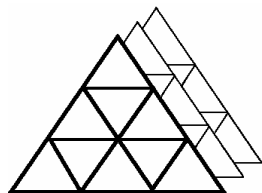


# Elektrische Messtechnik (5.0)

---

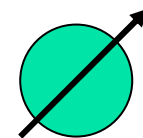
SS 2009

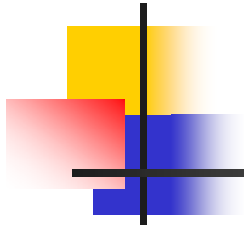
Prof. Dr. sc. nat. Manfred Schmidt  
Fachhochschule Jena  
Fachbereich Elektrotechnik/  
Informationstechnik



FACH  
HOCH  
SCHULE  
JENA

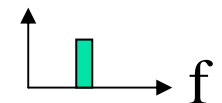
UNIVERSITY OF APPLIED SCIENCES





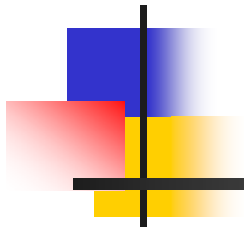
Dieses Material wurde ausschließlich für Lehrveranstaltungen am Fachbereich Elektrotechnik und Informationstechnik der Fachhochschule Jena im SS 2009 konzipiert und zusammengestellt.

Die verwendeten Abbildungen sind zum Teil aus den angegebenen Literaturstellen entnommen.



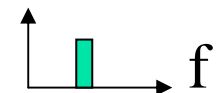
# Signale und Systeme

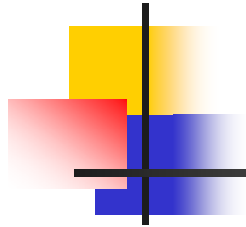
Zusammenstellung für Vorlesung  
Messtechnik II



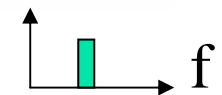
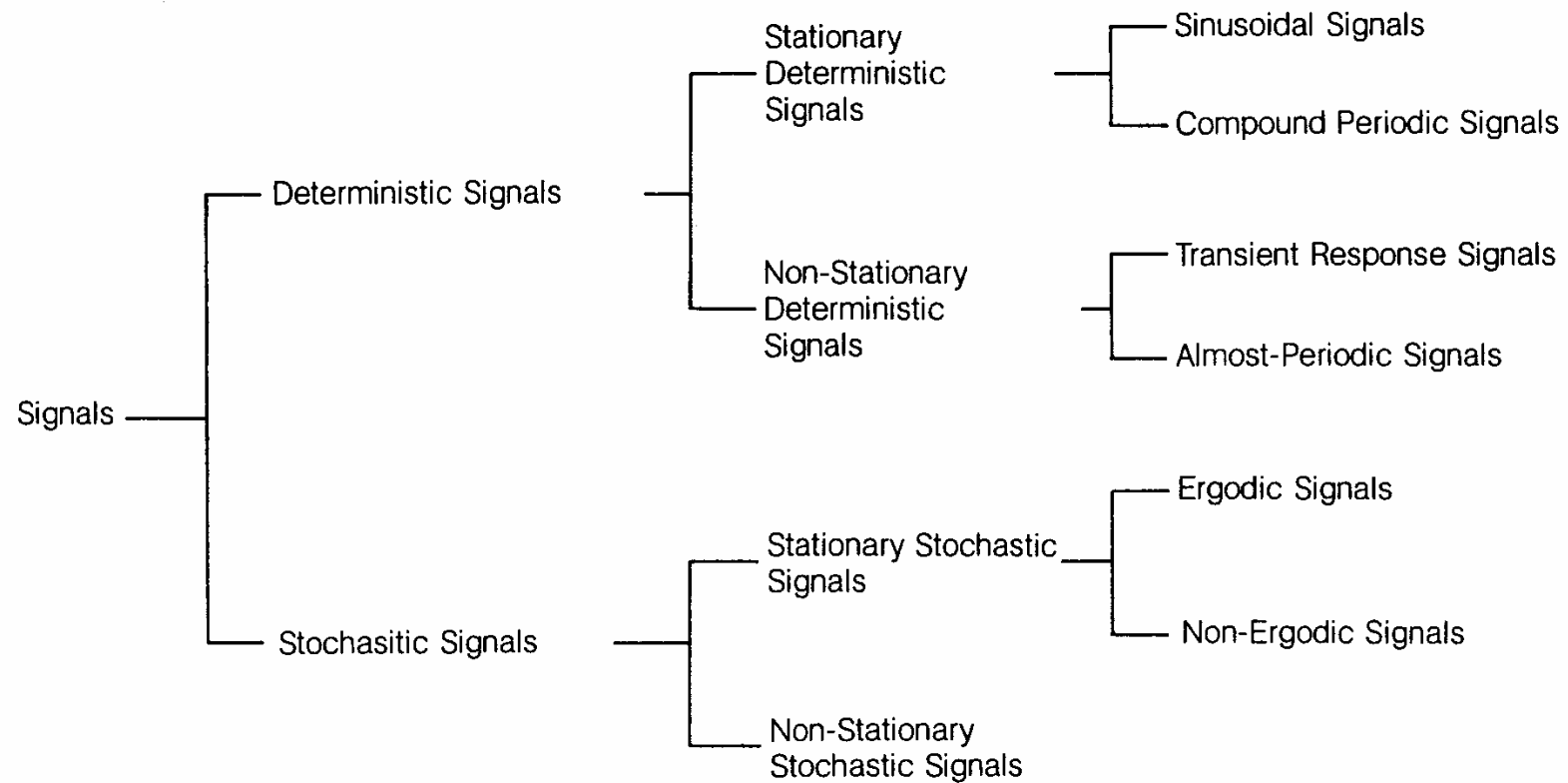
Dr. sc. nat. Manfred Schmidt  
Professor i. R.  
Fachhochschule Jena, Fachbereich Et / IT

Sommersemester 2009

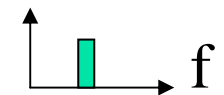
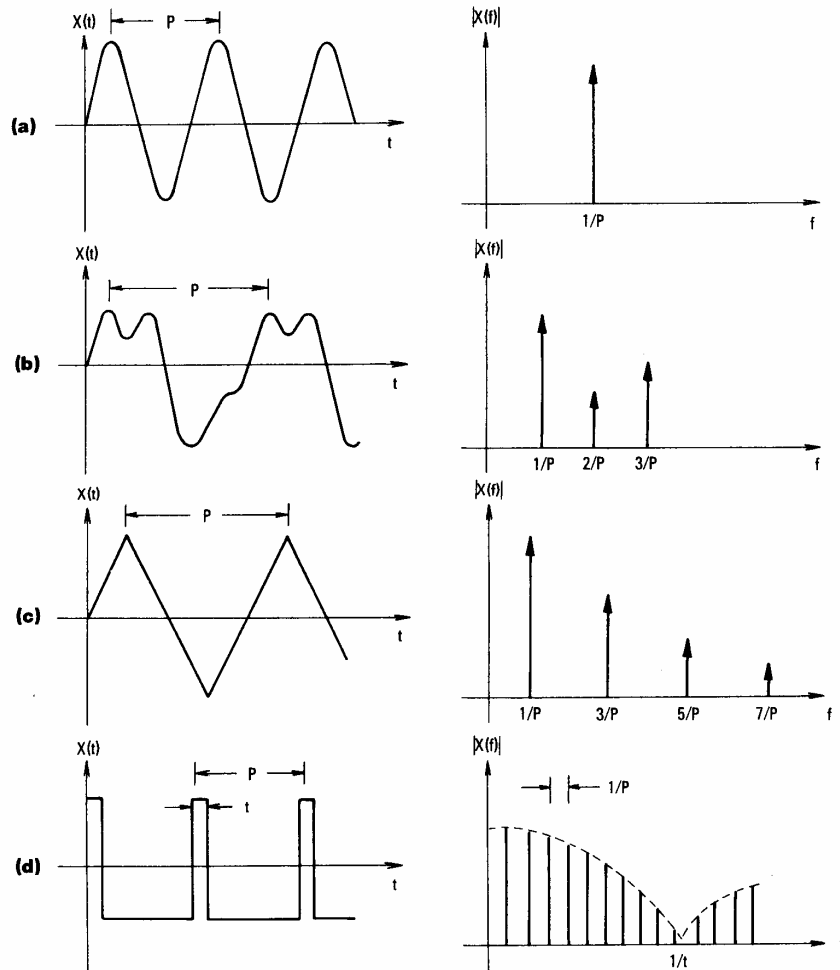




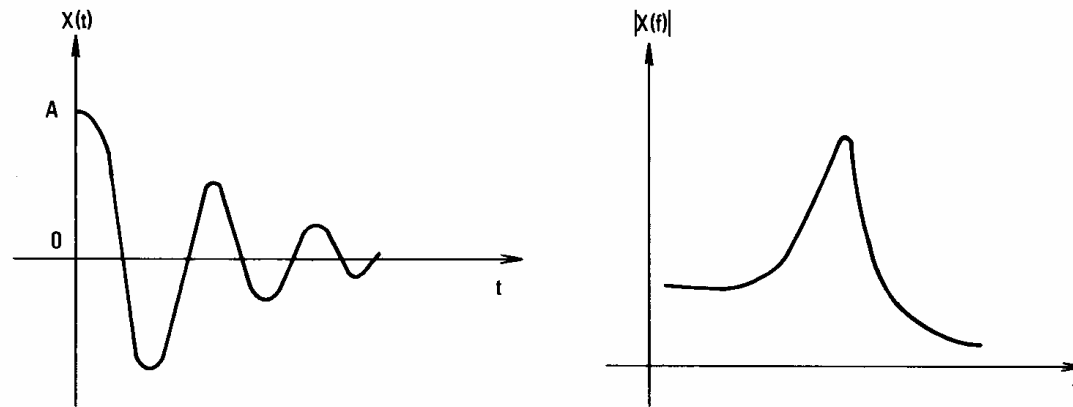
# Signale



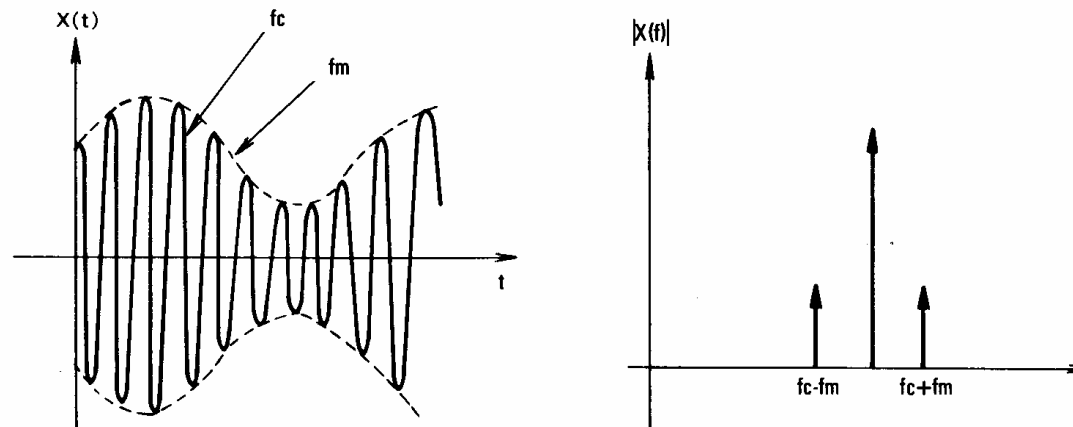
# Ausgewählte Signale und deren Spektren



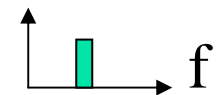
# Ausgewählte Signale und deren Spektren



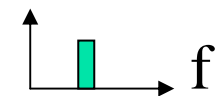
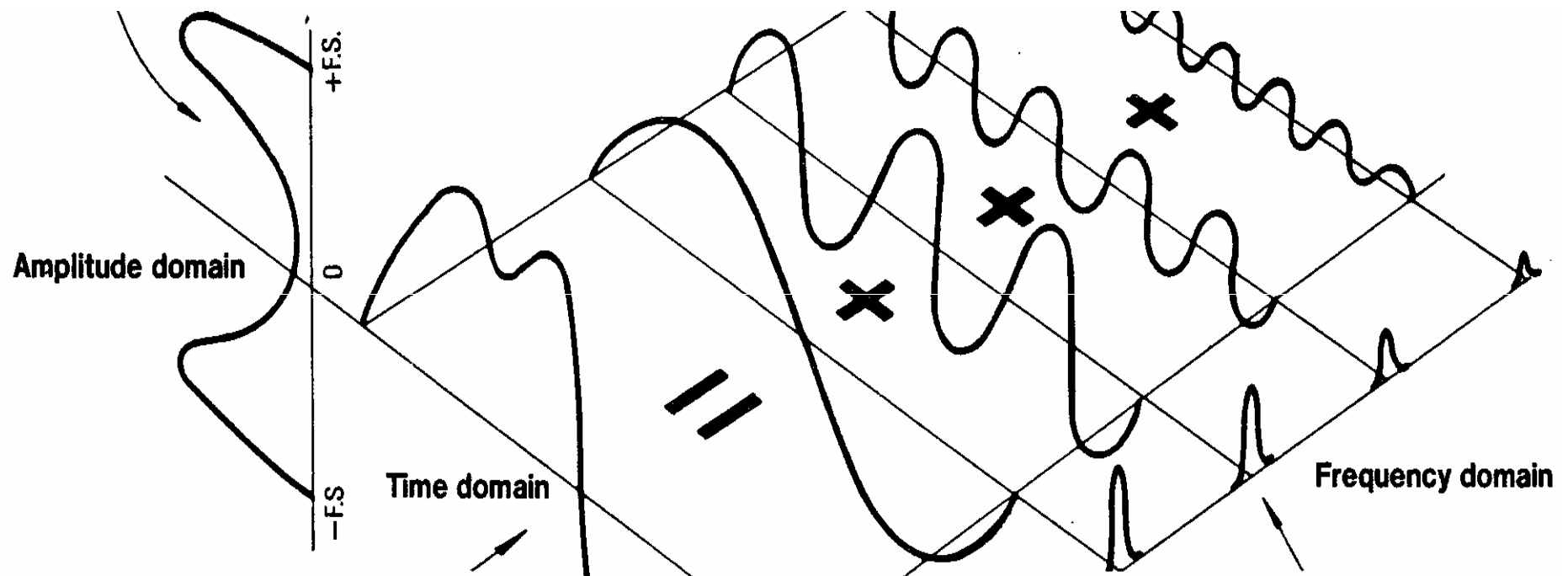
(a) Transient signal (data) and its spectrum



(b) AM signal (almost periodic data) and its spectrum

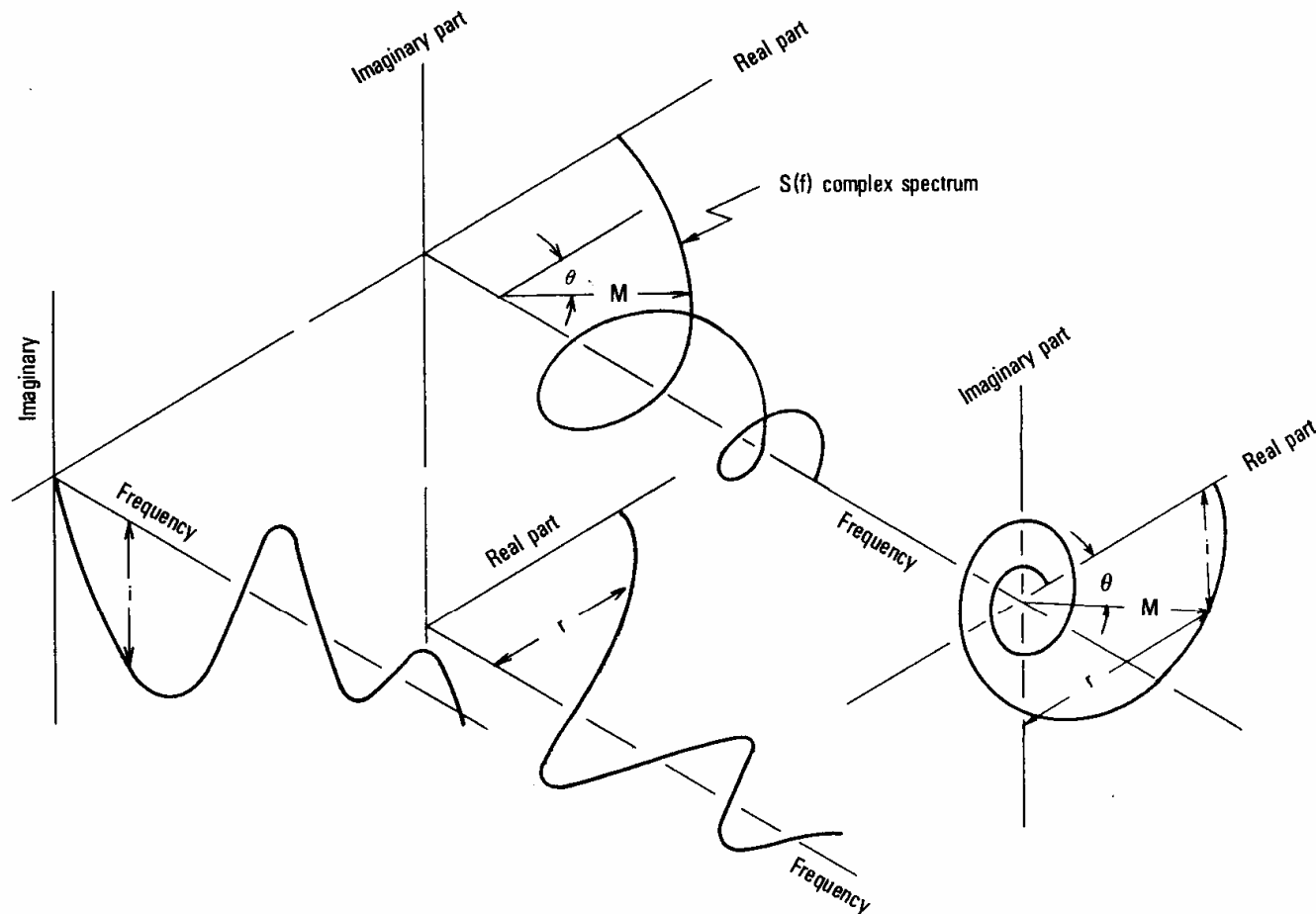


# Amplituden-, Zeit- und Frequenzbereich



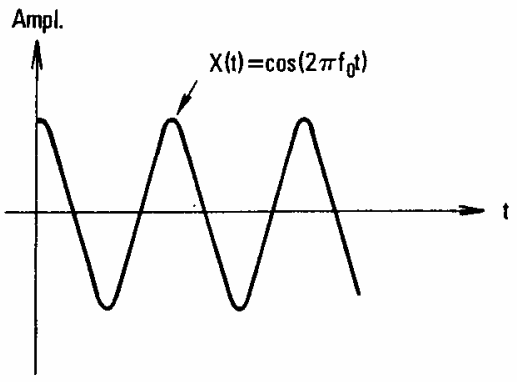
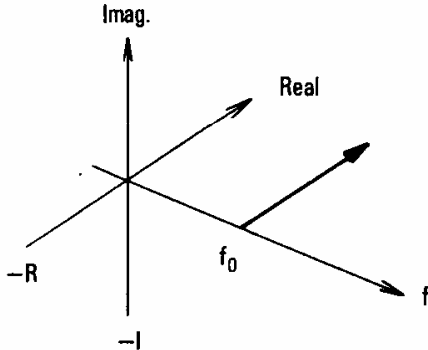
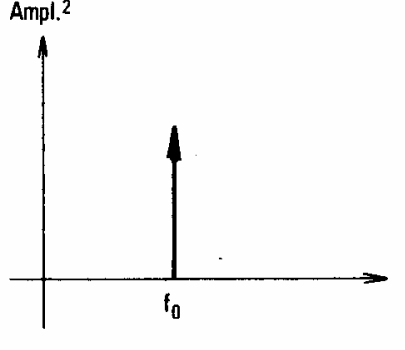
# Komplexes Spektrum:

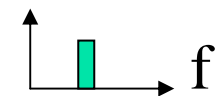
Realteil und Imaginärteil, Darstellung in der komplexen Ebene

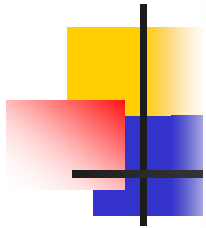




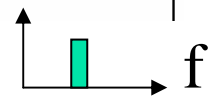
# Zeit, Phase, Frequenz, Leistungsspektrum

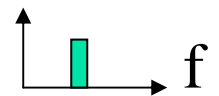
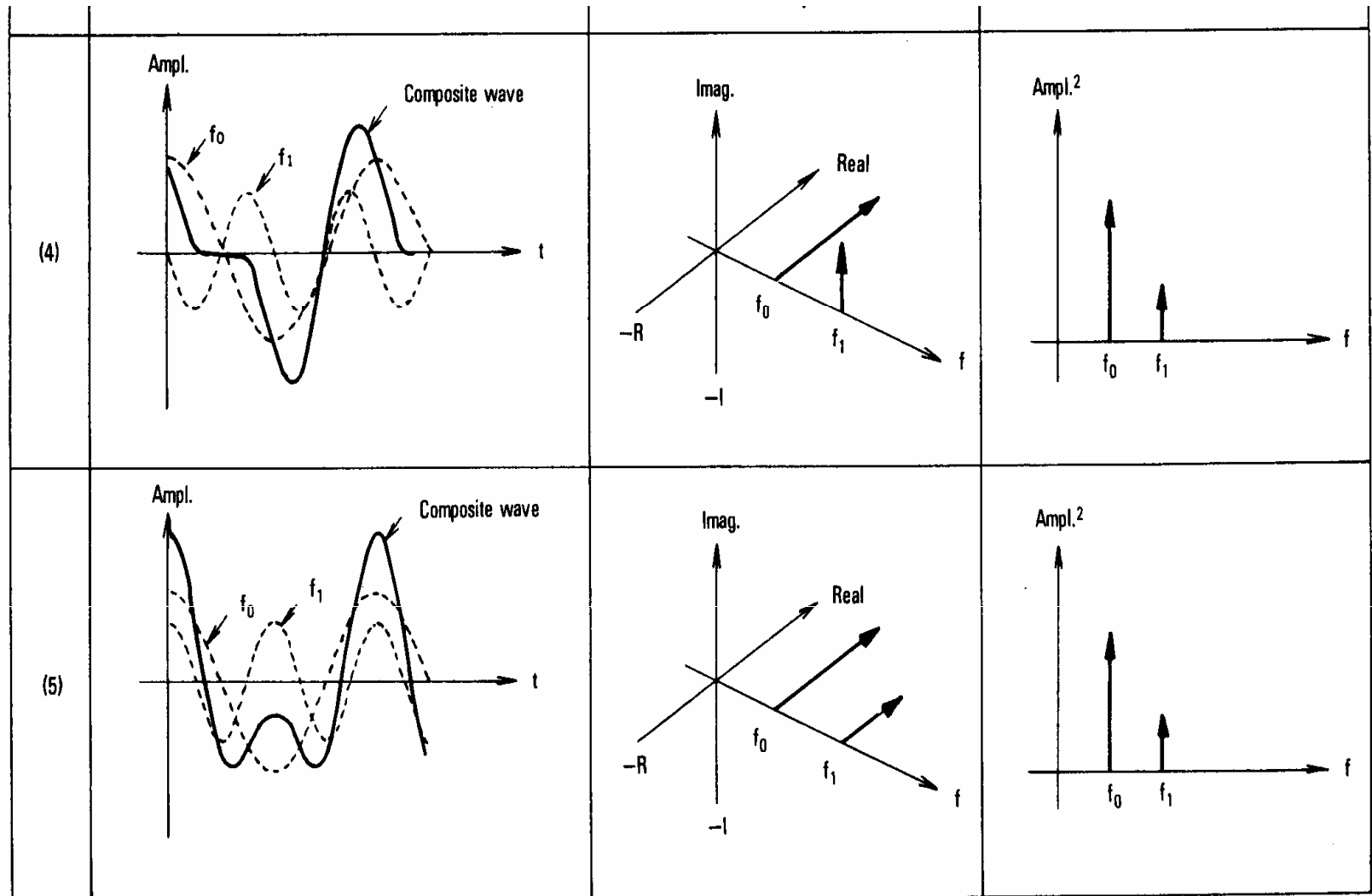
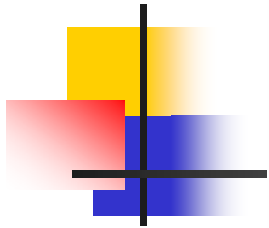
	Time domain	Phase & frequency domain	Power spectrum
(1)	 <p>Ampl.</p> <p><math>X(t) = \cos(2\pi f_0 t)</math></p> <p>t</p>	 <p>Imag.</p> <p>Real</p> <p><math>f_0</math></p> <p>f</p> <p>-R</p> <p>-I</p>	 <p>Ampl.<sup>2</sup></p> <p><math>f_0</math></p> <p>f</p>



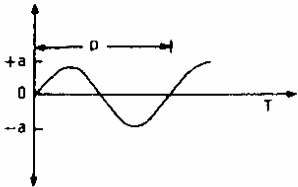
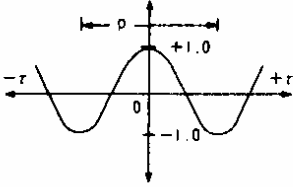
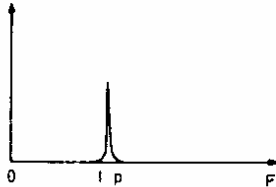
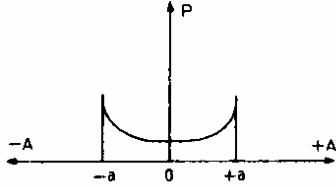


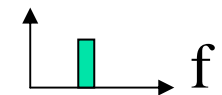
	Time domain	Phase & frequency domain	Power spectrum
(1)	<p><math>X(t) = \cos(2\pi f_0 t)</math></p>	<p><math>-R</math>, <math>f_0</math>, <math>-I</math></p>	<p><math>f_0</math></p>
(2)	<p><math>X(t) = \cos(2\pi f_0 t - \phi)</math></p>	<p><math>-R</math>, <math>f_0</math>, <math>-I</math>, <math>\phi</math></p>	<p><math>f_0</math></p>
(3)	<p><math>X(t) = \sin(2\pi f_0 t)</math></p>	<p><math>-R</math>, <math>f_0</math>, <math>-I</math></p>	<p><math>f_0</math></p>

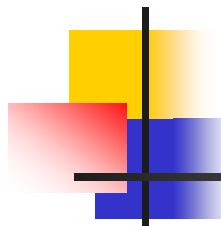




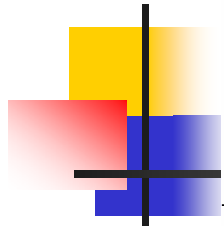
# Amplituden-, Zeit- und Frequenzbereich

Signal	Time Domain		Frequency Domain	Amplitude Domain
	Time Series	Auto-correlation	Frequency Spectrum	Probability Density
1. Sine Wave				

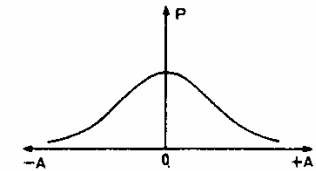
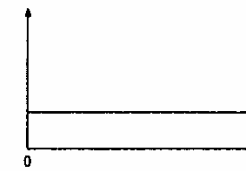
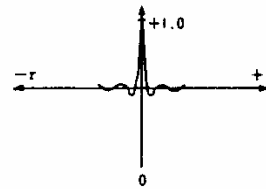




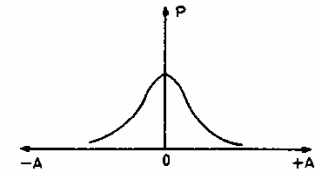
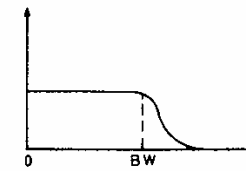
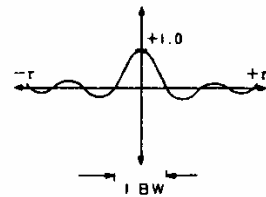
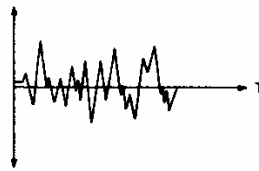
Signal	Time Domain		Frequency Domain	Amplitude Domain
	Time Series	Auto-correlation	Frequency Spectrum	Probability Density
1. Sine Wave				
2. Square Wave				
3. Pulse				
4. Triangular				
5. Sawtooth				



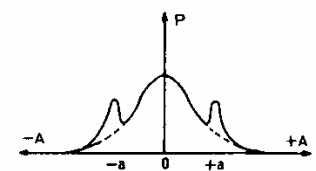
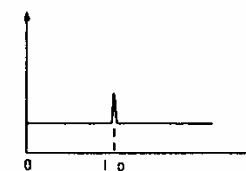
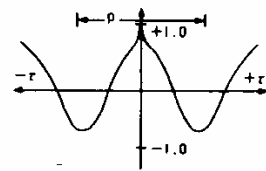
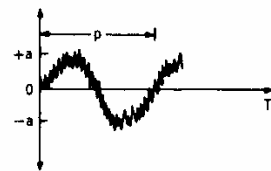
## 6. Wideband Gaussian Noise



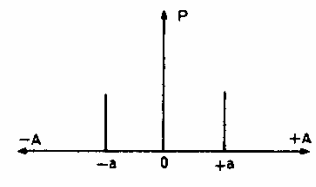
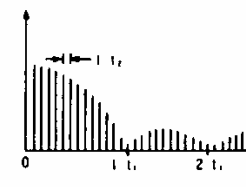
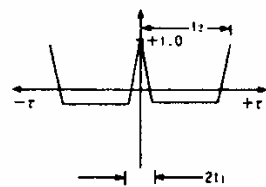
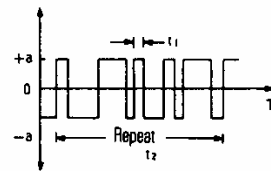
## 7. Bandlimited Noise



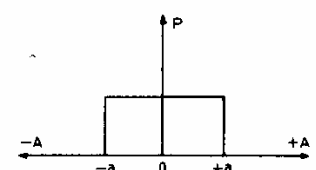
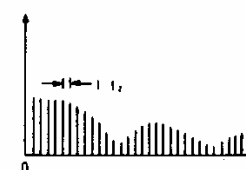
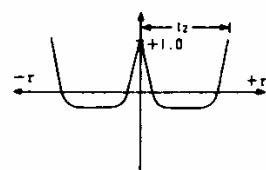
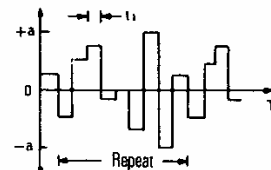
## 8. Sine Wave Plus Gaussian Noise



## 9. Pseudo-Random Binary Sequence Noise



## 10. Pseudo-Random Binary Level Noise

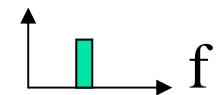


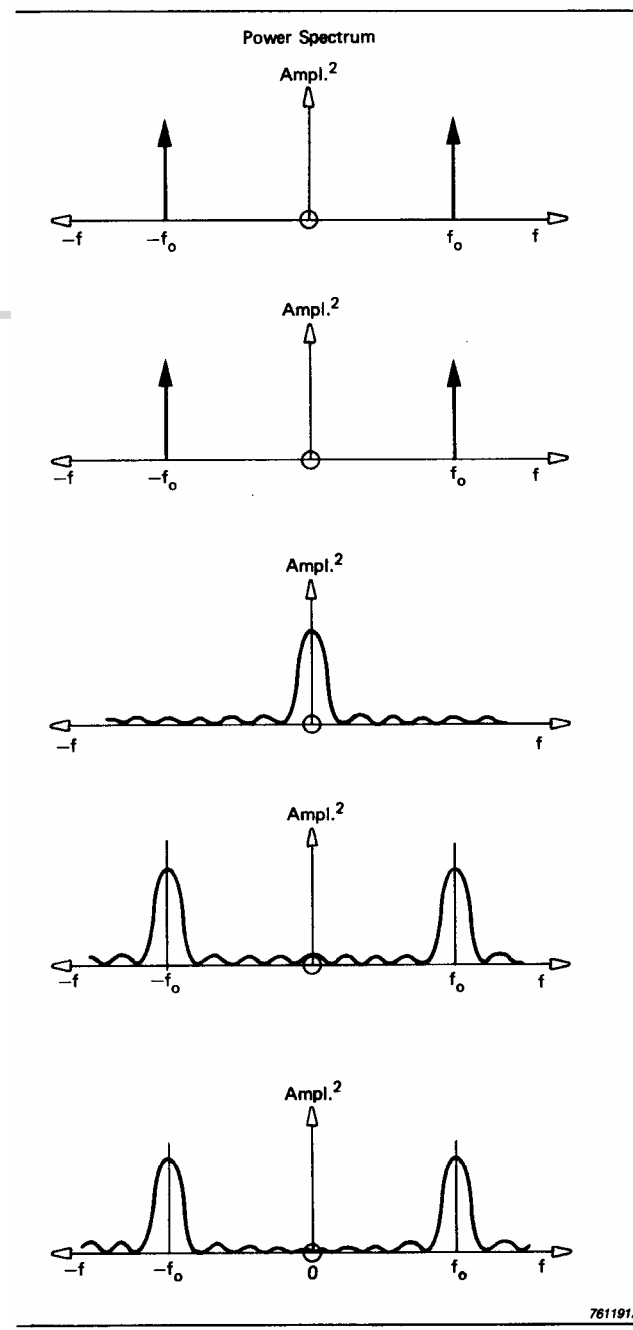
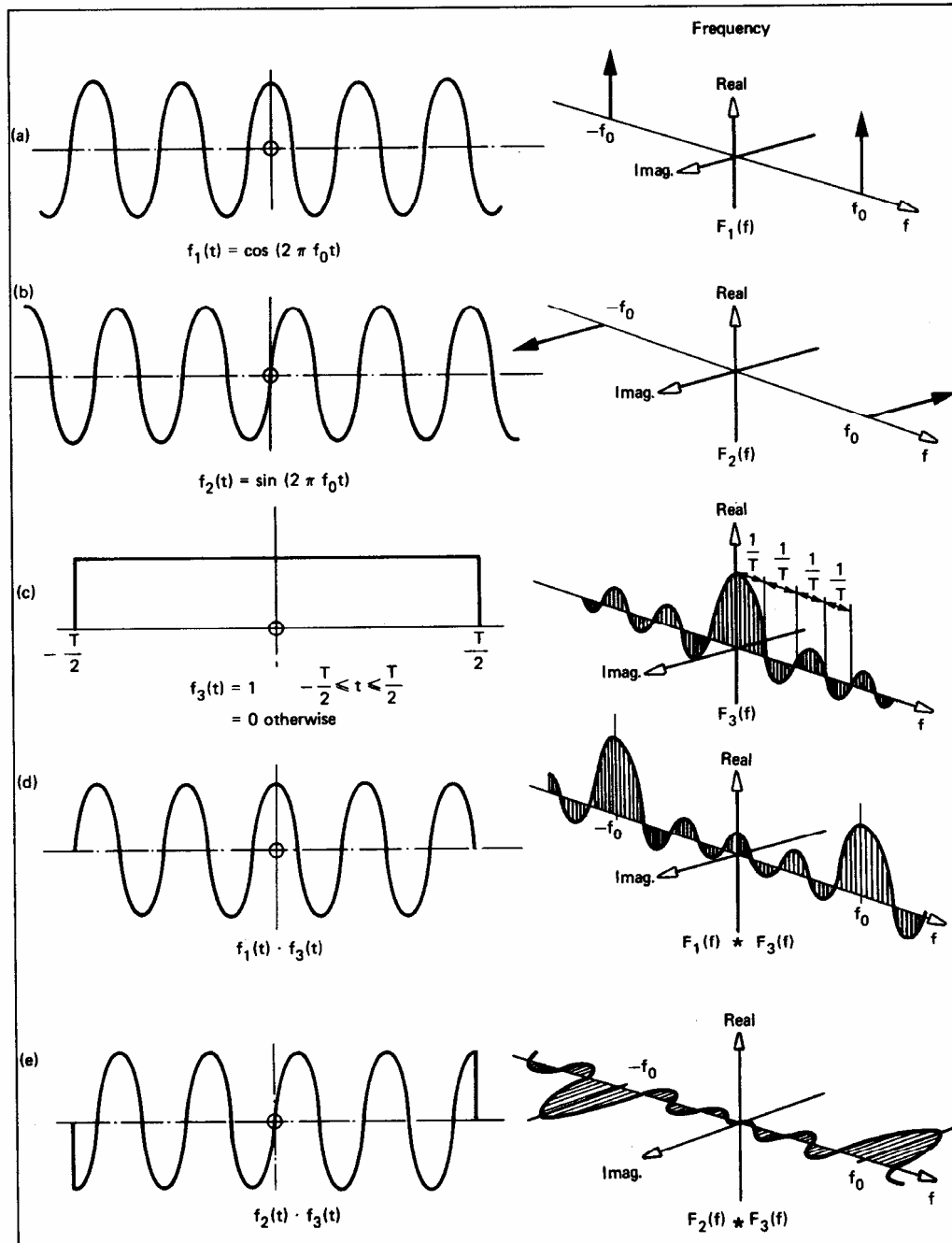


# Rechteckfenster

---

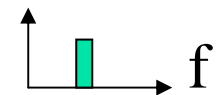
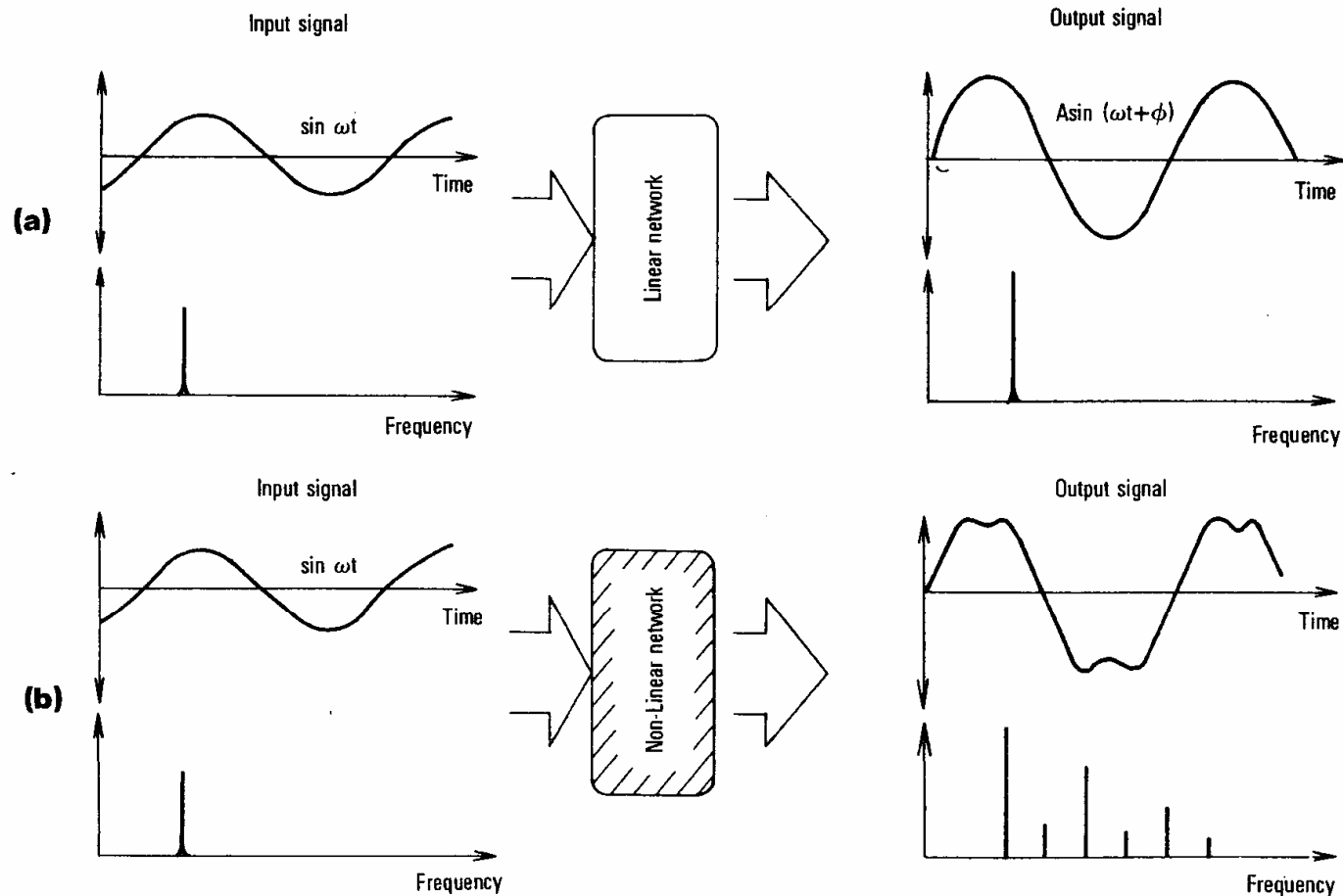
- Messpraxis: Auswahl eines endlichen Signalabschnittes
- Rechteckfenster im Zeitbereich
- Frequenzbereich: Multiplikation mit  $\text{sinc}/x$  - Funktion



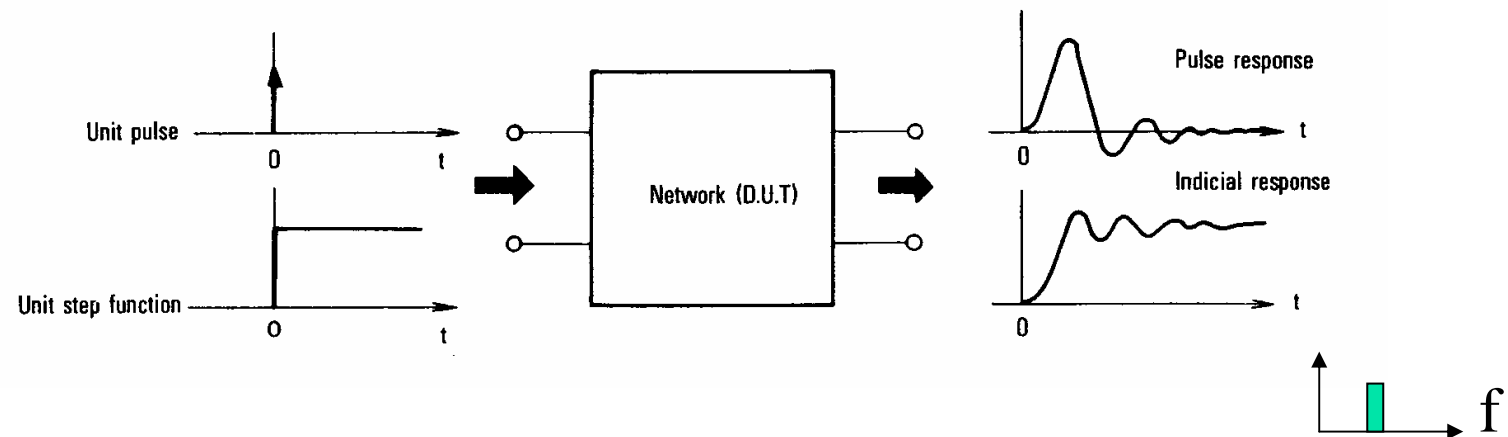
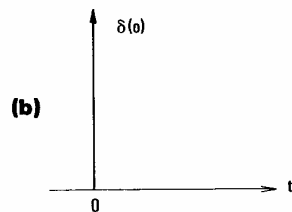
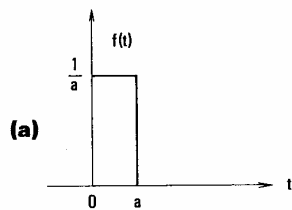




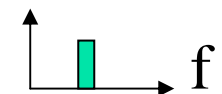
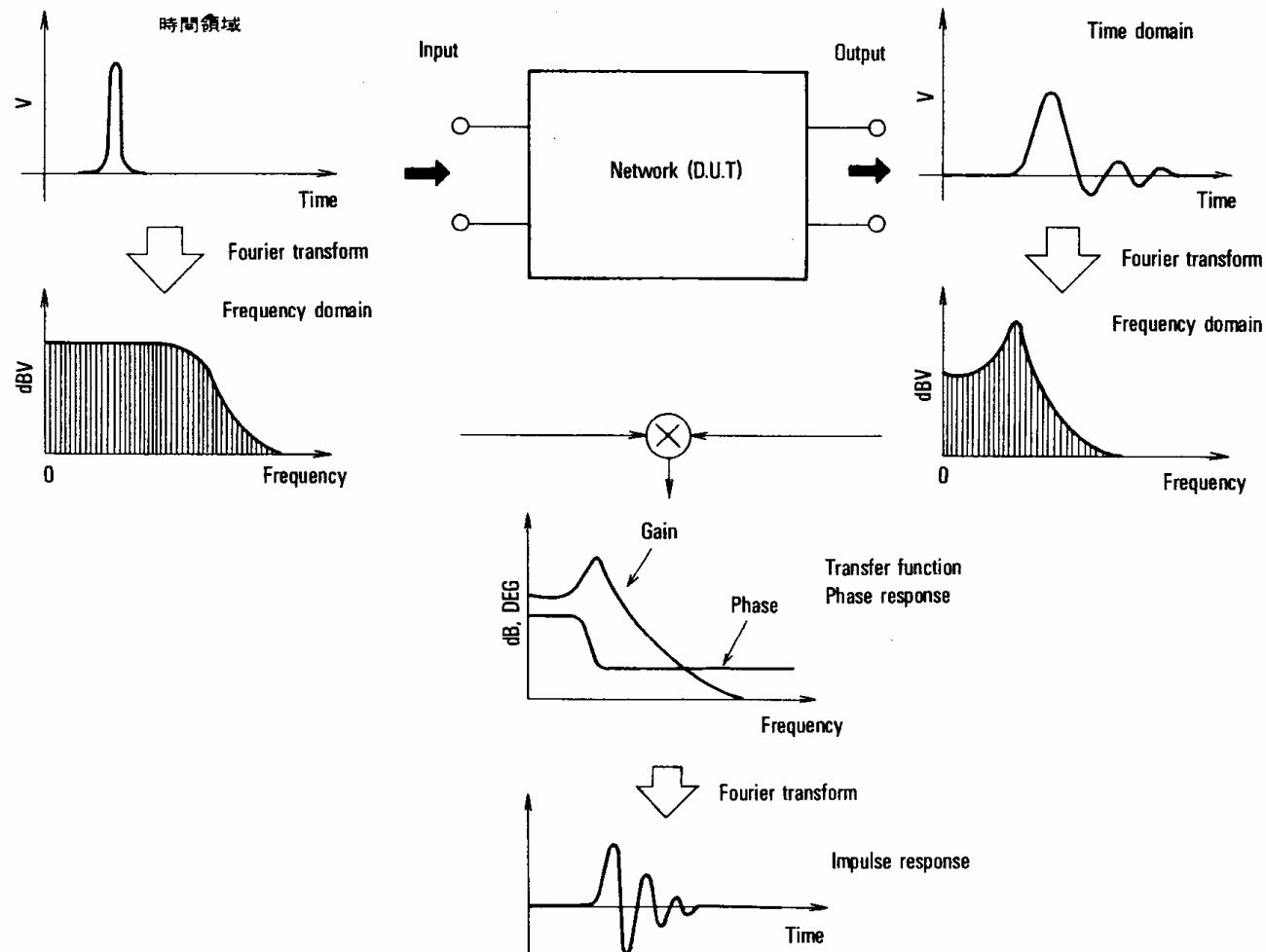
# Signale und lineare / nichtlineare Netzwerke



# Netzwerkanalyse im Zeitbereich

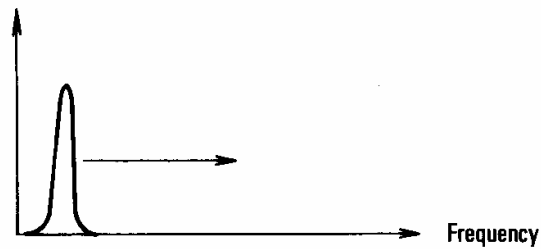
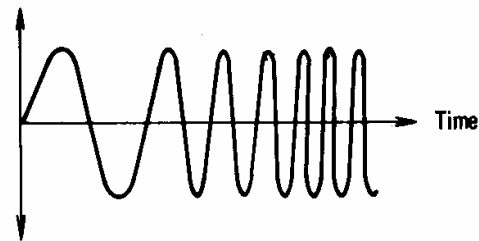


# Netzwerkanalyse im Frequenzbereich

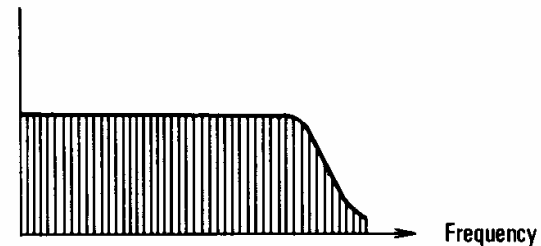
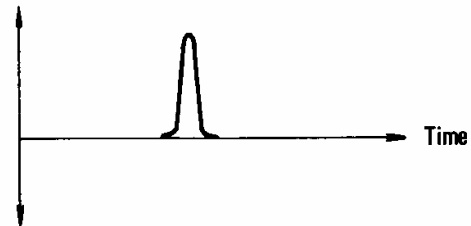


# Weitere Anregungsmethoden

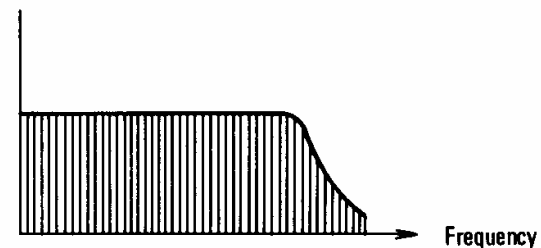
**(a) Sinewave sweep excitation method**



**(b) Impact excitation method**

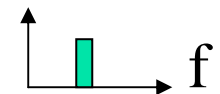


**(c) Random excitation method**

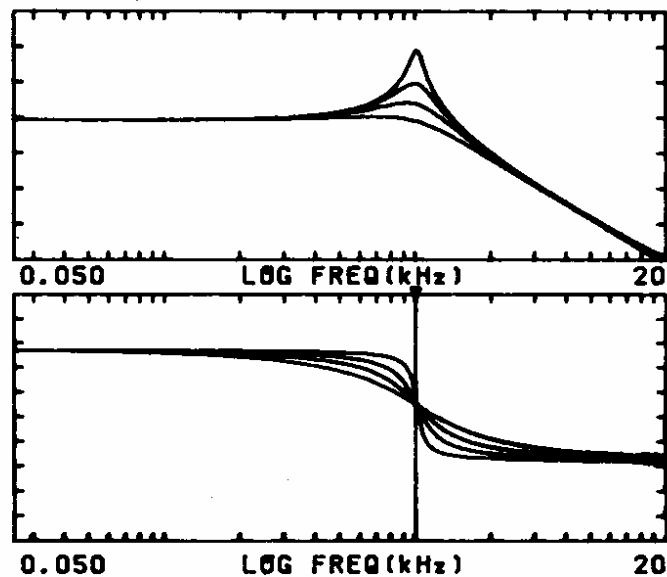


Time domain

Frequency domain

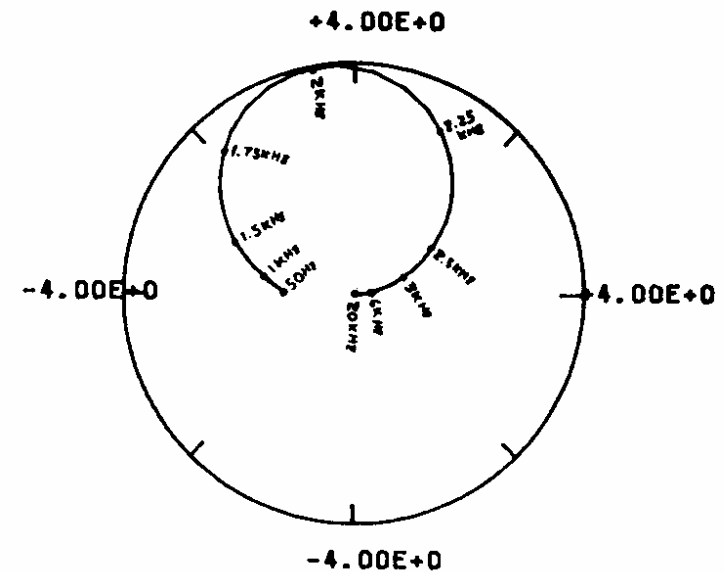


# Bode- und Nyquist- Diagramm



(a) Bode diagram

Amplitudencharakteristik  
Phasencharakteristik

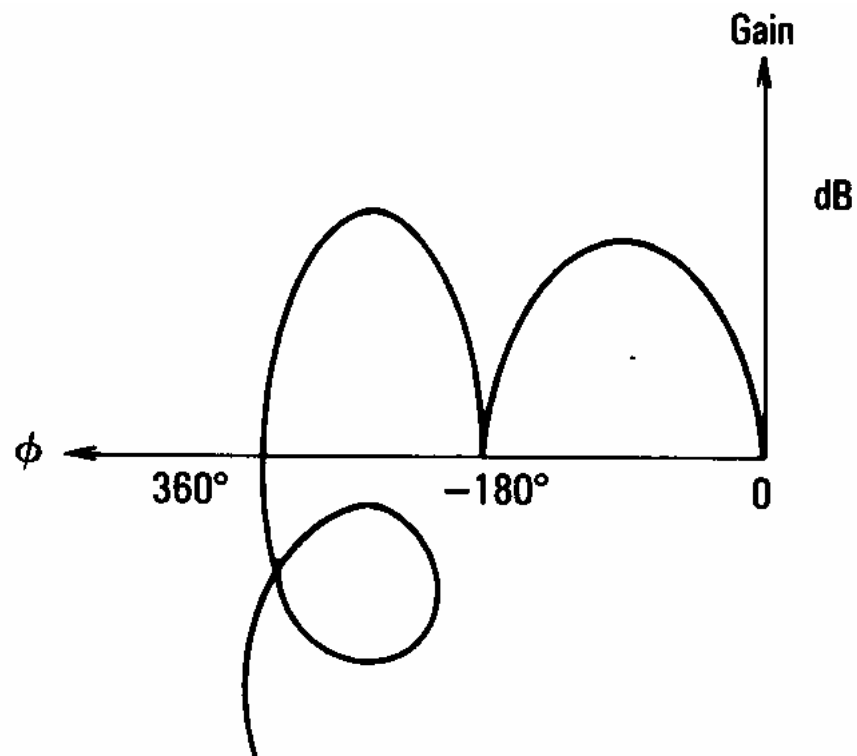


(b) Nyquist diagram

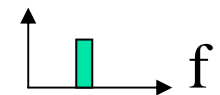
Vektorort der Übertragungs-  
funktion  $G(j\omega)$  in der komplexen  
Ebene

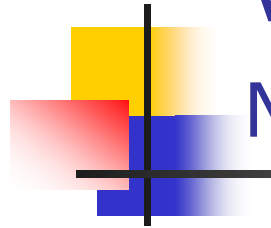


# Nichols - Diagramm



Verstärkung und Phase wird im rechtwinkligen Koordinatensystem dargestellt,  
Messung der mechanische Impedanz





# Vergleich

## Nyquist - Diagramm und Bode - Diagramm

Item	Nyquist diagram	Bode diagram
Unit	Real and imaginary vectors	f-dB, f-deg.
Coordinate	Polar coordinate	Orthogonal
Dynamic range	Small	Large
Stability identification	Easy	Easy
Order assignment	Easy	Easy
Presentation of system coupling	Difficult	Easy
Determination of transfer function	Slightly difficult	Easy
Others	Weak in frequency value reading	Weak in real and imaginary vector reading