



# Vortrag über die Bachelorarbeit

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ESSEN

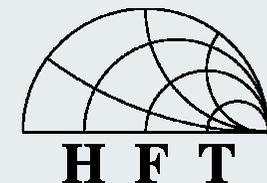
angefertigt von  
**cand.-ing. Hakan CAKMAK**  
bei  
**Prof. Dr.-Ing. K. Solbach**  
Fachgebiet  
Hochfrequenztechnik  
an der  
Universität Duisburg-Essen



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Thema:  
**Realisierung eines vektoriellen  
Netzwerkanalysators für den  
Frequenzbereich 1 MHz-60 MHz**

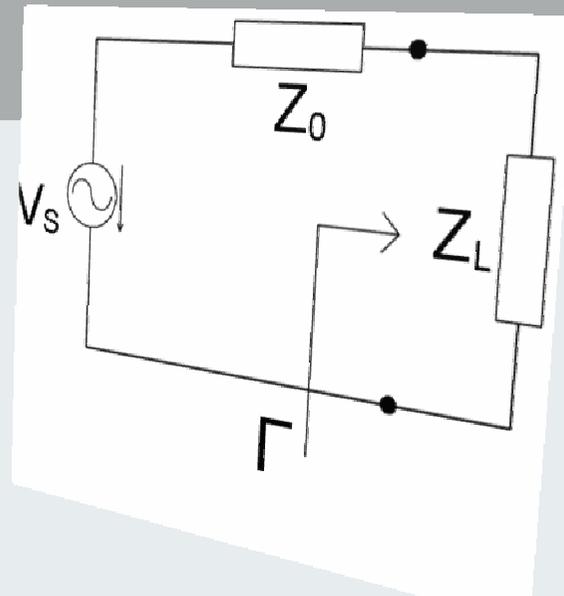
- Zielsetzung
- Vektornetzwerkanalysator Grundlagen
- Hardware-Entwicklung
- Softwareentwicklung
- Zusammenfassung



# Zielsetzung

- **AD9851: DDS-DAC Synthesizer**
- **AD8302: RF, IF Gewinn-und Phasen-Detektor/Komparator**
- **USB-Anschluss**
- **So kompakt, wie möglich**
- **Matlab Code**
- **Messungen an den Kalibrierungselementen\***
- **Eventuell ein Kalibrierungs-Algorithmus**

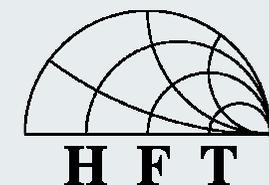
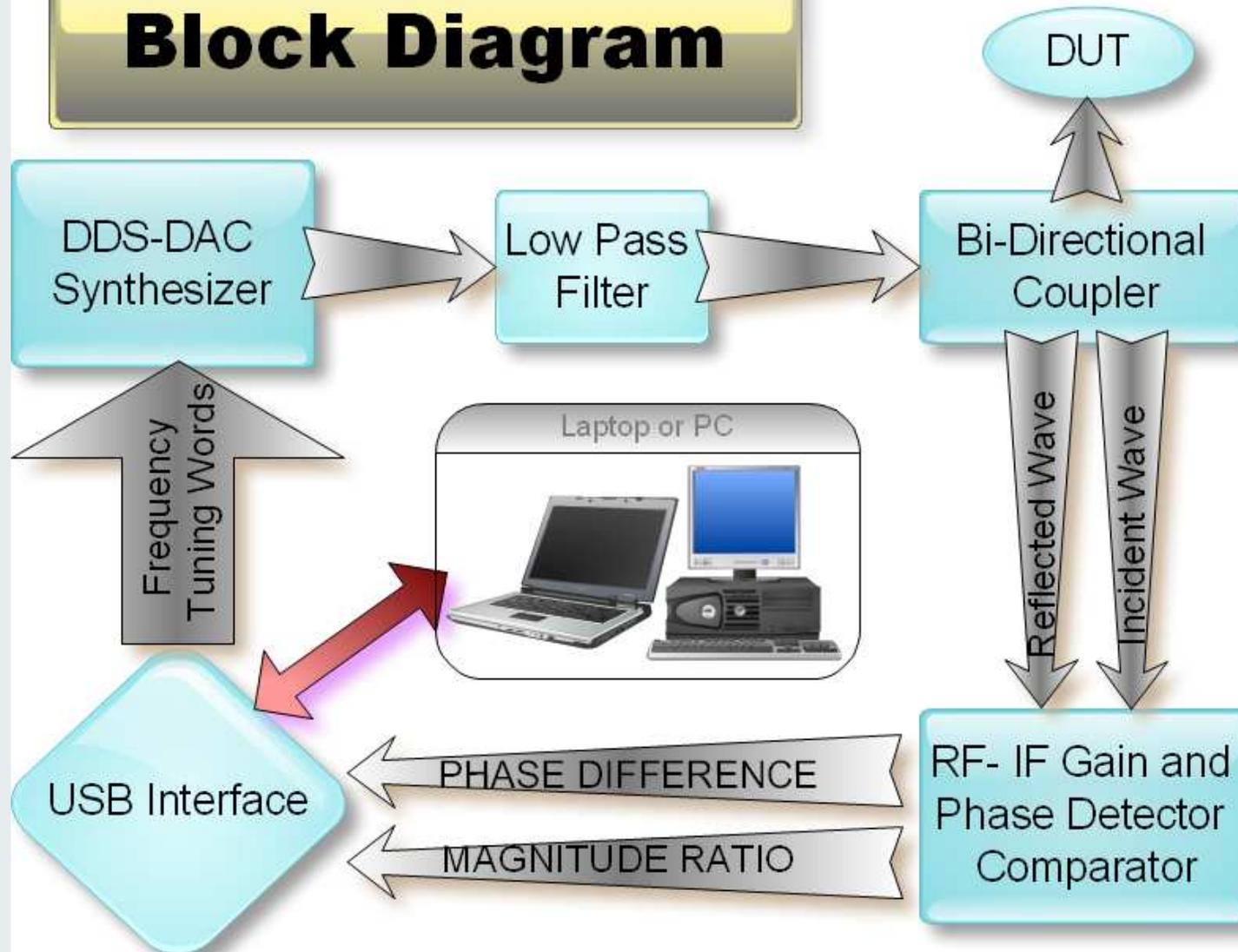




# VEKTORNETZWERKANALYSATOR GRUNDLAGEN

# Vectornetworkanalysator Grundlagen

## Block Diagram



# Messungslokal und Formeln

## RF Formeln

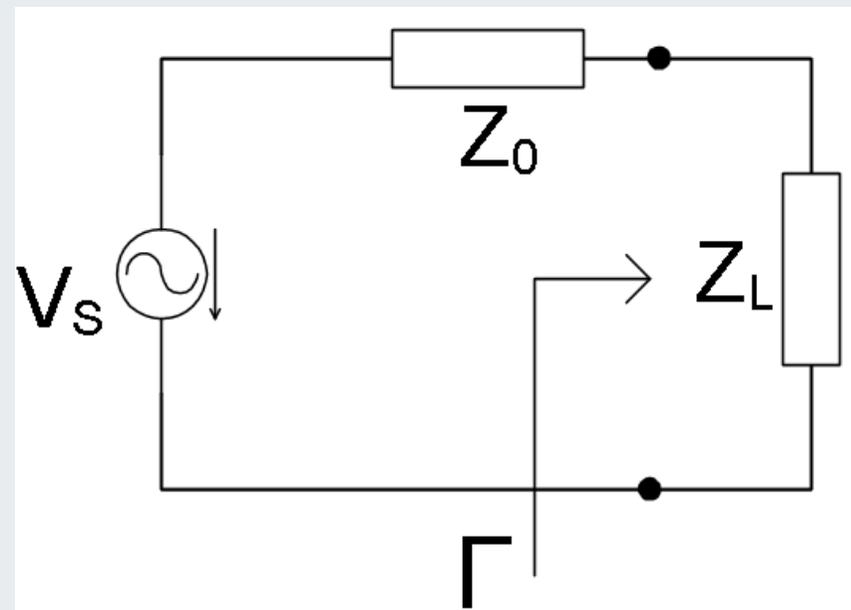
$$\Gamma = |\Gamma| \cdot e^{j\varphi_L} = \frac{V_r}{V_f} = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$Z_L = Z_0 \frac{1 + \Gamma}{1 - \Gamma}$$

$$Z_L = jX_S + R_S$$

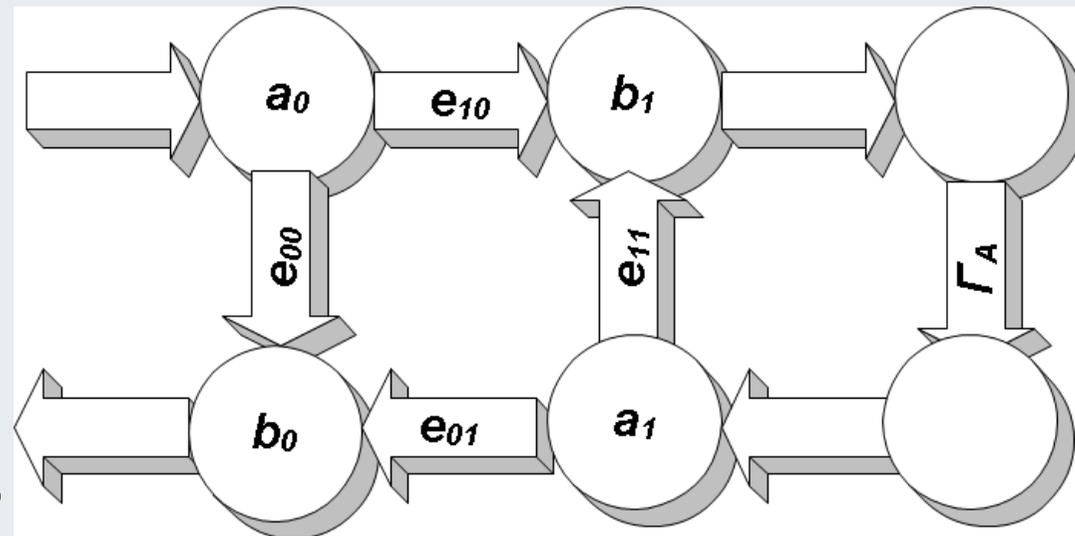
$$SWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

## Messungslokal

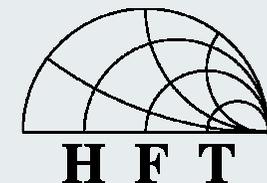


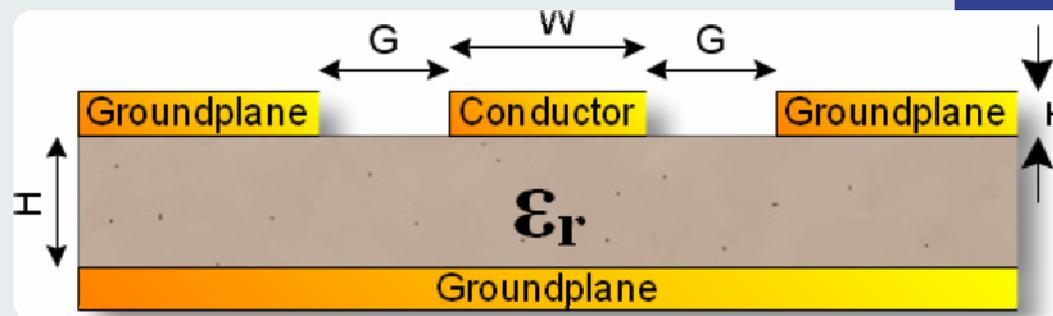
# Ein Tor Fehler Model

- $\Gamma_A$ : tatsächlicher Reflexionsfaktor
- $e_{10}e_{01}$ : Reflexion Verfolgungsfehler
- $e_{11}$ : Quellgleich Fehler
- $e_{00}$ : Leitbarkeitsfehler
- $\Gamma_M$ : gemessener Reflexionsfaktor



$$\Gamma_M = e_{00} + (e_{10}e_{01}) \cdot \frac{\Gamma_A}{(1 - e_{11} \cdot \Gamma_A)}$$



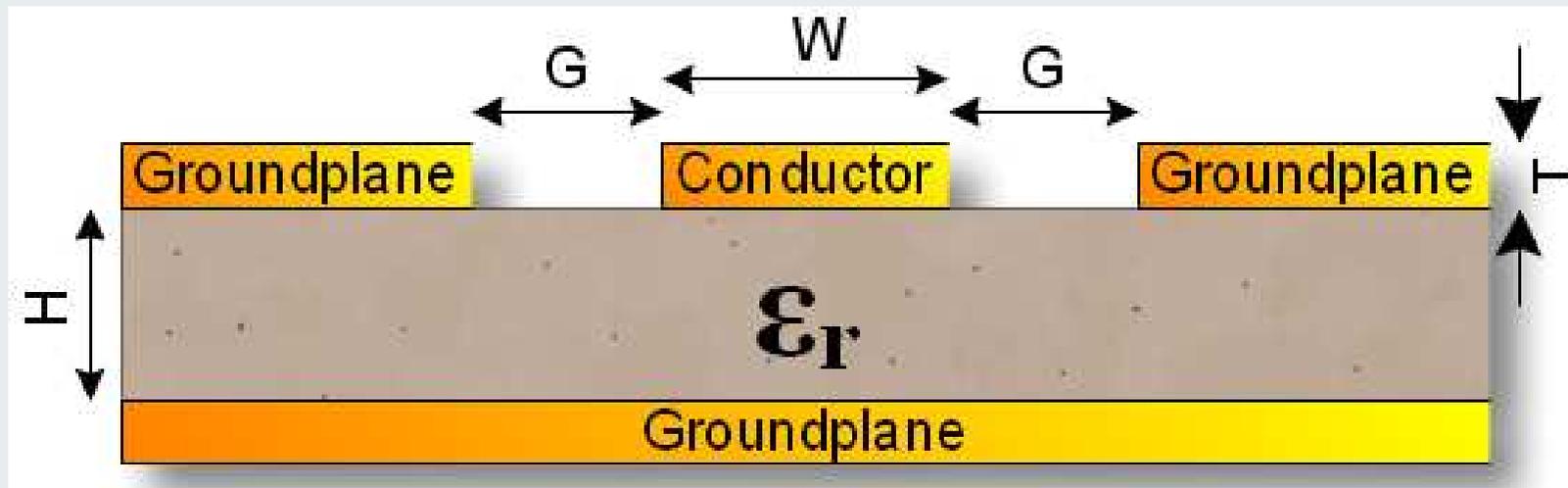


# HARDWARE-ENTWICKLUNG

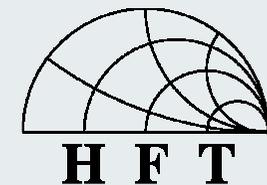
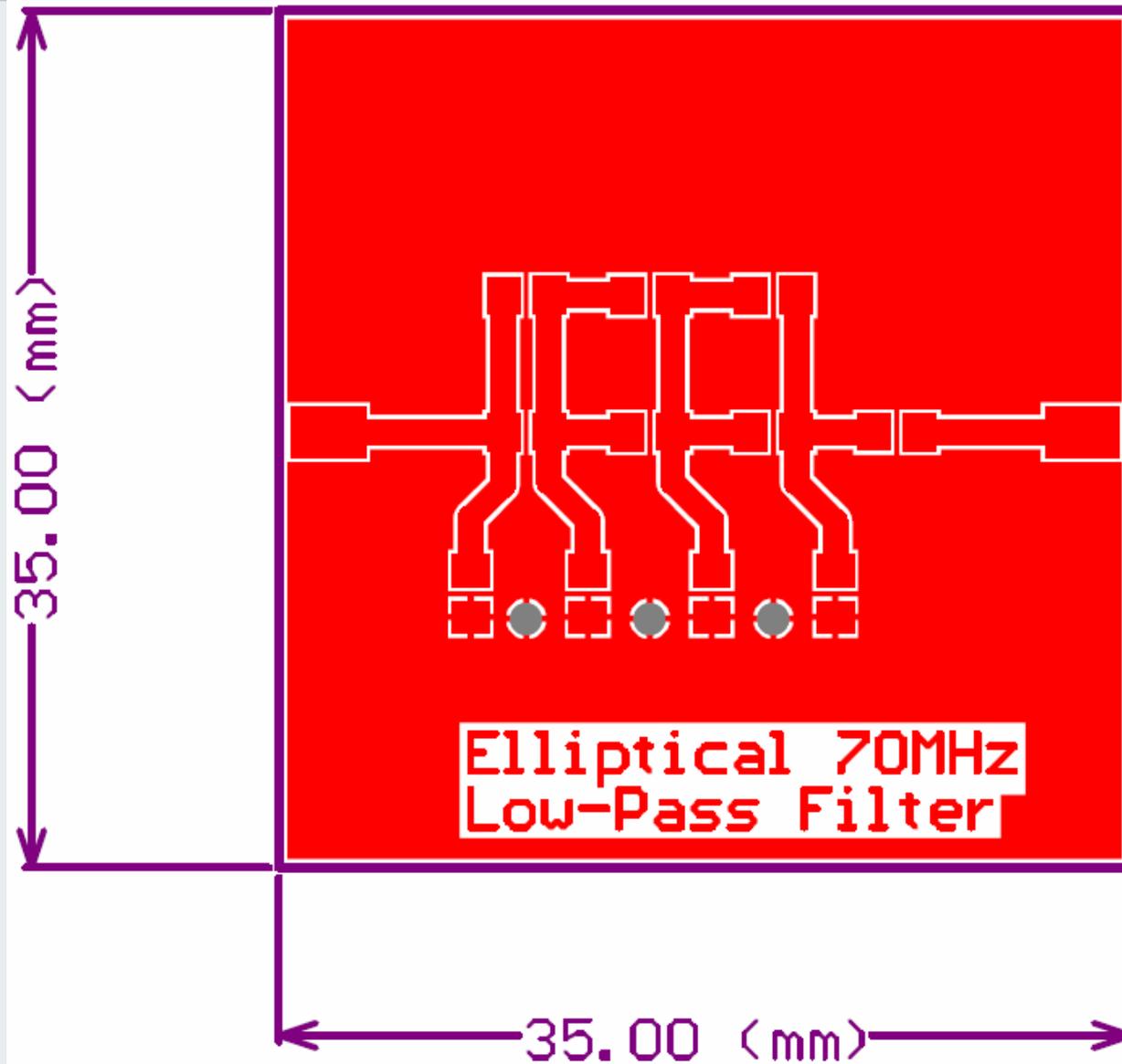
# Koplanar Wellenleiter Technik

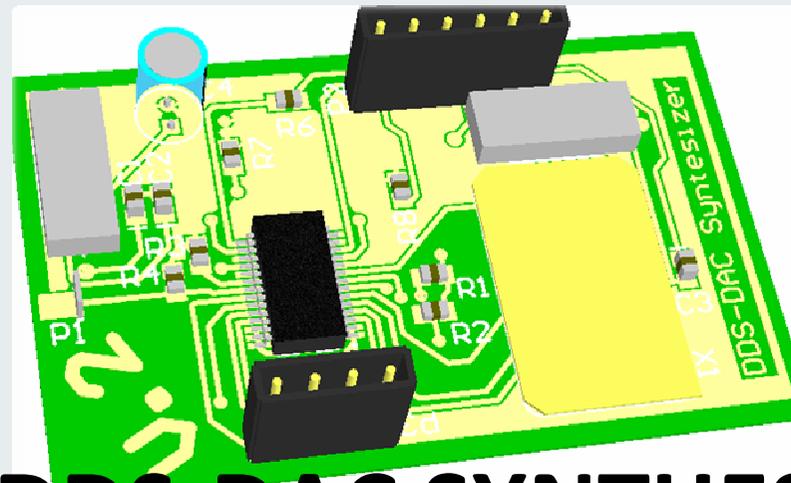
## Mithilfe ADS LineCalc

- Koplanar Wellenleiter Technik auf FR4 Material
- $G = 0.2 \text{ mm}$ ,  $Z_0 = 50 \text{ Ohm}$
- Breite  $W$  der Leiter berechnet.



# Beispiel für CPWG

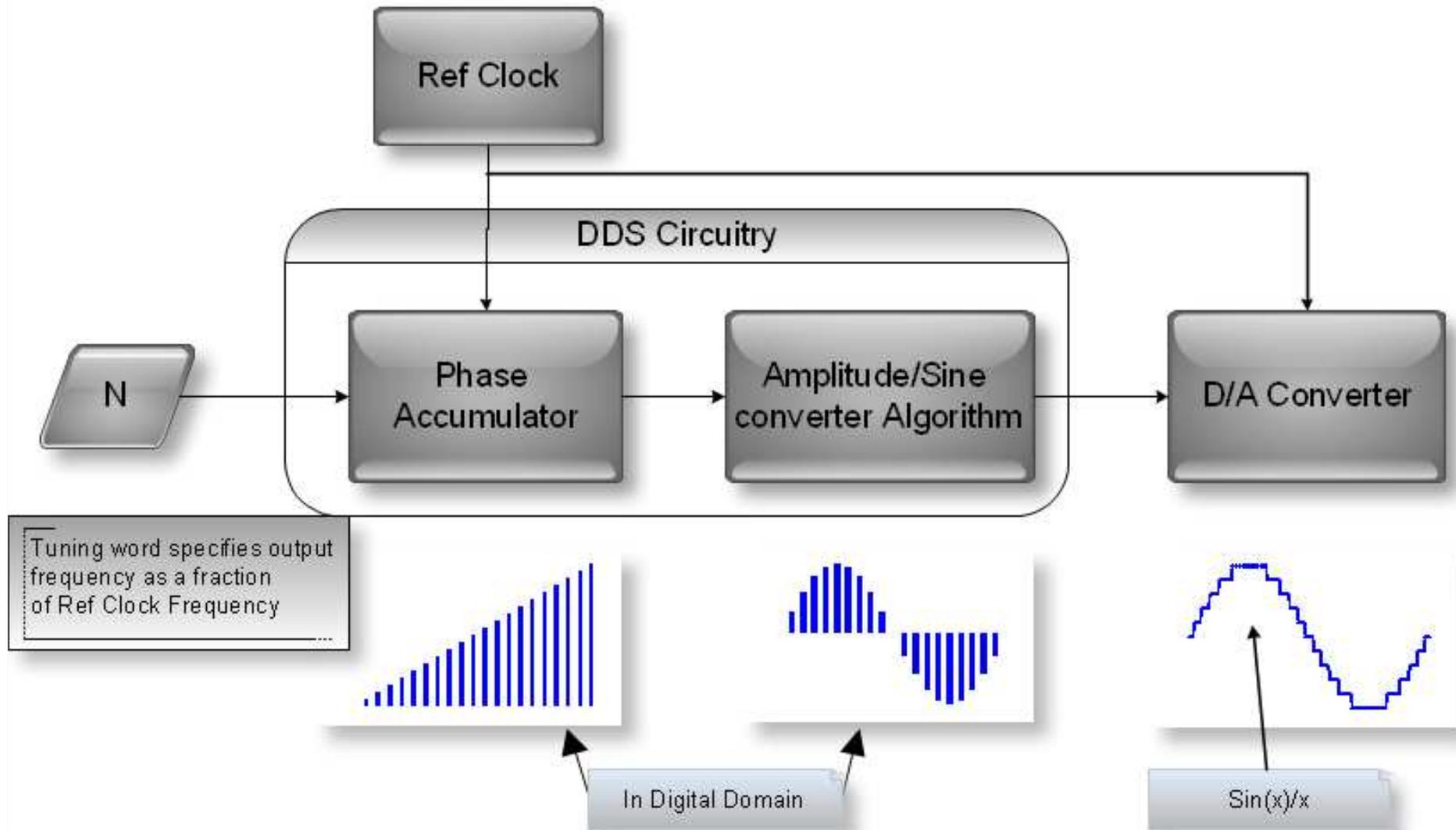




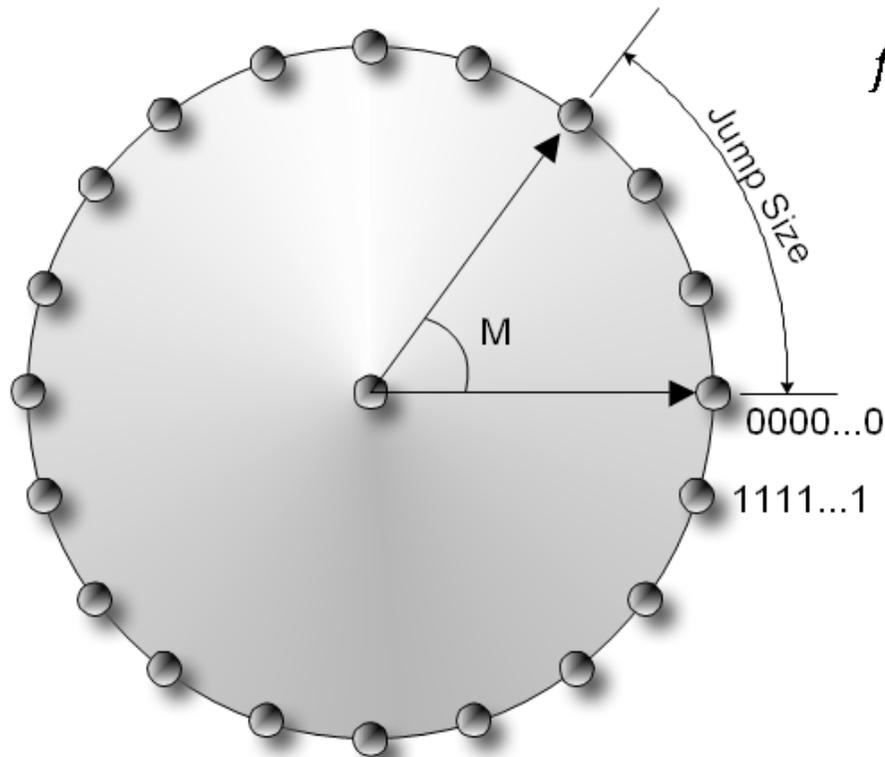
Grundbausteine

# AD9851: DDS-DAC SYNTHESIZER

## Signal flow through the DDS architecture



## Digital Phase Wheel



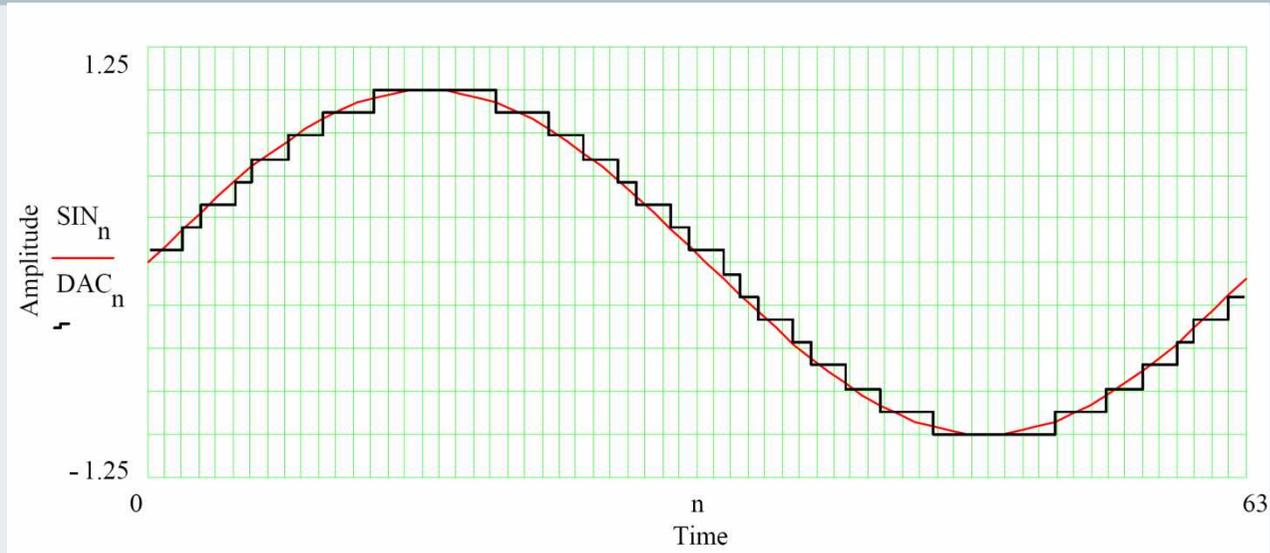
$$f_o = \frac{M \times f_c}{2^N}$$

n	Number of Points
8	256
12	4096
16	65535
20	1048576
24	16777216
28	268435456
32	4294967296
48	281474976710656

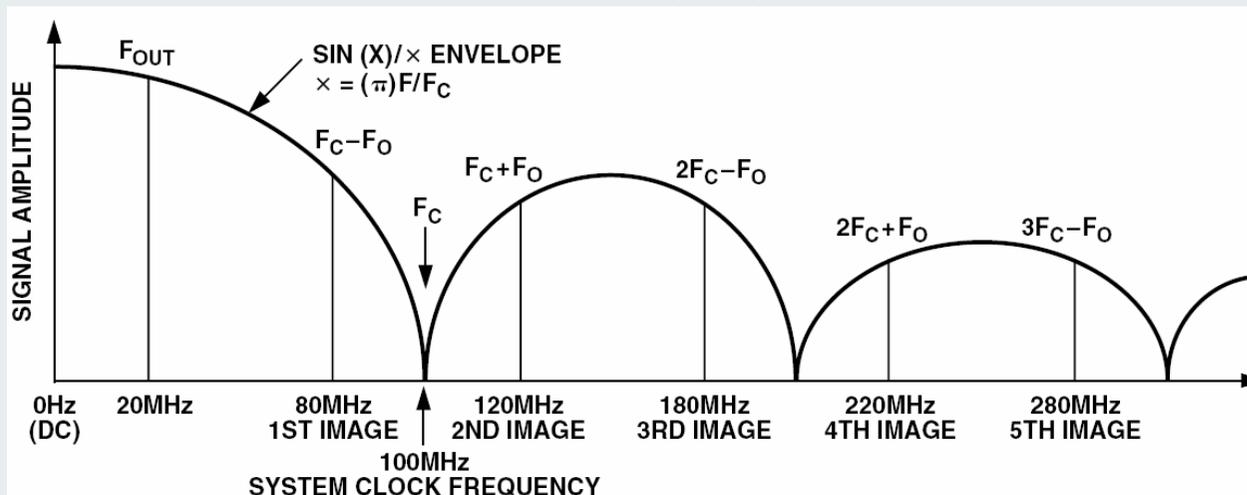
Each designated point on the phase wheel corresponds to the equivalent point on a cycle of a sine waveform. One revolution of the vector around the phase wheel, at a constant speed, results in one complete cycle of the output sinewave.

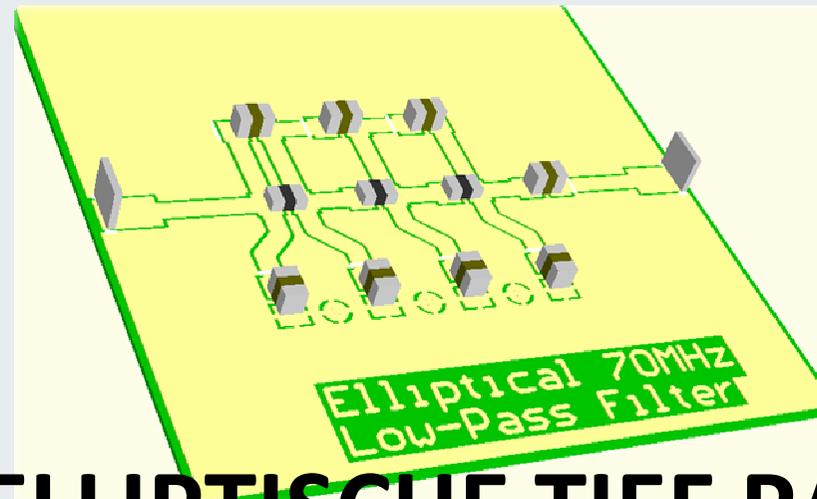


# Effekt der DAC Resolution



## Spektralanalyse des Ausganges



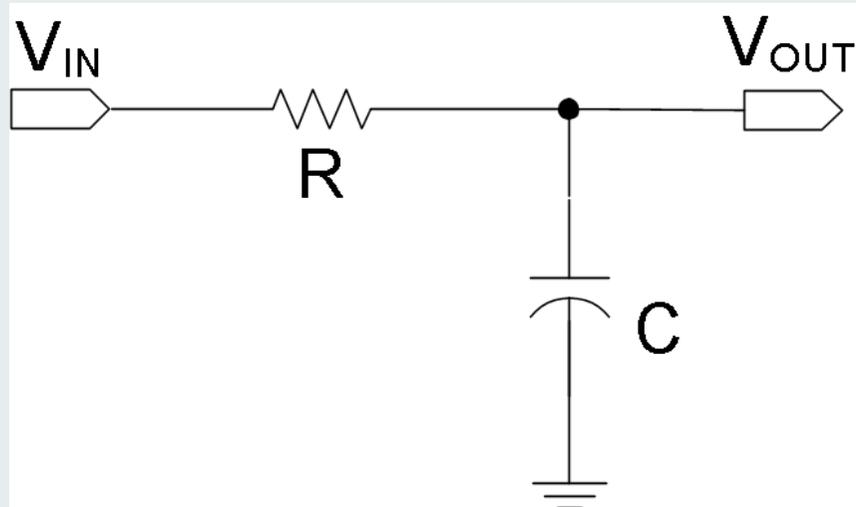


Grundbausteine

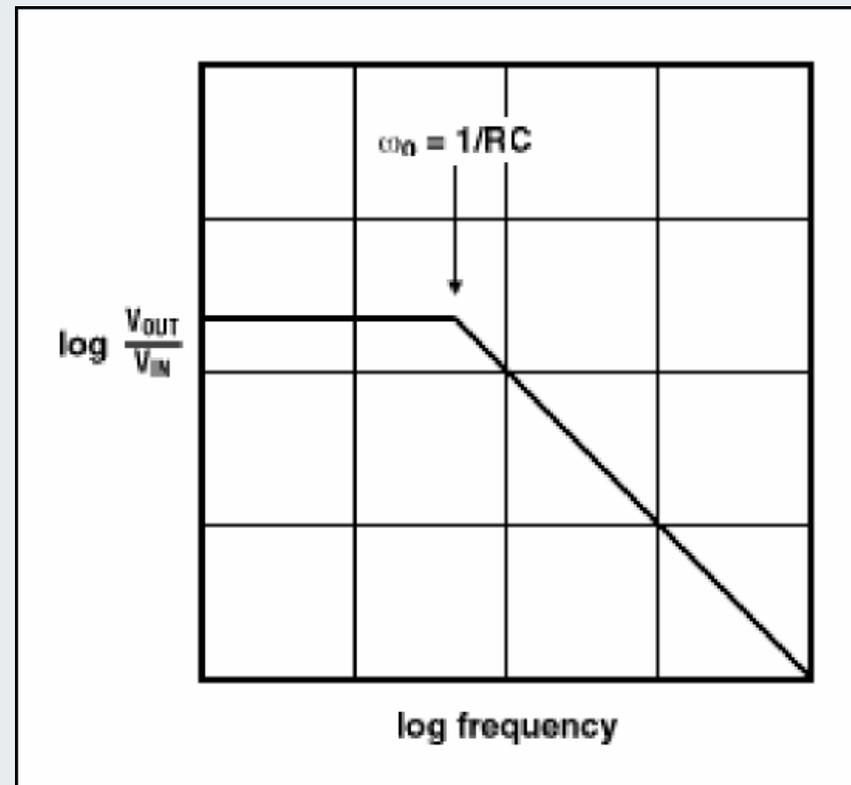
# 70 MHz ELLIPTISCHE TIEF PASS FILTER 7TEN GRAD

# Einfache Tief Pass Filter

## RC-typ Tief Pass



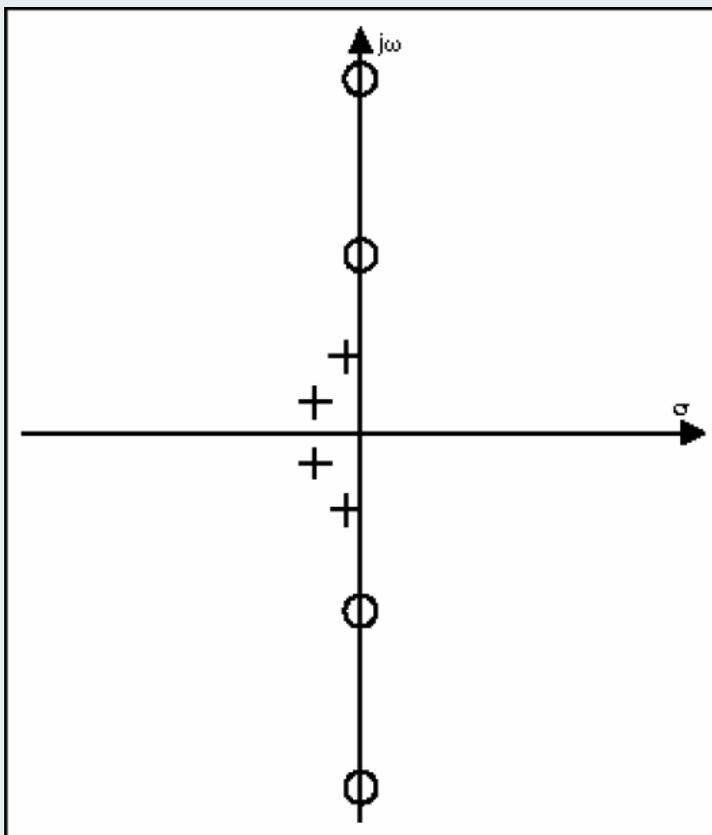
## Bode Plot



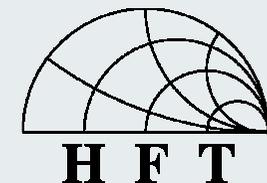
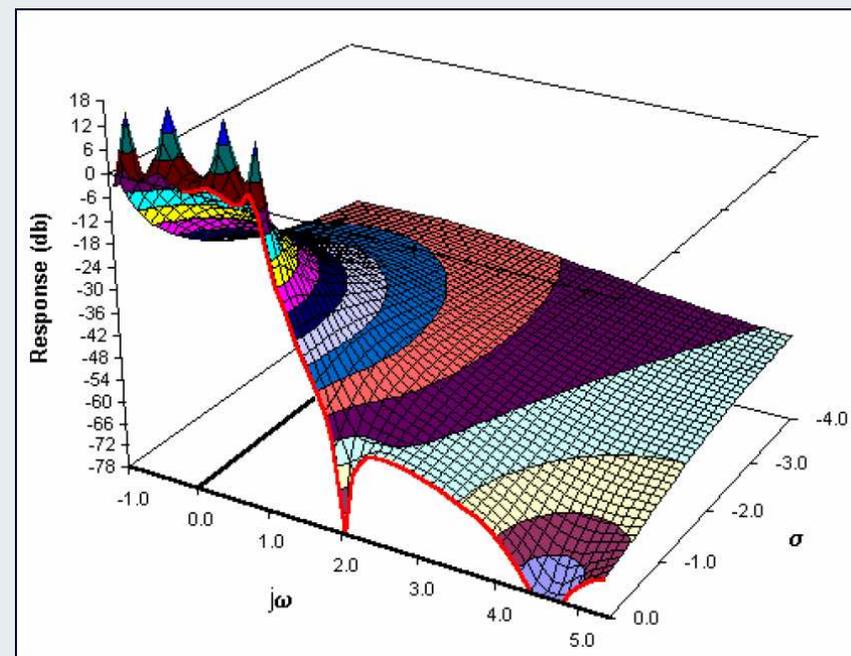
HFT

# Elliptische Tief Pass Filter vierten Grads

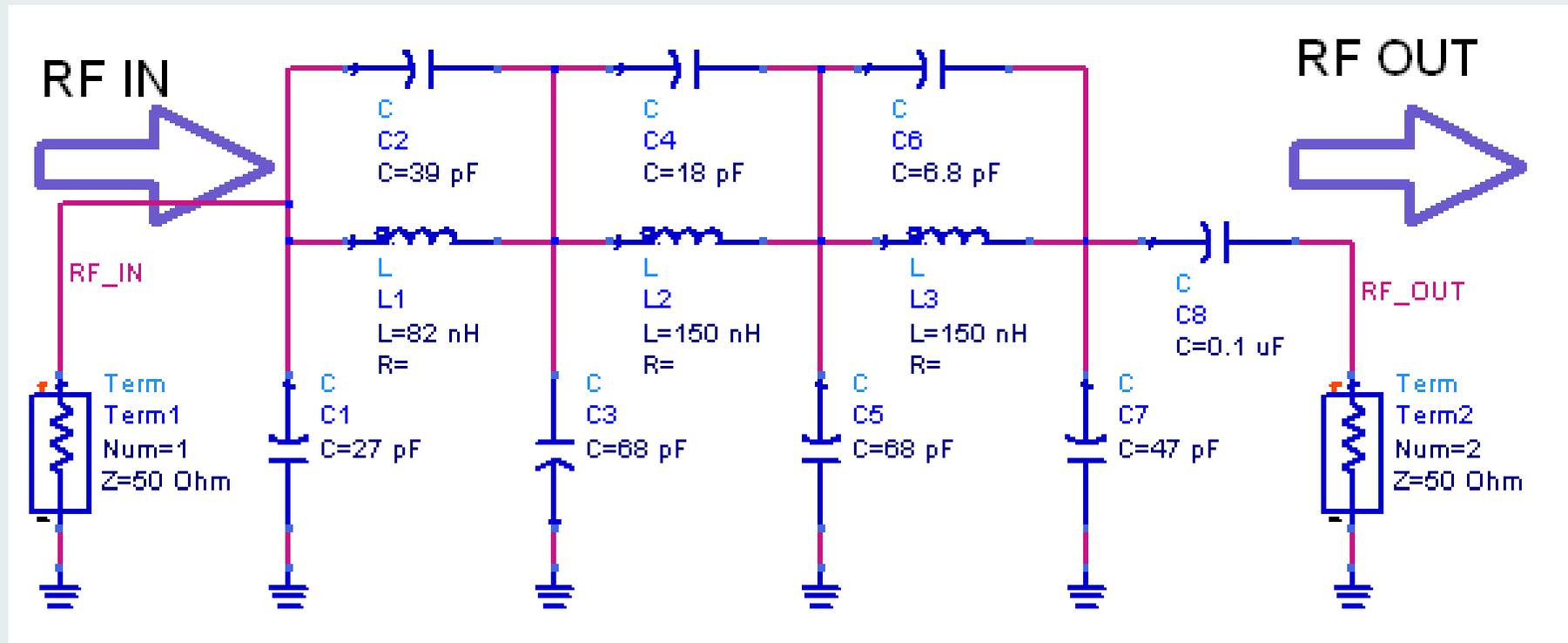
pole-zero diagram



The complex function

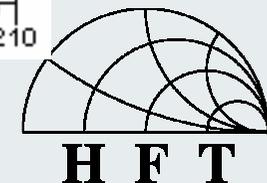
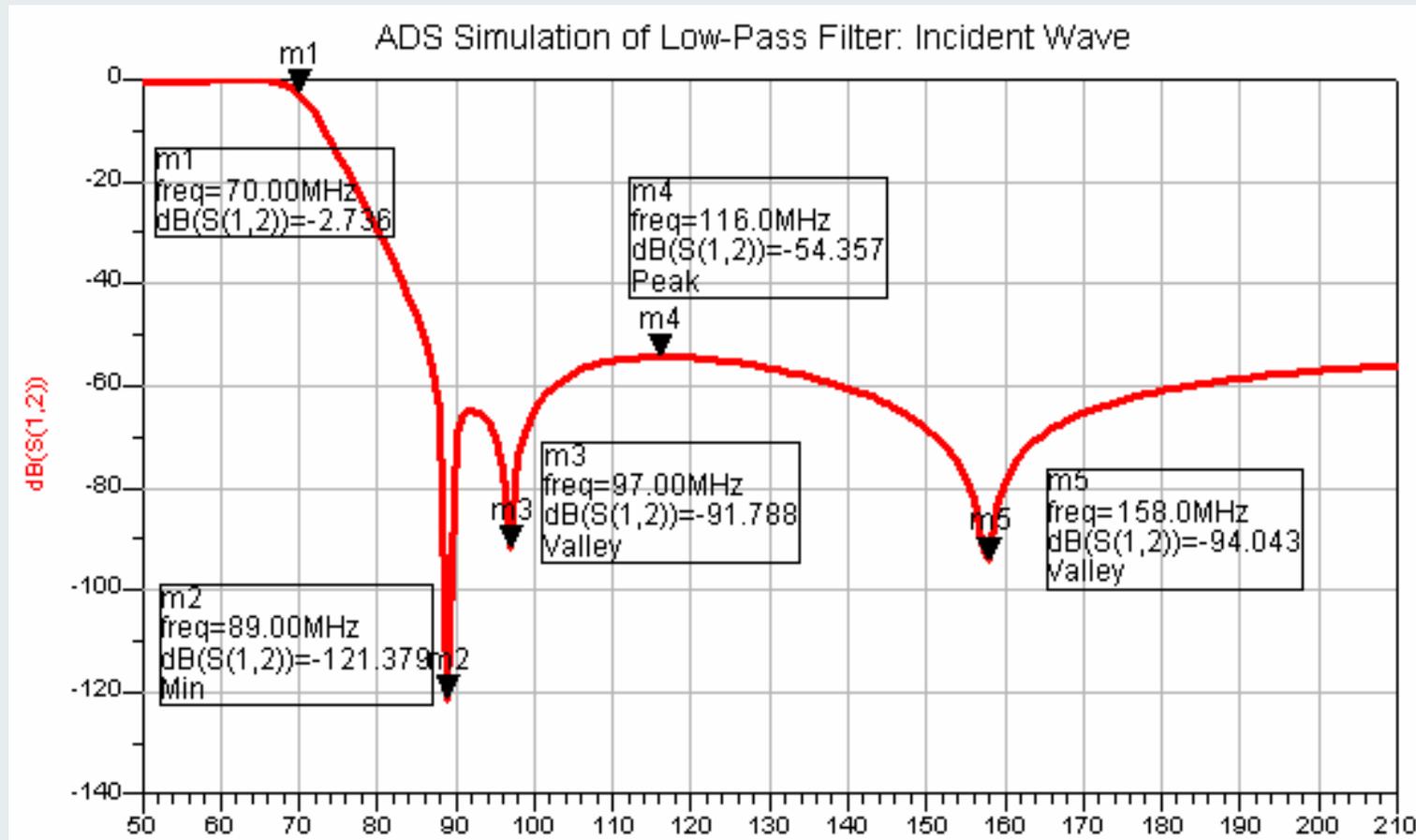


# Elliptische Tief Pass Filter Design in ADS

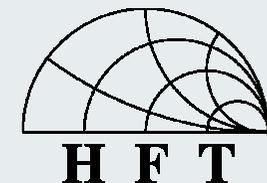
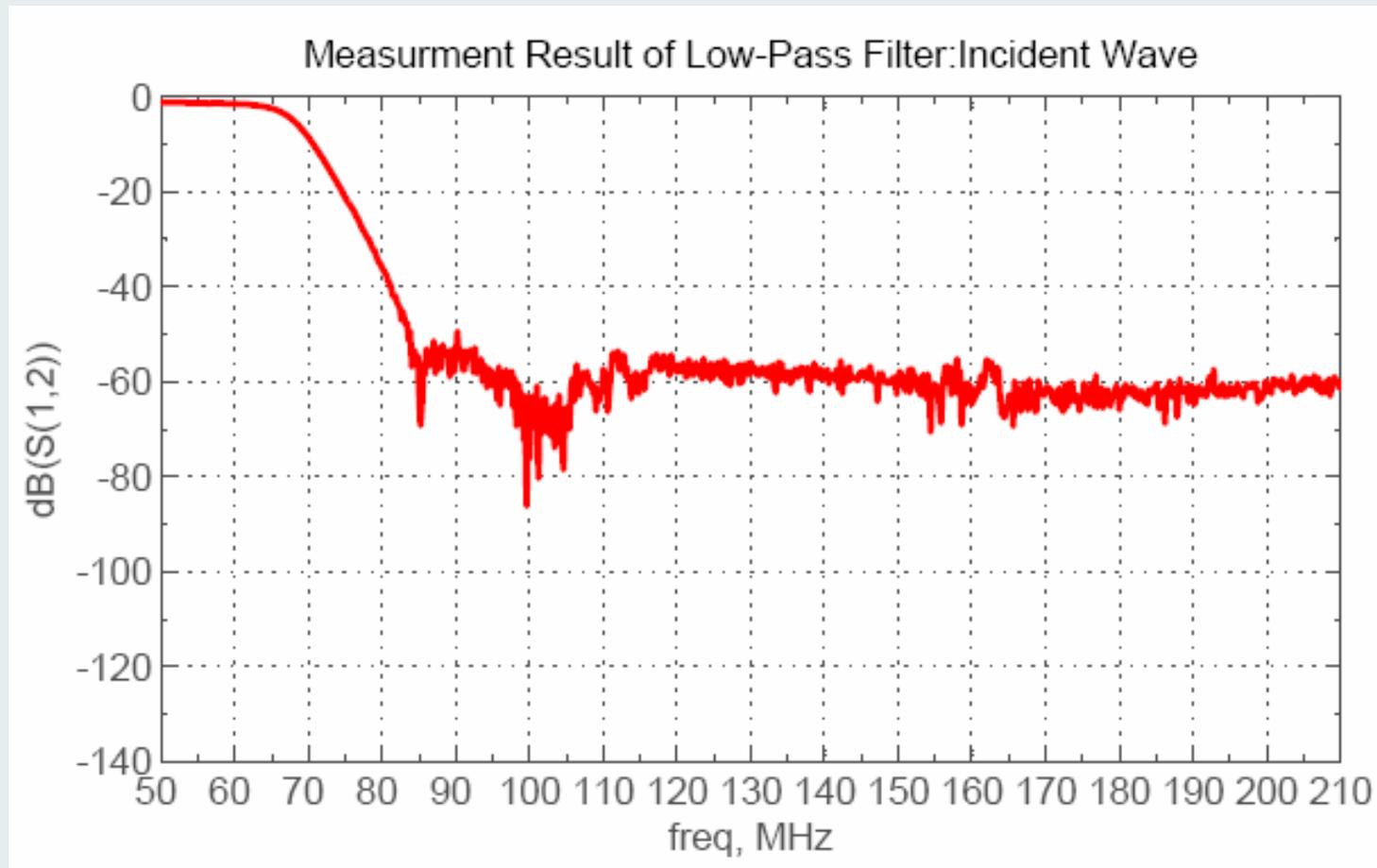


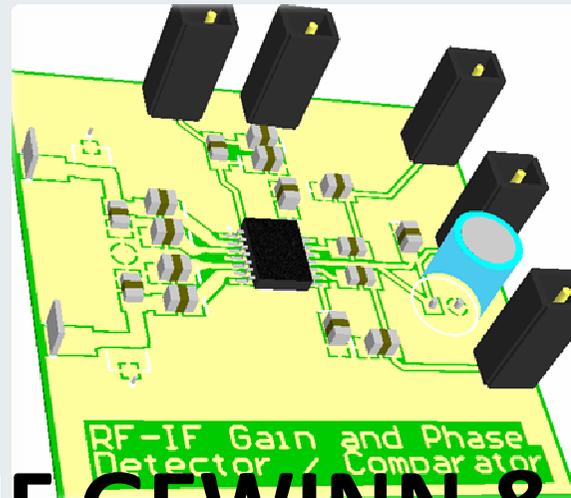
# Vergleichung der Simulationsergebnissen mit Realergebnissen 1

## ADS Simulation des Tiefpaßfilters



# Vergleichung der Simulation mit Realergebnissen 2



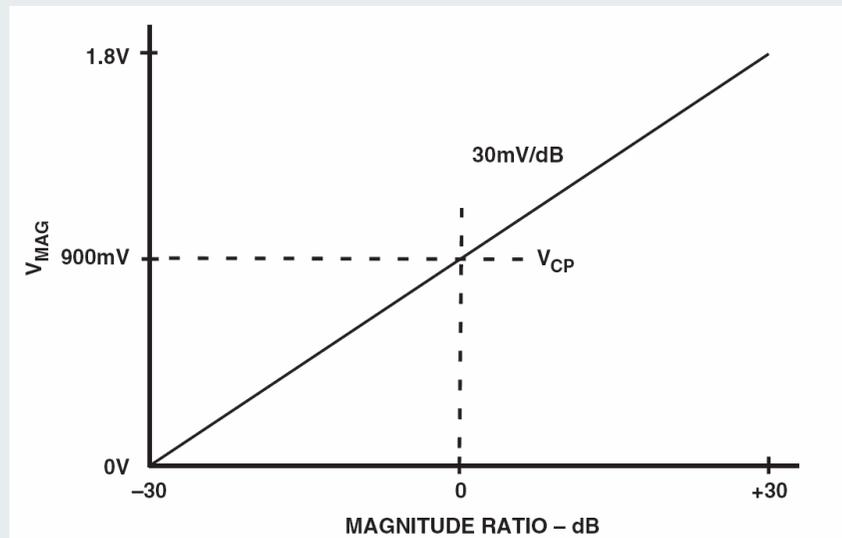


Grundbausteine

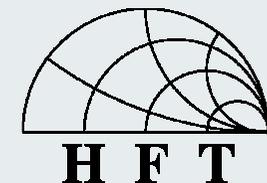
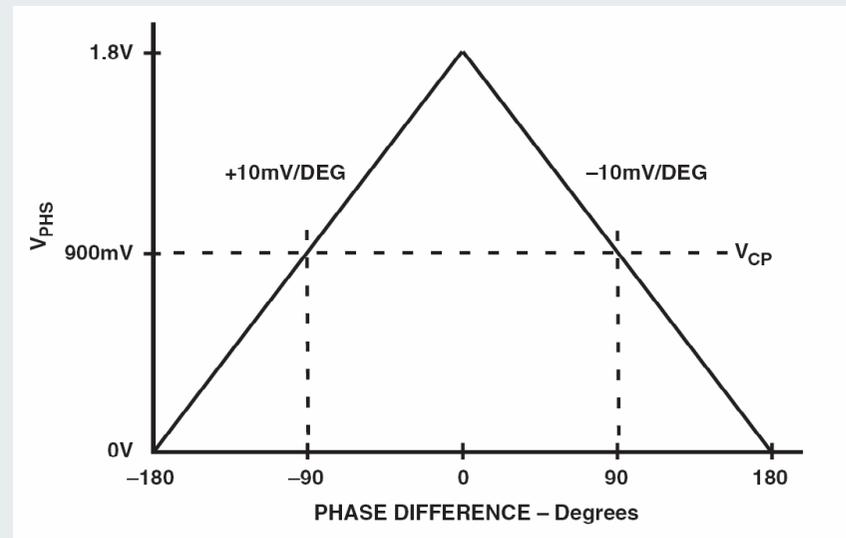
# AD8302: RF, IF GEWINN & PHASE- DETEKTOR/KOMPARATOR

# Messungsskala der RF, IF Gewinn & Phasen-Detektor/Komparator

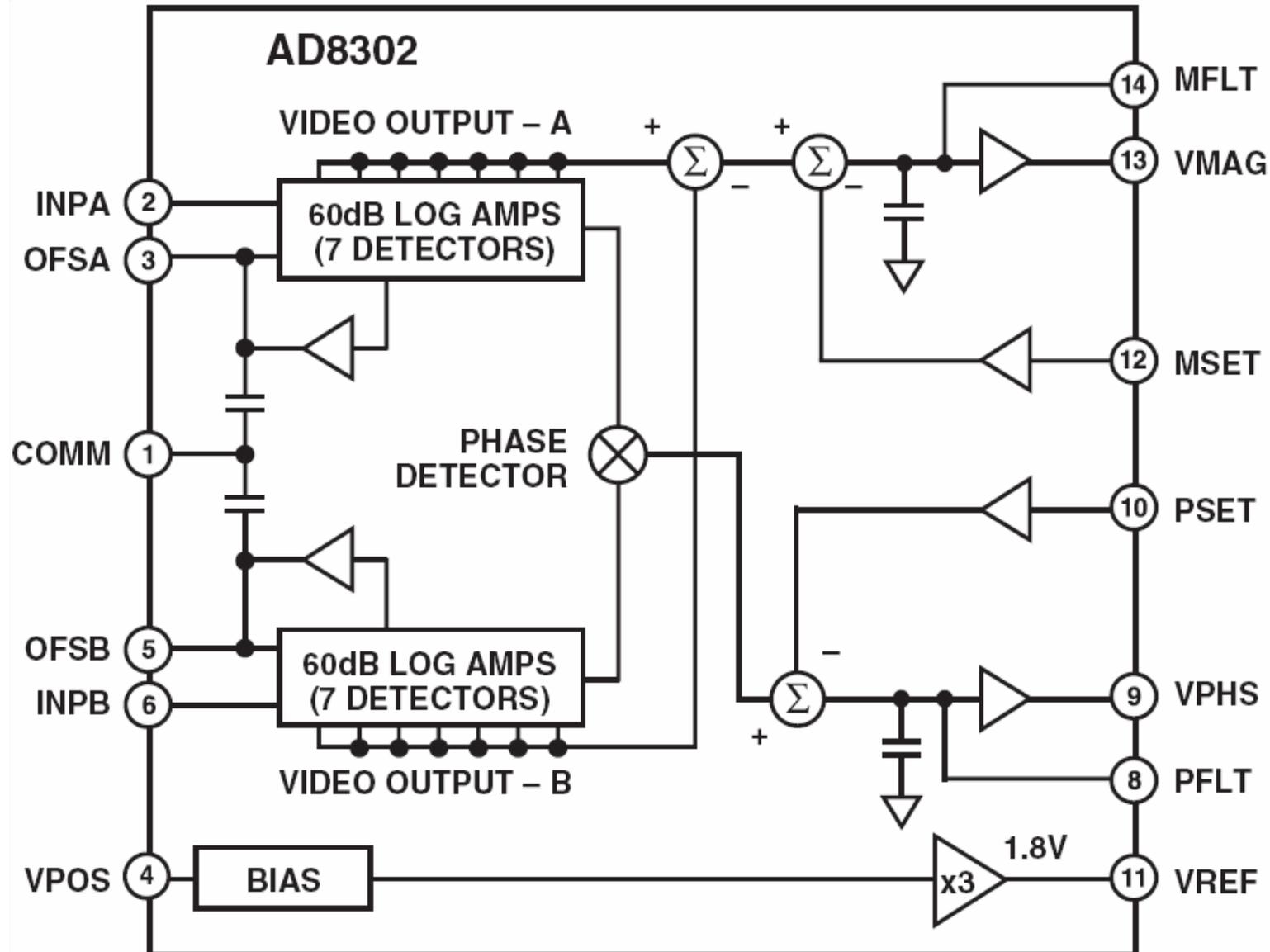
## Amplitudenverhältnis



## Phasendifferenz



# AD8302:Blockdiagramm



# Ein einfaches Logarithmier

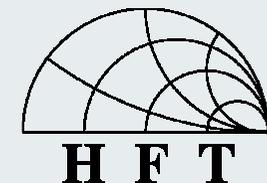
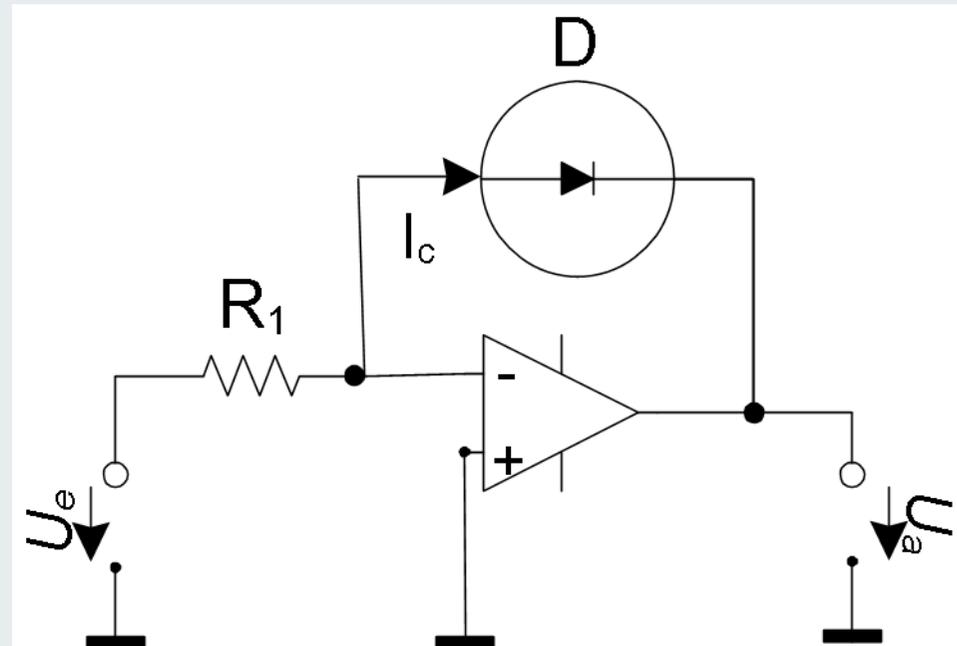
Umformung der Diodengleichung

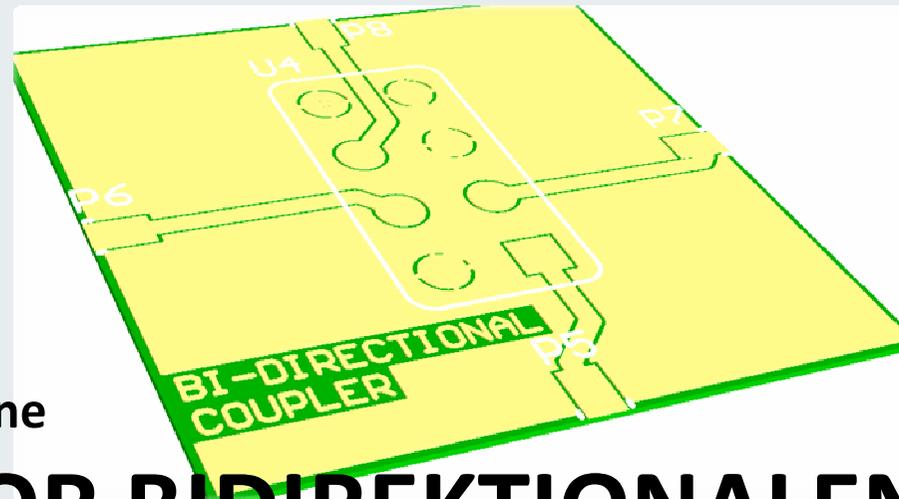
$$I_A = I_S e^{\frac{U_{AK}}{nU_T}}$$

$$U_{AK} = nU_T \ln \frac{I_A}{I_S}$$

$$U_a = -nU_T \ln \frac{U_e}{I_S R_1}$$

Logarithmischer Verstärker  
mit Diode

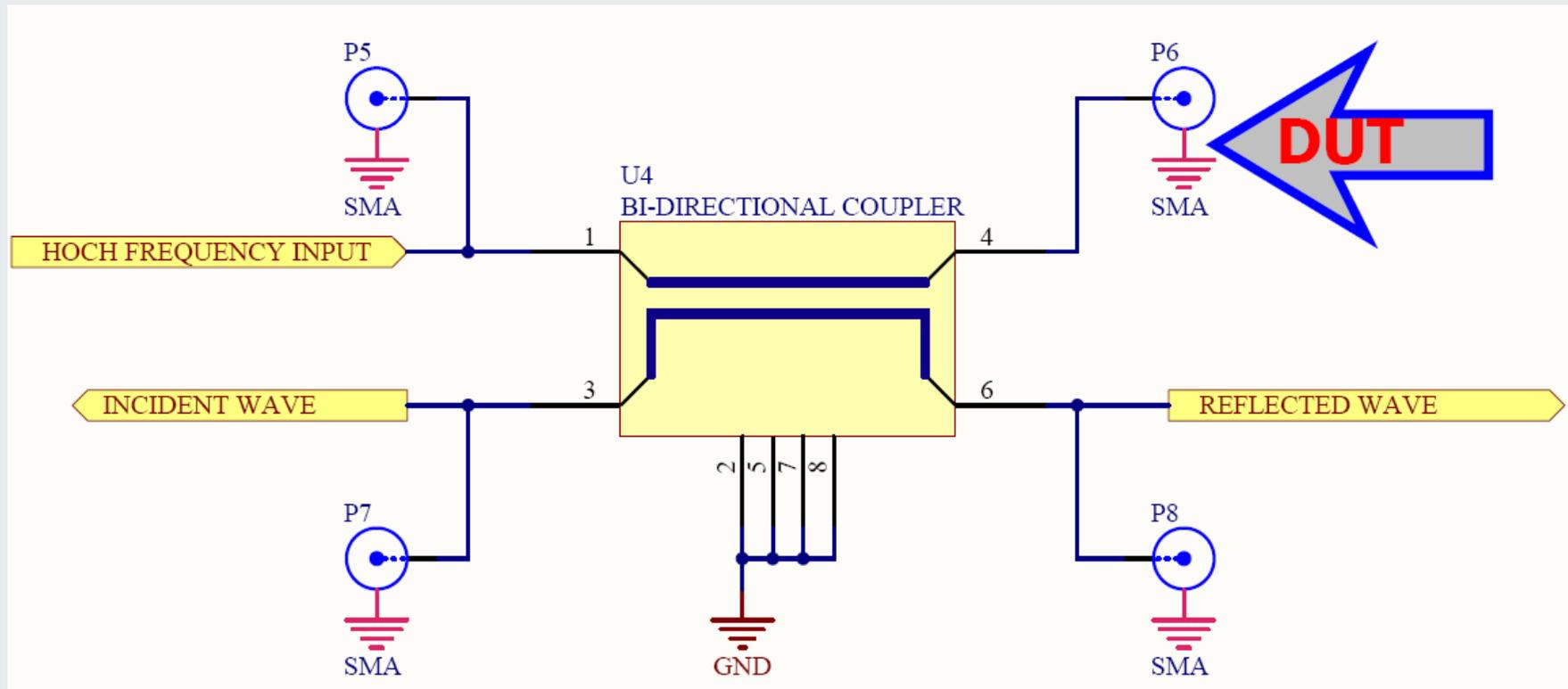


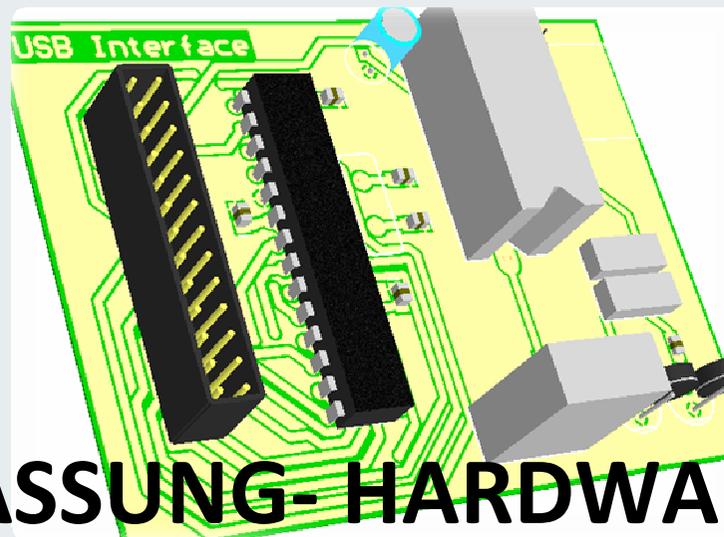


Grundbausteine

# VIER TOR BIDIREKTIONALEN KOPPLER

# Diagramm des bidirektionalen Kopplers





Grundbausteine

# DATENERFASSUNG-HARDWARE: USB MIKROCONTROLLER PIC18F2550

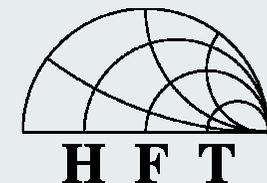
- **Anforderungen**
  - 2 x A/D Konverter mit Referenz Eingänge
  - 4 x digital Ausgänge
  - USB Interface
- **PIC18F2550 Eigenschaften**
  - 10 x A/D Konverter (10bit) mit einstellbare Referenz Eingänge
  - 24 x IO
  - Fullspeed USB 12 Mbit/s



# Softwareentwicklung



- **MATLAB® Code**
- **Grafische Benutzeroberfläche**
- **Kommunikation zwischen Maß-Hardware und Datenerfassungs-Hardware.**
- **Sendung abstimmdes Wort der Frequenz**
- **Interpretieren den Wert vom Messung**





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# Zusammenfassung

- **Koplanar Wellenleiter**
- **Erroneous DDS Synthesizer Design V1**
  - Ersetzt mit einer kommerziellen Signalquelle
  - Neues vermutlich besseres Design V2
- **Low Pass Filter Design**
- **AD8302: RF, IF Gewinn & Phasen-Detektor/Komparator**
- **Bi-Direktionale Koppler**
- **Datenerfassung - Hardware**
- **SLO Kalibrierung mit Mathcad®**

