Chapter 1 Introduction

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Slides to accompany *Intuitive Analog Circuit Design* by Marc T. Thompson © 2006-2008, M. Thompson

Analog Design is Not Dead

- The world is analog
- •...(well, until we talk about Schrodinger)

Partial Shopping List of Analog Design

- Analog filters: Discrete or ladder filters, active filters, switched capacitor filters.
- Audio amplifiers: Power op-amps, output (speaker driver) stages
- Oscillators: Oscillators, phase-locked loops, video demodulation
- Device fabrication and device physics: MOSFETS, bipolar transistors, diodes, IGBTs, SCRs, MCTs, etc.
- IC fabrication: Operational amplifiers, comparators, voltage references, PLLs, etc
- Analog to digital interface: A/D and D/A, voltage references
- Radio frequency circuits: RF amplifiers, filters, mixers and transmission lines; cable TV
- Controls: Control system design and compensation, servomechanisms, speed controls
- Power electronics: This field requires knowledge of MOSFET drivers, control system design, PC board layout, and thermal and magnetic issues; motor drivers; device fabrication of transistors, MOSFETs (metal oxide semiconductor field effect transistors), IGBTs (insulated gate bipolar transistors), SCRs (siliconcontrolled rectifiers)
- Medical electronics: instrumentation (EKG, NMR), defibrillators, implanted medical devices
- Simulation: SPICE and other circuit simulators
- PC board layout: This requires knowledge of inductance and capacitive effects, grounding, shielding and PC board design rules.

Lilienfeld Patent (c. 1930)

March 7, 1933.

J. E. LILIENFELD

1,900,018



1st Bipolar Transistor (c. 1948) Point contact transistor, demonstrated December 23, 1947 at Bell Labs (Shockley, Bardeen and Brattain)



Reference: Probir K. Bondyopadhyay, "W = Shockley, the Transistor Pioneer --- Portrait of an Inventive Genius," *Proceedings of the IEEE*, vol. 86, no. 1, January 1998, pp. 191-217

1st Bipolar Transistor (c. 1948) Patent

• US Patent # 2,524,035, filed 6/17/48, issued 10/3/50



Fig. 2. Schematic of the point-contact transistor [3].

Reference: Probir K. Bondyopadhyay, "W = Shockley, the Transistor Pioneer --- Portrait of an Inventive Genius," *Proceedings of the IEEE*, vol. 86, no. 1, January 1998, pp. 191-217

Shockley US Patent (1951)

Sept. 25, 1951

W. SHOCKLEY

2,569,347

CIRCUIT ELEMENT UTILIZING SEMICONDUCTIVE MATERIAL

Filed June 26, 1948

3 Sheets-Sheet 1









Bardeen and Brattain US Patent (1951)





More History

- Bell Labs licenses transistor technology
- By 1953-54 hearing aids and radios use transistors



Regency transistor radio of 1954, from Smithsonian Information Age exhibit



Sony transistor radio of 1955 with green case, from Smithsonian Information Age exhibit

More History

- 1955---Shockley leaves Bell Labs to form his own company (Shockley Semiconductors)
- 1957 --- Fairchild Semiconductor formed; several of Shockley employees join Fairchild
 - •The "traitorous eight" were Julius Blank, Victor Grinich, Jean Hoerni, Gene Kleiner, Jay Last, Gordon Moore, Robert Noyce, and Sheldon Roberts.

Texas Instruments' IC Patent (1964)





Reference: W. F. Brinkman, et. al., "A History of the Invention of the Transistor and Where It Will Lead Us," *IEEE Journal of Solid State Circuits*, vol. 32, no. 12, December 1997, pp. 1858-1865

Fairchild IC Patent (1961)

• R. N. Noyce



Reference: W. F. Brinkman, et. al., "A History of the Invention of the Transistor and Where It Will Lead Us," *IEEE Journal of Solid State Circuits*, vol. 32, no. 12, December 1997, pp. 1858-1865

Moore's Law (c. 1965)

 Gordon Moore predicted that the density of ICs doubles every 18 months

 This prediction has been remarkably good for 40 years





G. E. Moore is one of the new breed of electronic engineers, schooled in the physical sciences rather than in electronics. He earned a B.S. degree in chemistry from the University of California and a Ph.D. degree in physical chemistry from the California Institute of Technology. He was one of the founders of Fairchild Semiconductor and has been Director of the research and development laboratories since 1959.

Reference: G. Moore, "Cramming More Components into Integrated Circuits," *Proc. IEEE*, vol. 86, no. 1, January 1998, reprinted from *Electronics*, April 19, 1965

Early History of ICs

Historic time line on the evolution of the monolithic integrated circuits.

Date	Event
April 25, 1956	William B. Shockley files for patent on Semiconductor Shift Register
September 1957	Robert N. Noyce joins Fairchild Semiconductors
May 1958	Jack S. Kilby joins Texas Instruments
February 6, 1959	Jack S. Kilby files for patent on Miniaturized Electronic Circuits
July 30, 1959	Robert N. Noyce files for patent on Semiconductor Device-and-Lead Structure
January 10, 1961	William B. Shockley obtains patent on Semiconductor Shift Register U.S. Patent No. 2,967,952
April 25, 1961	Robert N. Noyce obtains patent on Semiconductor Device-and-Lead Structure. U.S. Patent No. 2,981, 877
June 23, 1964	Jack S. Kilby obtains patent on Miniaturized Electronic Circuits U.S. Patent No. 3,138,743

Reference: Probir K. Bondyopadhyay, "W = Shockley, the Transistor Pioneer --- Portrait of an Inventive Genius," *Proceedings of the IEEE*, vol. 86, no. 1, January 1998, pp. 191-217 Introduction

Logarithmic Amplifier





Translinear Circuit

• Using the "translinear principle" we can find currents if we have a circuit with a loop of V_{BE} s





• Could be e.g. an analog video filter, etc. (Note the 75 ohm source and termination; could be a video BNC cable)



Nomenclature

• In transistor circuits, we often work with total variables, bias point variables, and small-signal variations

$$v_{BE} = V_{BE} + v_{be}$$

Book Outline

- Chapters 1-2: Introductory materials
- Chapters 3-4: Bipolar device physics, diodes, BJTs
- Chapters 5-8: Transistor amplifiers—biasing, gain and bandwidth
- Chapter 9: MOS device physics and MOS amplifiers
- Chapter 10: Bipolar transistor switching
- Chapter 11: Feedback systems
- Chapter 12: Voltage feedback operational amplifiers
- Chapter 13: Current feedback op-amps
- Chapter 14: Analog lowpass filter design
- Chapter 15: Real-world design issues and a PC board layout case-study
- Chapter 16: Potpourri of design techniques and loose-ends

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All patents listed are available on the U.S. Patent and Trademark website: www.uspto.gov.

Another good reference: Google patents