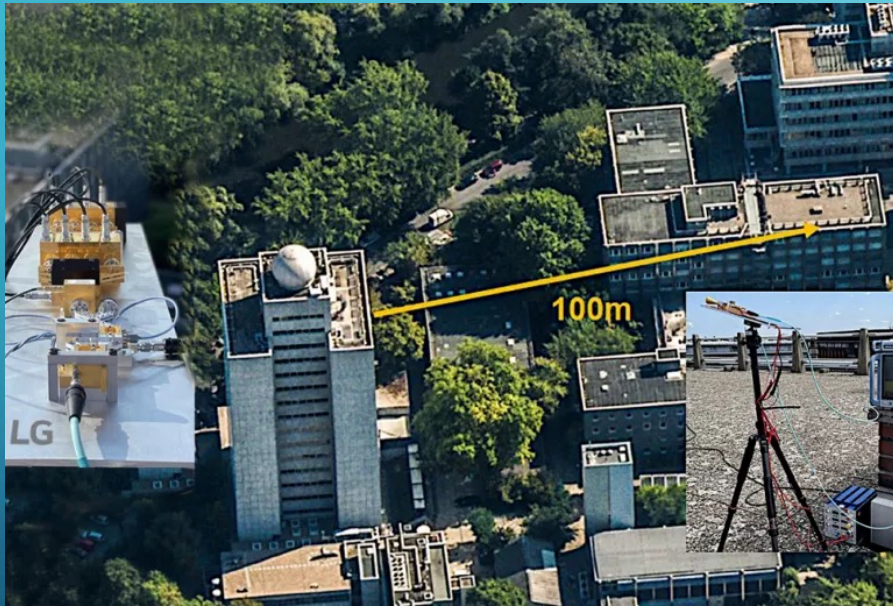
# WHAT TECHNOLOGIES CAN WE EXPECT TO BE USED 6G IN 2030?

## SOME CURRENT RESEARCH AREAS ARE

- Faster data transmission using higher frequencies & wider bandwidth
- JCAS – Joint communication and sensing combining communication and “radar” like functions
- AI and ML for better performance on the physical layer
- RIS – Reflective intelligent surfaces for better and more dynamic coverage
- New network structure with LEO and GEO satellites, drones and others to provide true worldwide coverage
- Increased security – Quantum secure encryption
- Energy harvesting
- Edge computing



# 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 ?



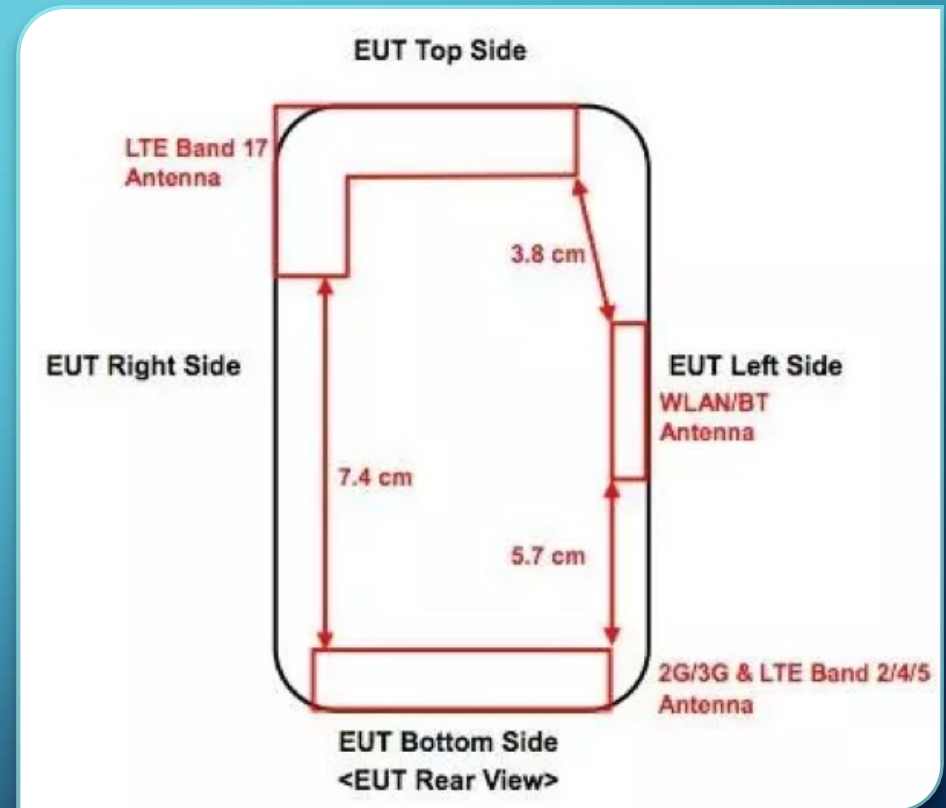
**Qualcomm QTM052 mmWave  
Antenna Module & Snapdragon  
X50 5G modem**



# 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





# 5G AND ENERGY CONSUMPTION

- Current 5G devices consume more energy when using 4G+5G (NSA)
- 5G devices with low (FR1) and high frequency (FR2) consume more than devices with FR1 only
- Most of the power in a cell phone is used during monitoring of control information
- Improvements to increase efficiency is being standardized
- 5G Networks consume less power than 4G Networks
- Energy consumption is a major expense for network operators

<https://www.ericsson.com/en/blog/2020/2/mobile-devices-and-energy-efficiency>

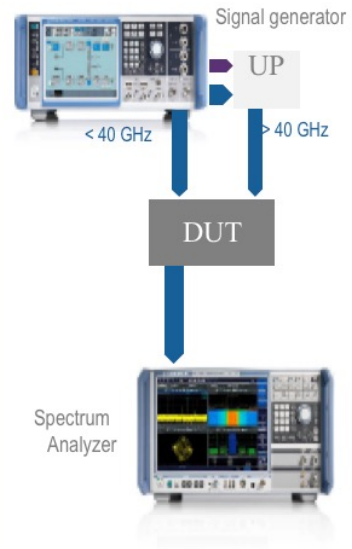




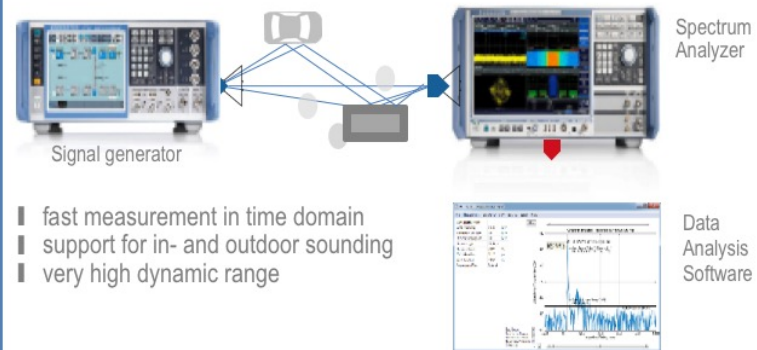
## GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

What tools are available for the RF engineers ?

### Wideband Signal Testing



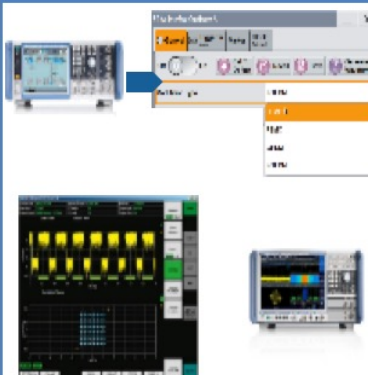
### Channel Sounding Solution



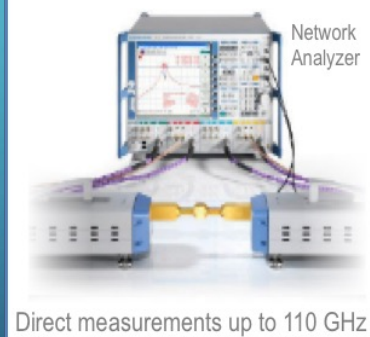
### Massive MIMO - Beamforming



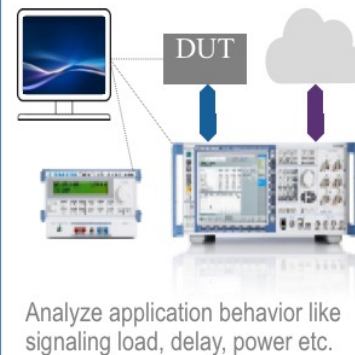
### New 5G PHY Candidates



### Component Characterization



### E2e Application Testing





# GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Requirements For Modern Adaptive Students

# Requirement For Modern Educators (Professors)

“Professional programs must prepare workers to become professional practitioners in their chosen field of practice. As educators, we want our students to appreciate the importance of both classroom and field educational experiences and learn that there is nothing more practical than a good theory. While experience is a great teacher, it cannot replace what can be best taught in a classroom and vice versa”

*Enhancing Learning by Integrating Theory and Practice Jan Wrenn and Bruce Wrenn, Andrews University*

Not all curriculums are equal and have different focuses but need a blend of theory and practice.

In RF measurement setups, instrument capabilities and associated uncertainties as well as tools for data analytics need to be taught.

This applies to me too





# 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



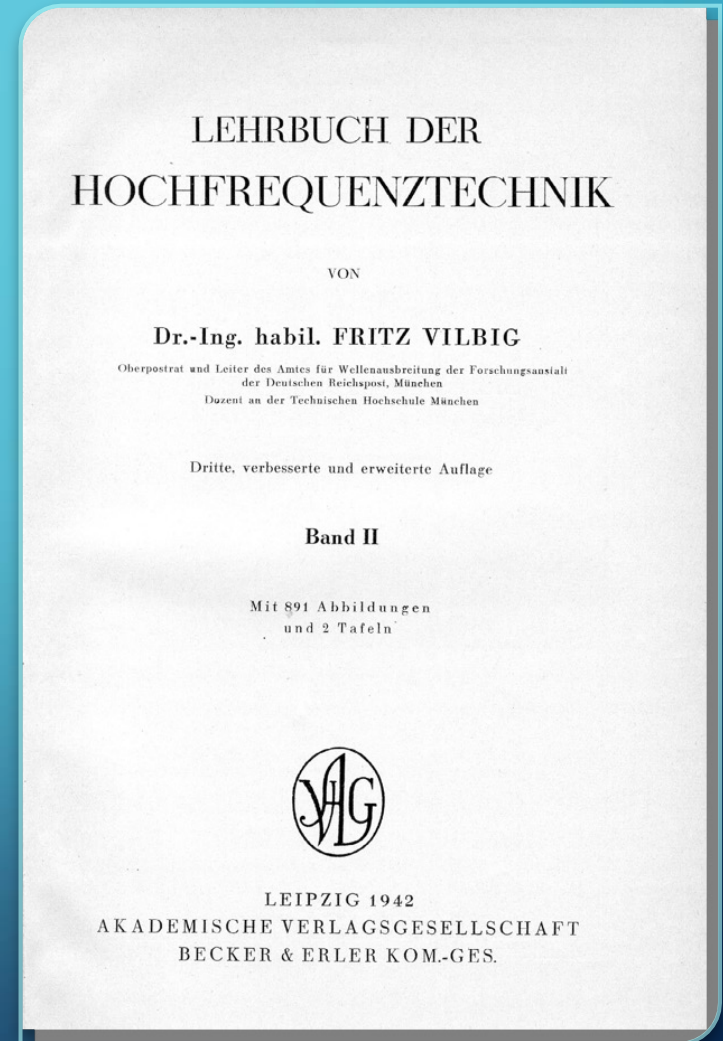
# GLOBAL MARKETS, GLOBAL TECHNOLOGY, GLOBAL STUDENTS

Literature- How did it all started



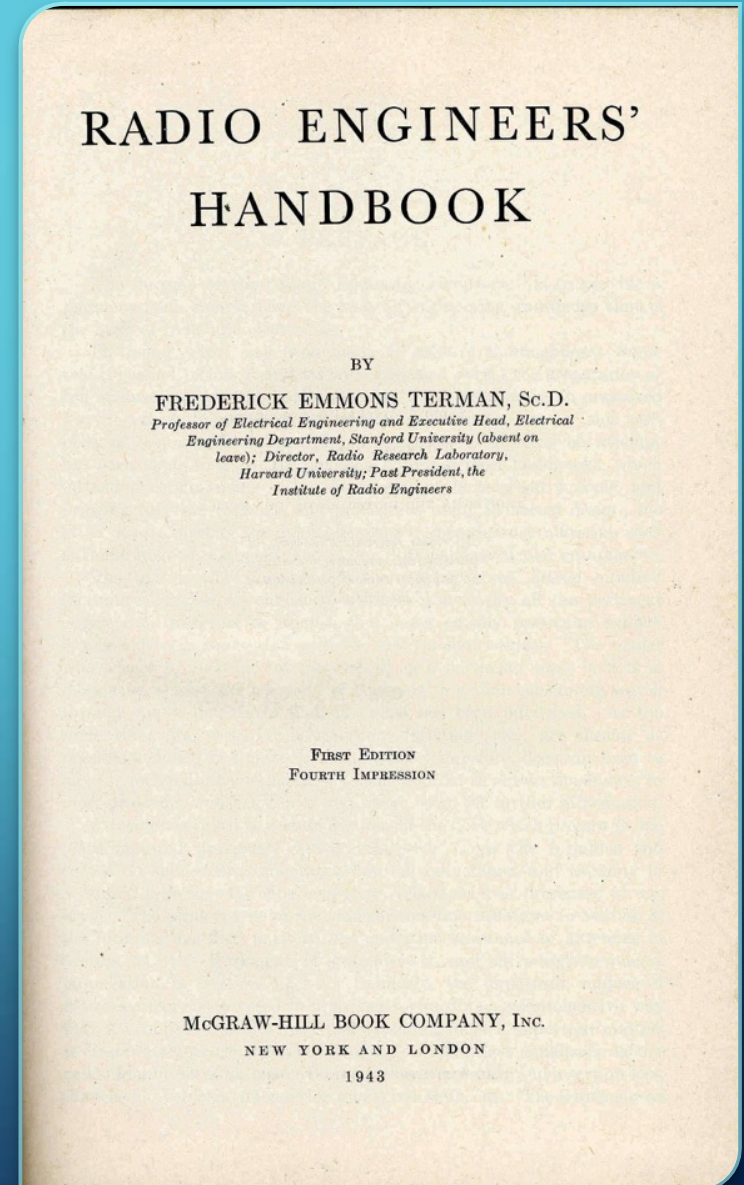
From 1942

- 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)



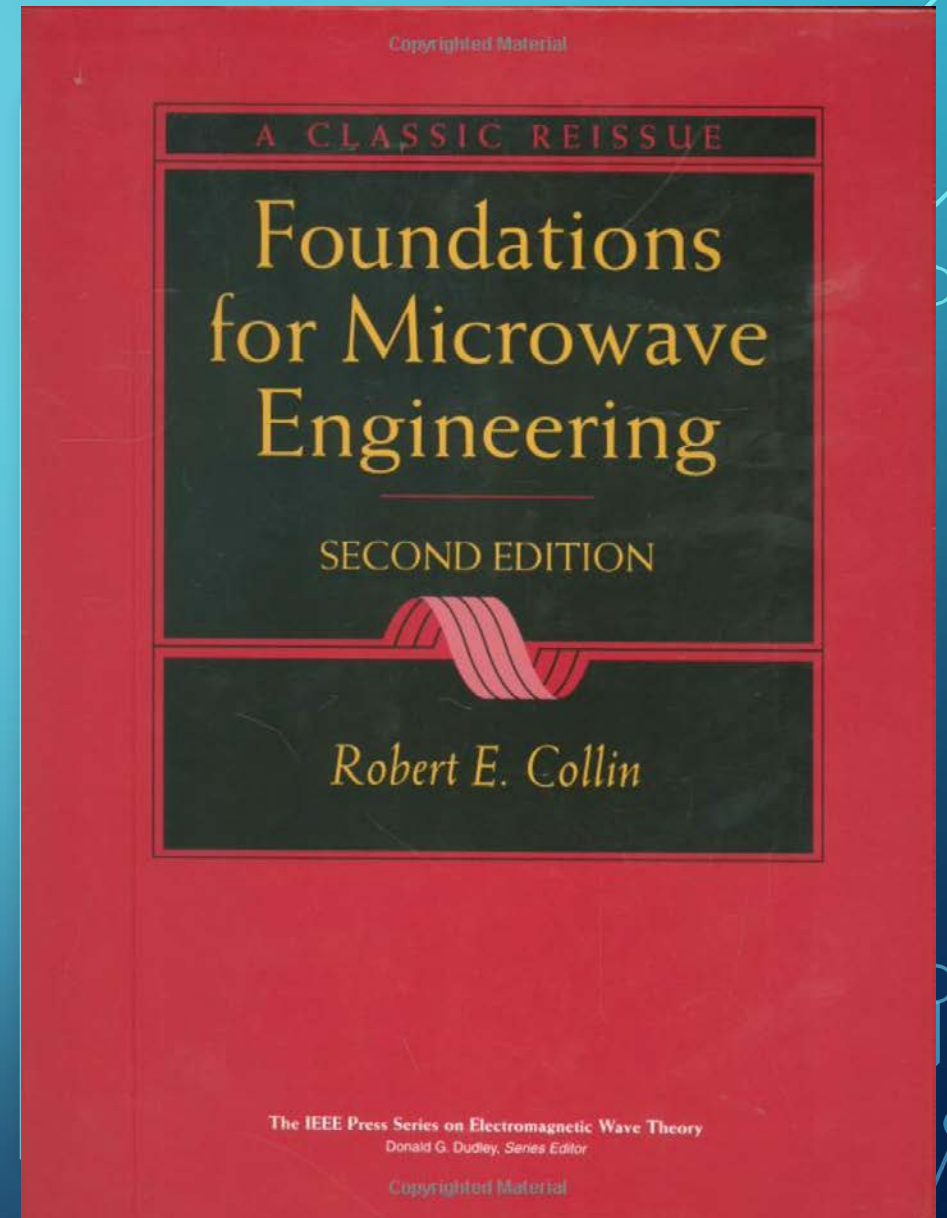
From 1943

- 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)



FROM 2001

Covers the major topics of microwave engineering. Its presentation defines the accepted standard for both advanced undergraduate and graduate level courses on microwave engineering. An essential reference book for the practicing microwave engineer.

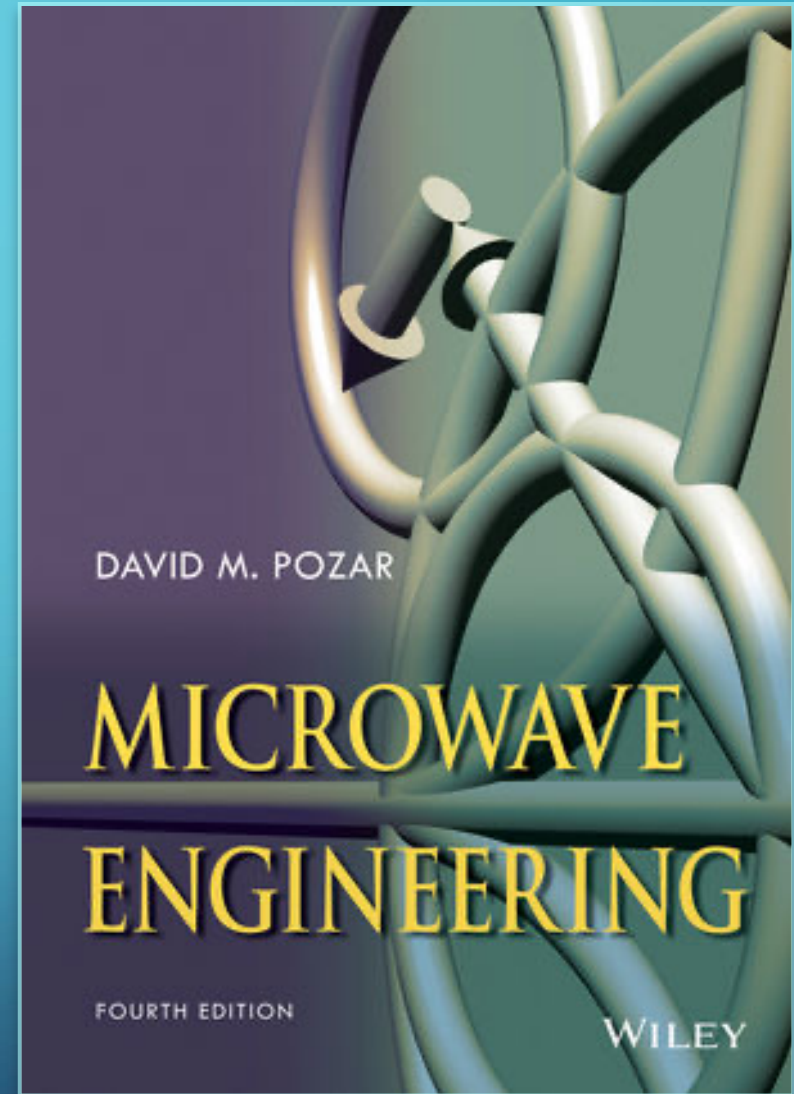




FROM 2011

Covers

- Design of microwave oscillators, amplifiers, and mixers
- Microwave network analysis, impedance matching, directional couplers and hybrids, microwave filters, ferrite devices, noise, nonlinear effects

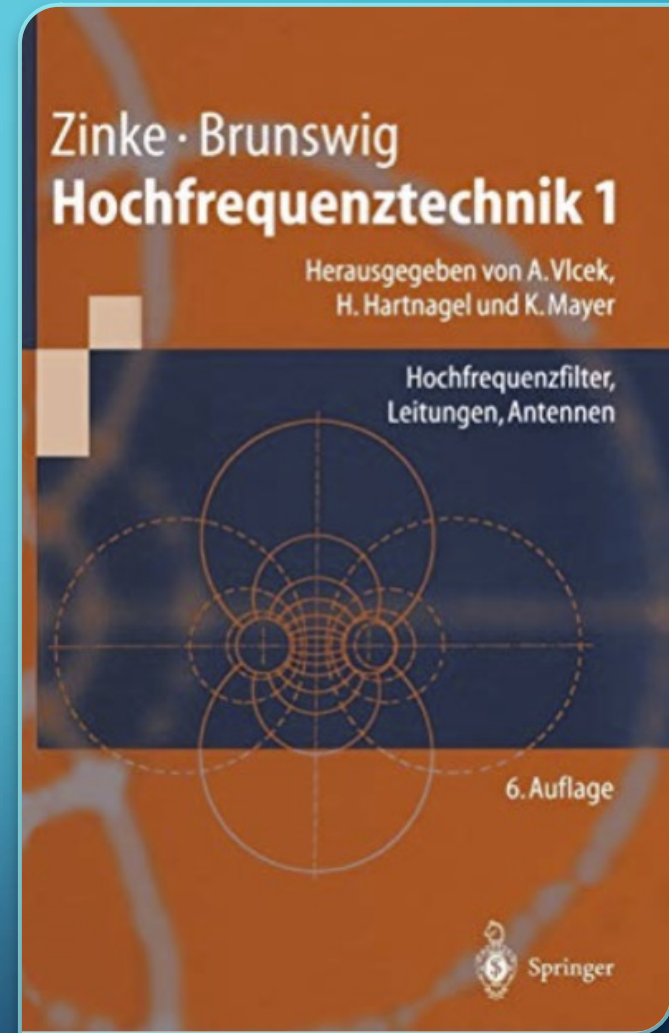




# FIRST EDITION 1960 THIS TWO-VOLUME STANDARD

Covers the generation, amplification, propagation, radiation, and application of electromagnetic signals over the full frequency range, from a few kHz to optical communications.

Volume 1 addresses resonant circuits, high-frequency transformers and filters, characteristics of coaxial cables, microstrip lines, coplanar and fin lines, directional couplers, optical waveguides, surface acoustic wave filters, waveguides, gyromagnetic media, antennas, and quartz filters.



# FIRST EDITION 1960

Volume two addresses:

Electron tubes and semiconductors, Interference and Noise, Amplifier, Oscillators, Mixing and Frequency Multiplication, Modulation, Sampling and Demodulation



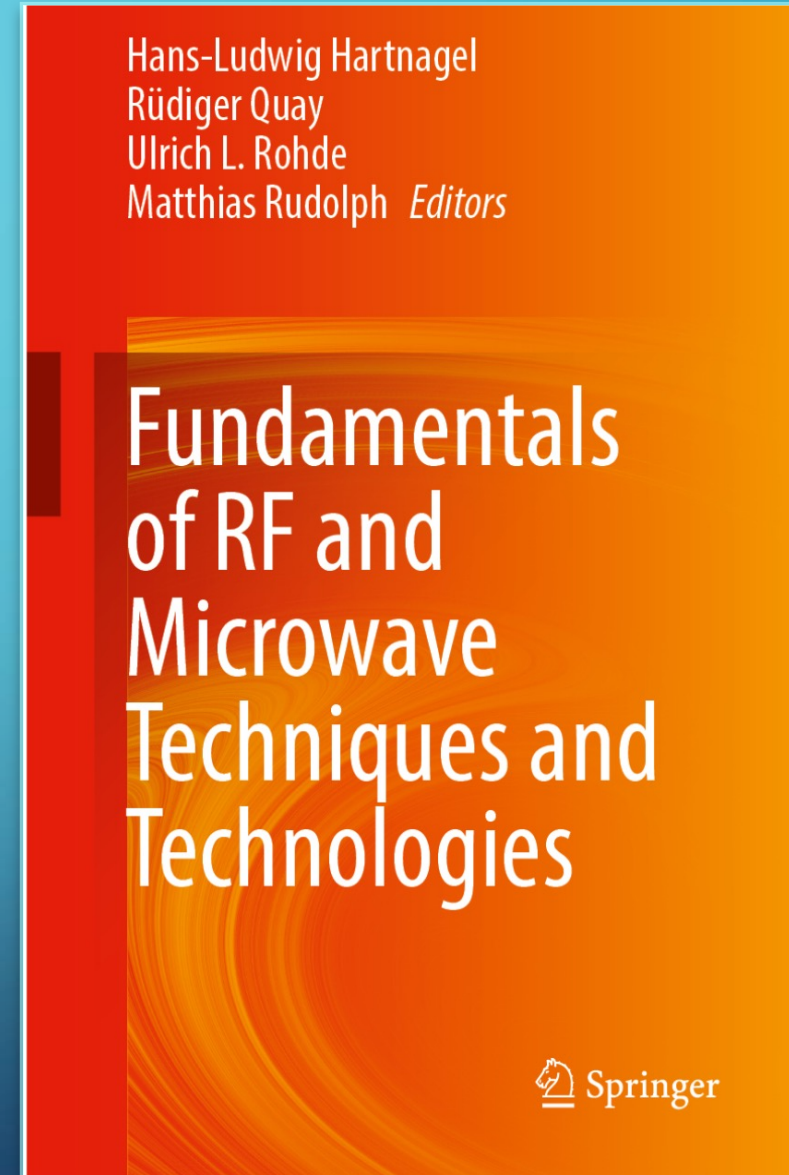
From 2023

Successor of Zinke – Brunswig textbook, now in English

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.



Hans-Ludwig Hartnagel  
Rüdiger Quay  
Ulrich L. Rohde  
Matthias Rudolph *Editors*

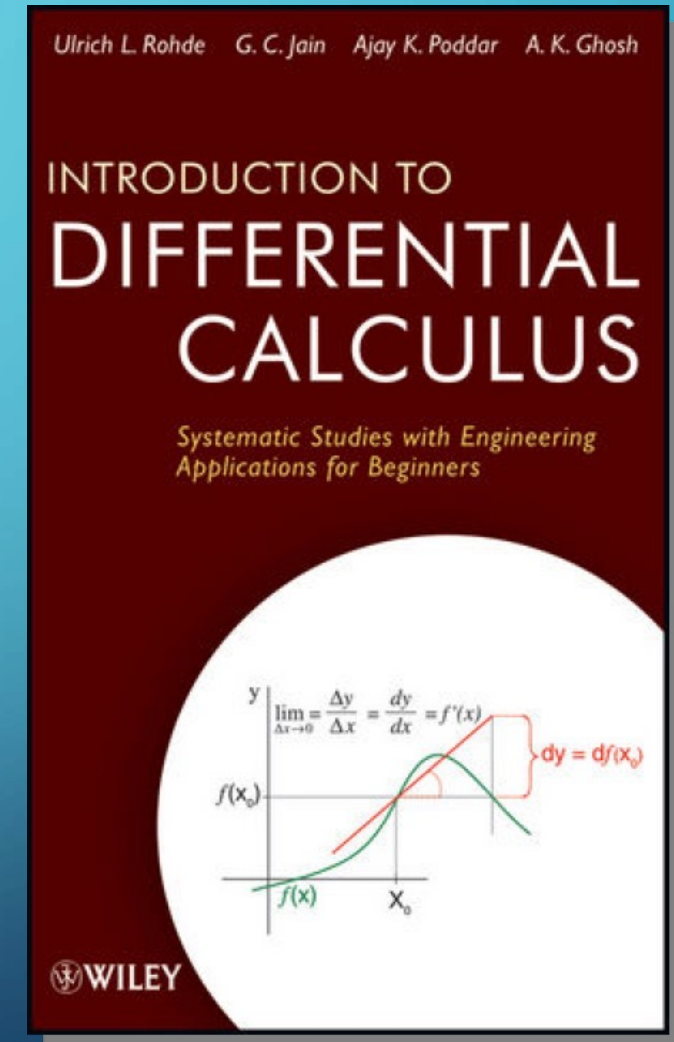
# Fundamentals of RF and Microwave Techniques and Technologies

 Springer

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

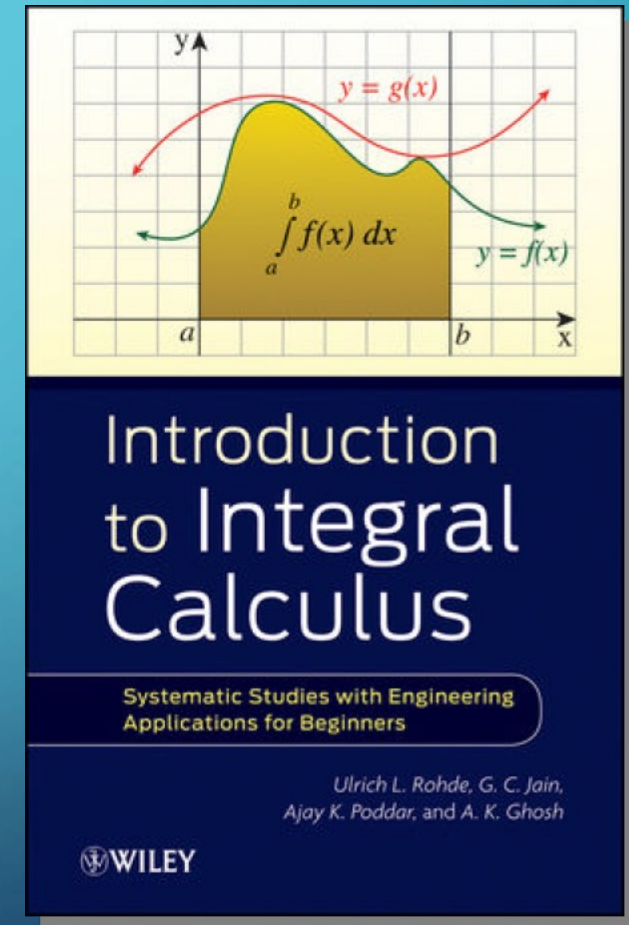




From 2012

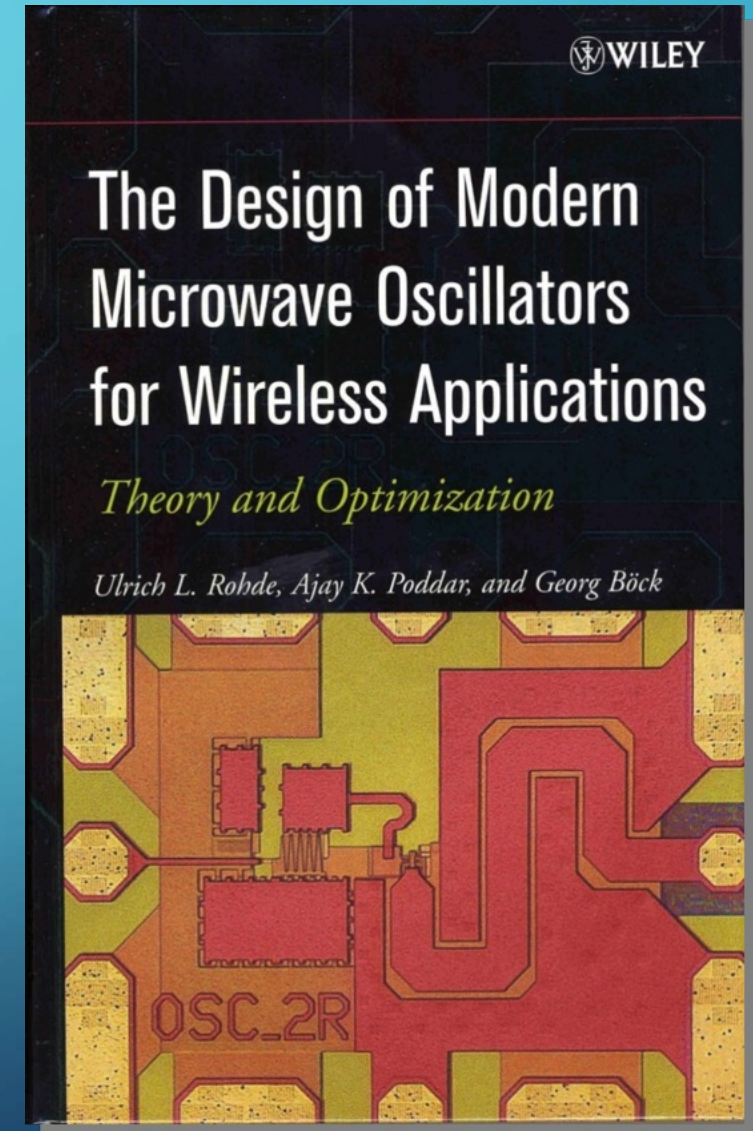
Integration is an important function of calculus, and Introduction to Integral Calculus combines fundamental concepts with scientific problems to develop intuition and skills for solving mathematical problems related to engineering and the physical sciences

- 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



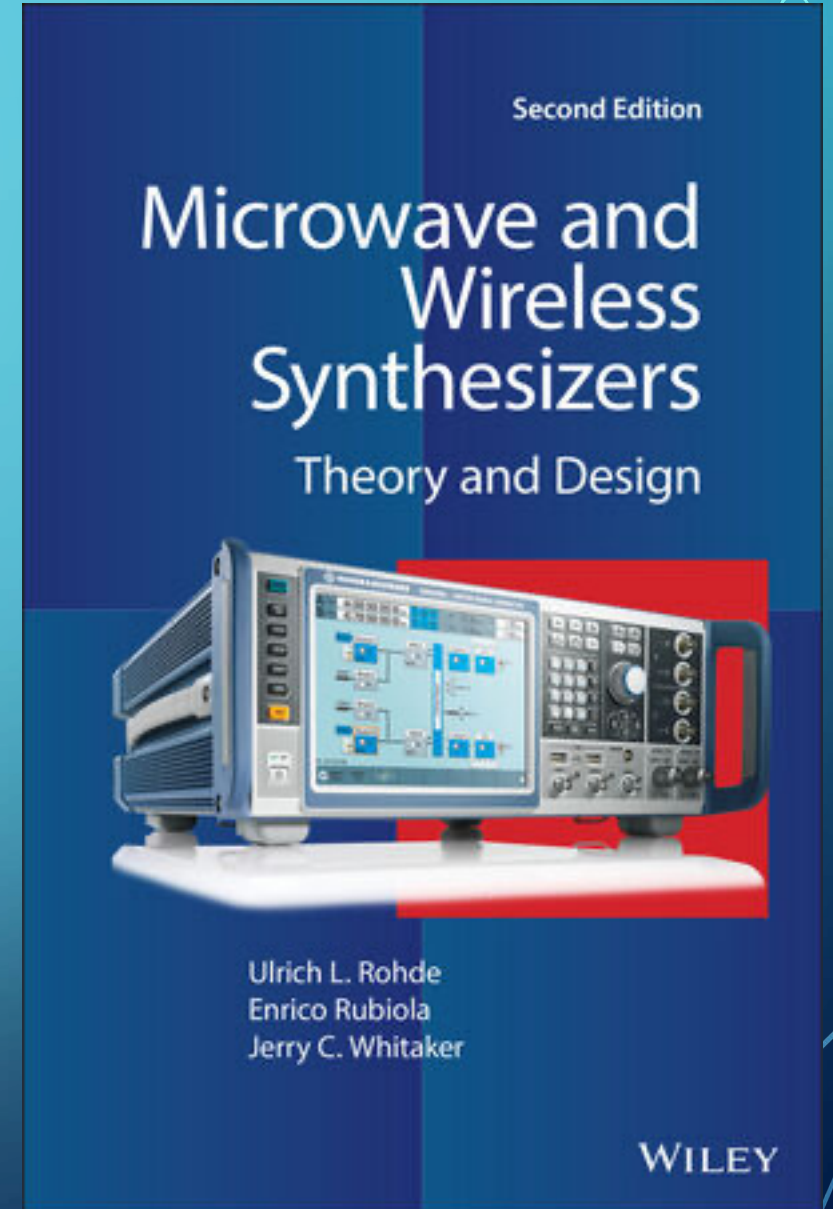
From 2005

- 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 1997 > 2021

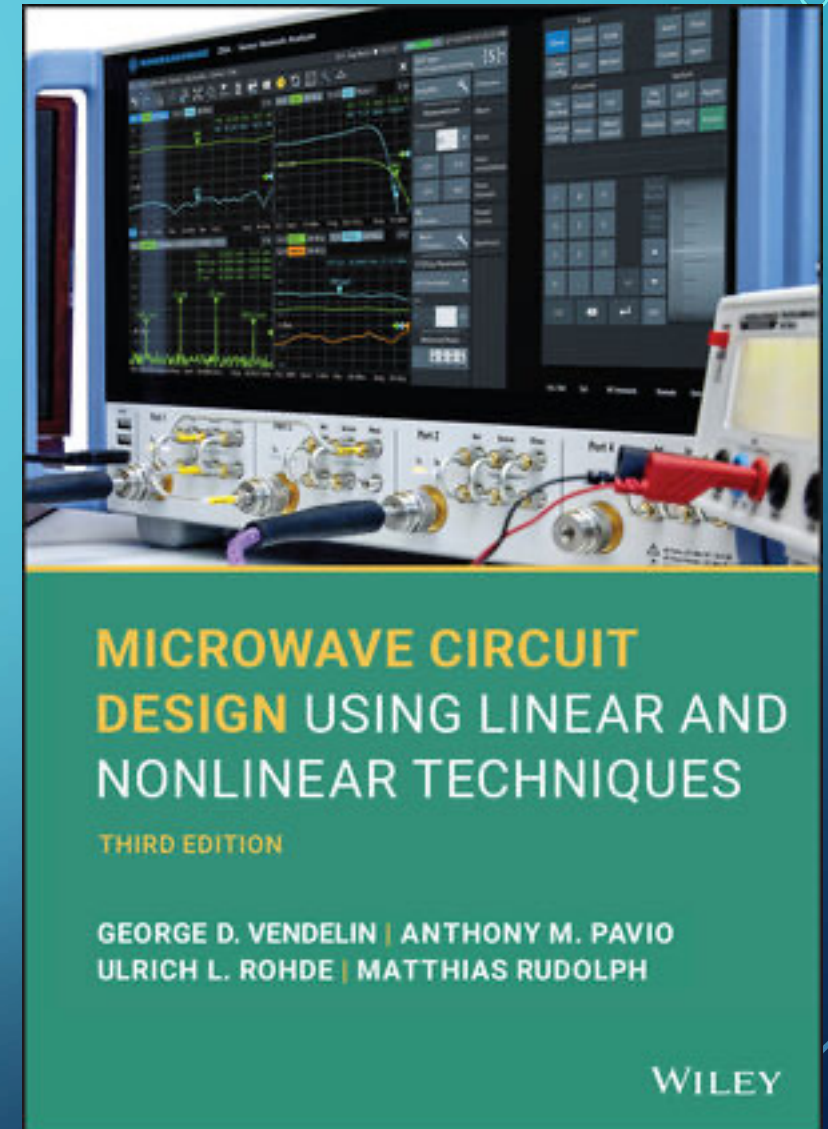
- Microwave and Wireless Synthesizers-the first book to emphasize both practical circuit information from RF to millimeter-wave frequencies and up-to-date theory.
- In-depth look at the practical side of the phase-lock loop (PLL) in synthesizers-including special loops, loop components, and practical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





From 2005 > 2021

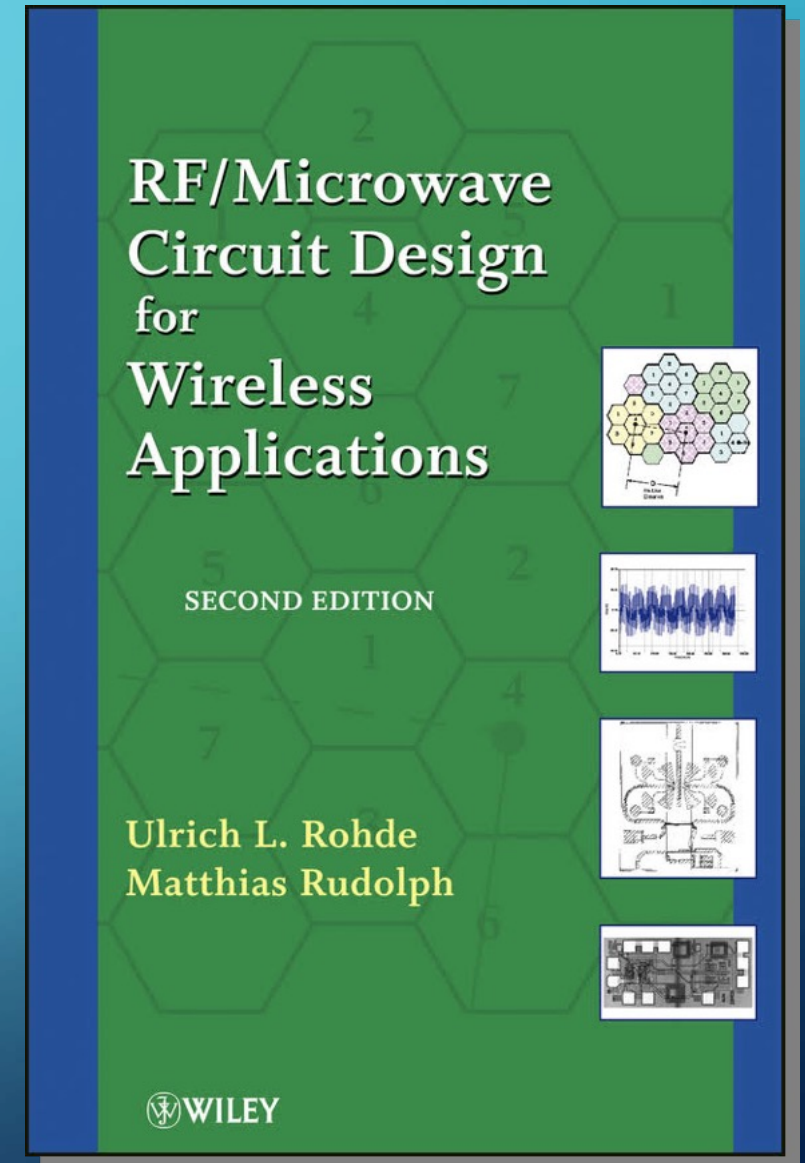
- Linear and nonlinear circuit analysis treatment  
3rd edition 2021
- Best in class
- Covers all relevant material
- Ideal reference material





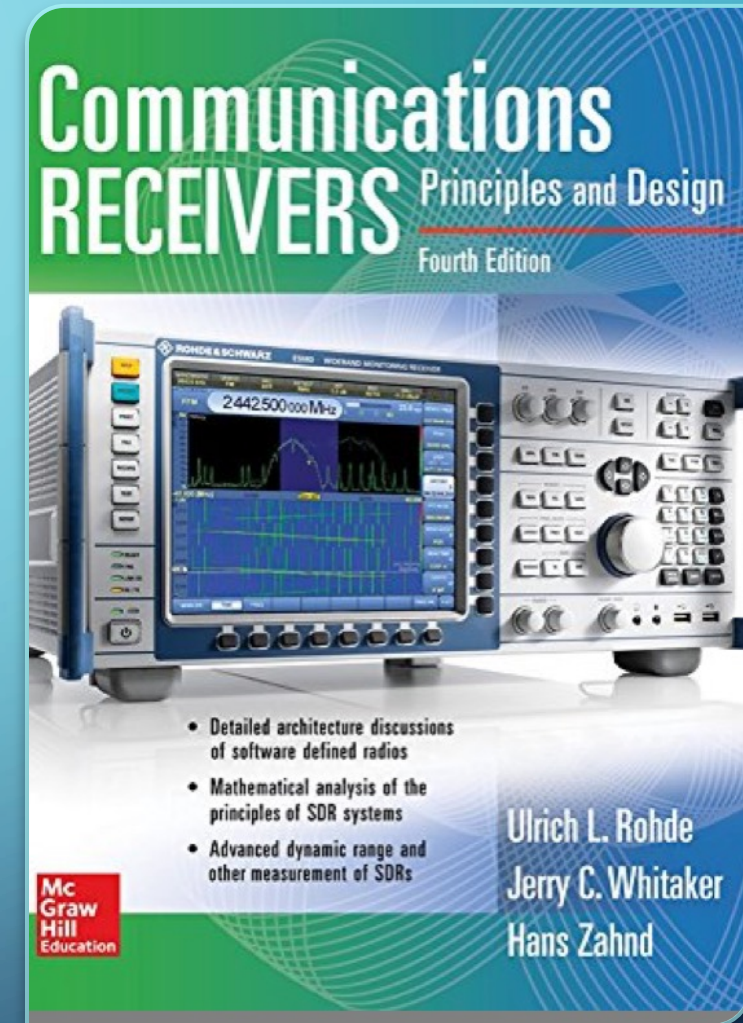
From 2013

- 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



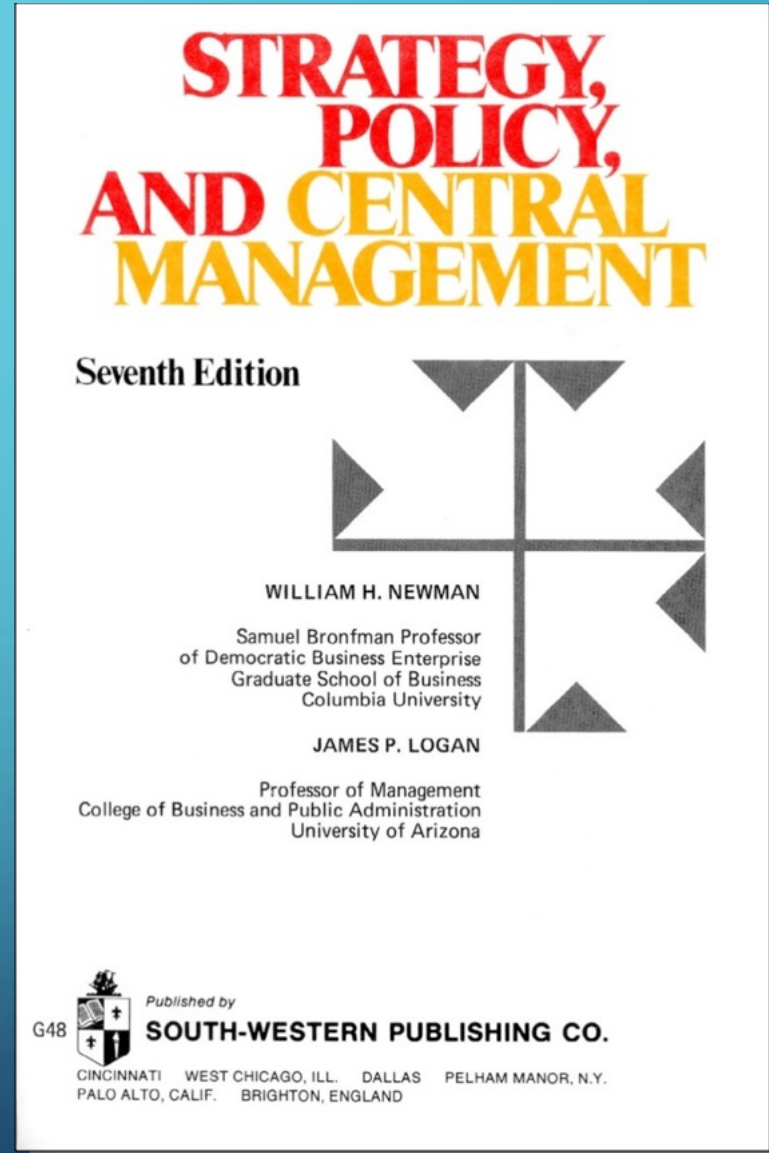
FROM 1988>2017

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



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



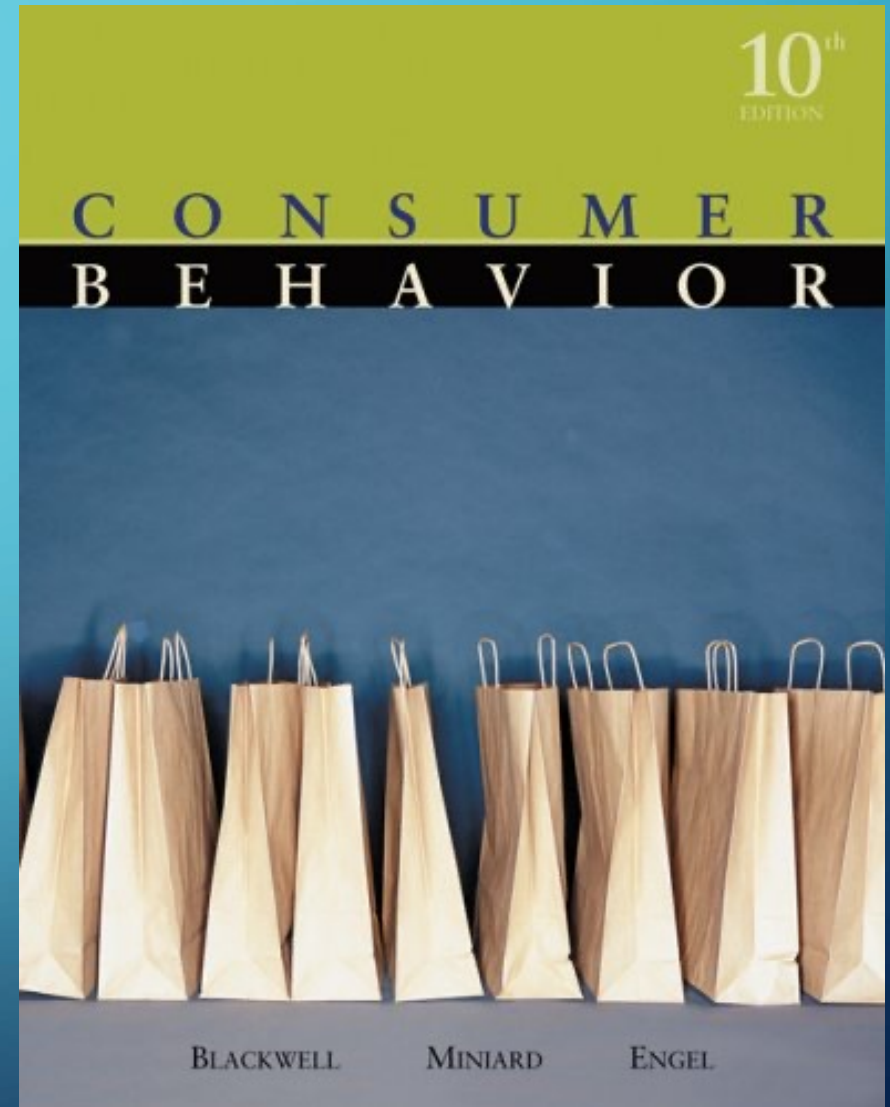


## Models of consumer behavior: The state of the art

BLACKWELL, MINARD AND ENGEL

From 1981 > 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 !