Generierung des Eingangssingals für Barrier Bucket RF Systeme and der GSI

TECHNISCHE UNIVERSITÄT DARMSTADT

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Projektseminar Beschleunigertechnik

Outline

Problemstellung

- Barrier-Bucket System
- Ziel

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- Barrier-Bucket System :
  - Longitudinale Manipulation der Bunches
- Ziel

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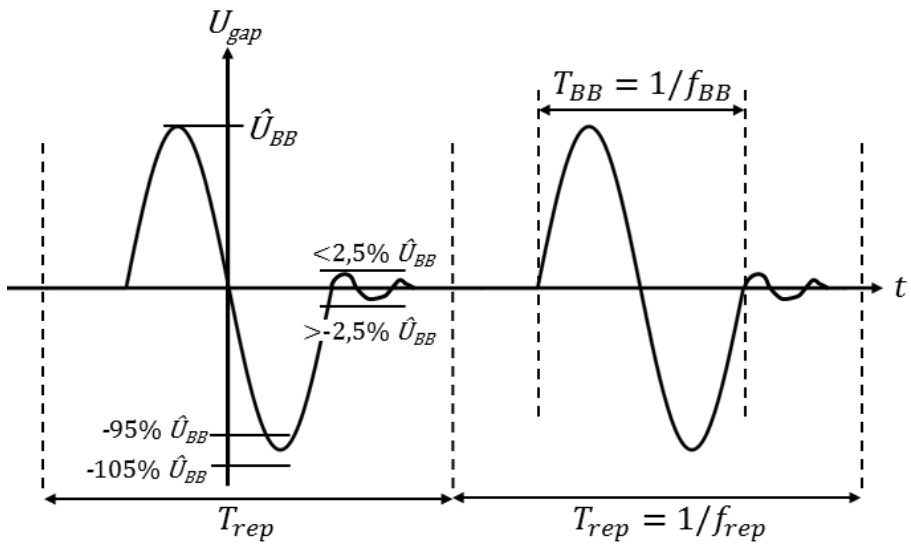
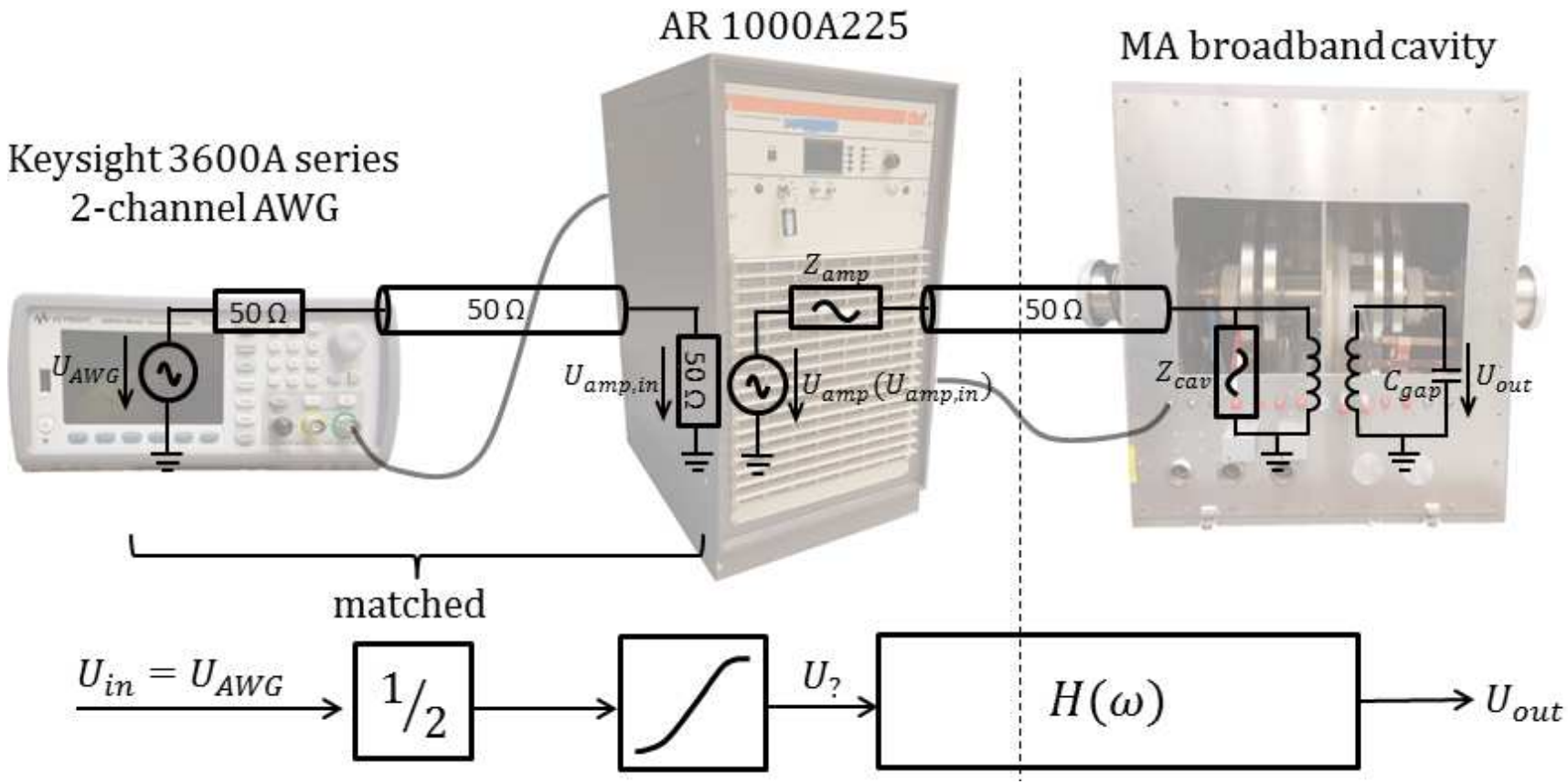
- Barrier-Bucket System :
  - Longitudinale Manipulation der Bunches
- Ziel :
  - Gap Spannung in Form einer Ein-Sinus Periode
  - Qualität das Signals



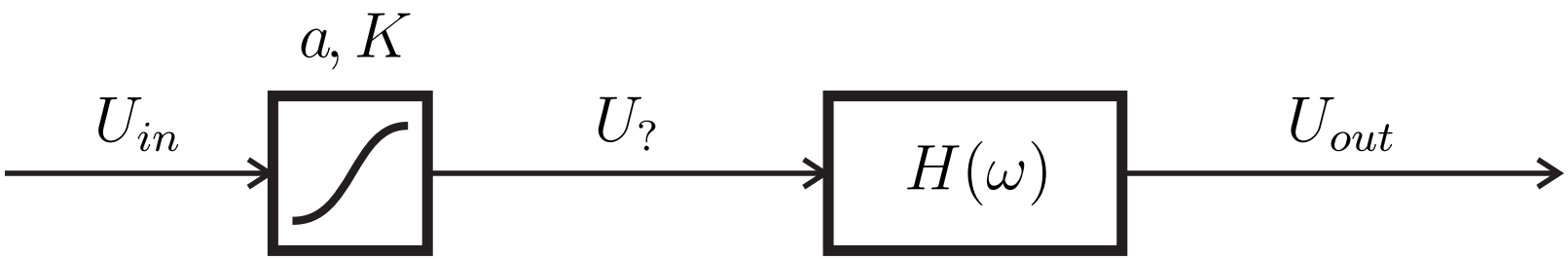
Aufbau und Modell



Aufbau und Modell

- Hammerstein Modell

- Zielsetzung



Aufbau und Modell

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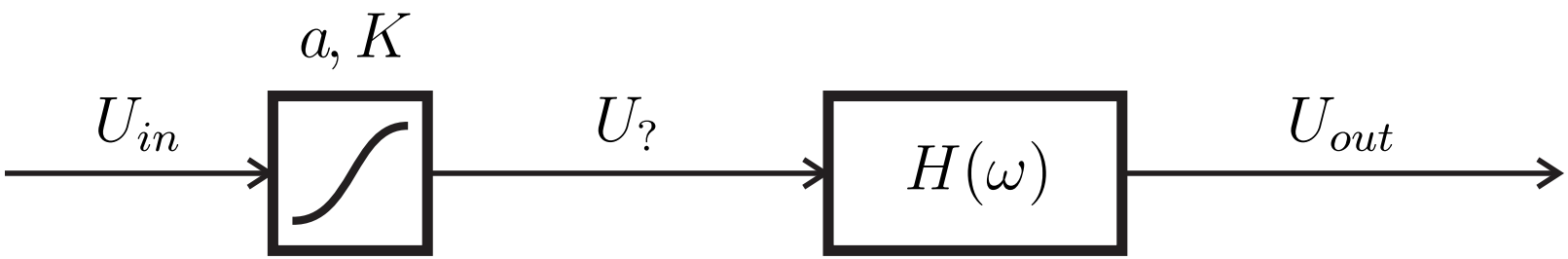
  - System ist linear bis $\hat{U}_{BB} \approx 550\,V$
  - Ergänzung um eine nichtlineare Vorverzerrung
  - Potenzreihenansatz $U_?(t) = \sum_{n=1}^{N} a_n \left[U_{in}(t)\right]^n$
- Zielsetzung



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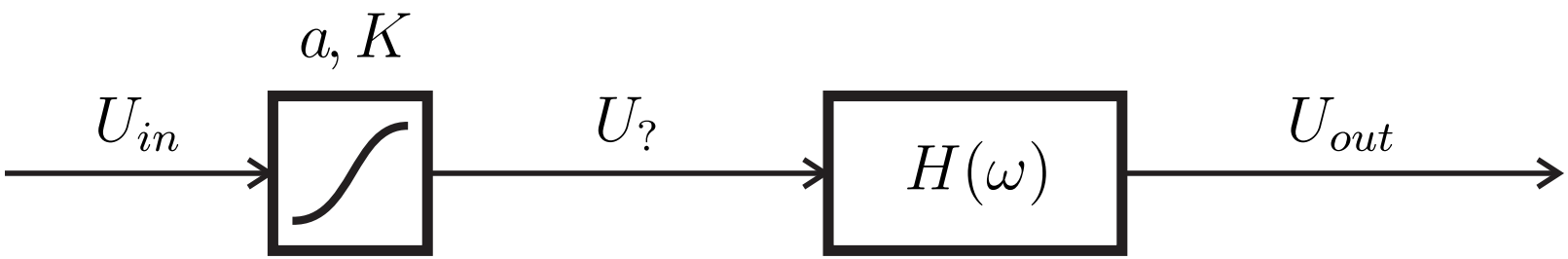

Dokumentation und Gerätekommunikation

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  - Bedienung des Programms
  - Ausführliches Kommentieren der Code-Funktionalität
- Gerätekommunikation

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- Gerätekommunikation :
  - Treiber und Programmer-Manuals zur Nutzung des Programms von anderen Geräten aus
  - Laufzeitoptimierung durch Abfrage von Gerätezuständen mittels VISA
  - Verbesserung der Auflösung des Signals durch Anpassung der Darstellung des Oszilloskops mittels VISA

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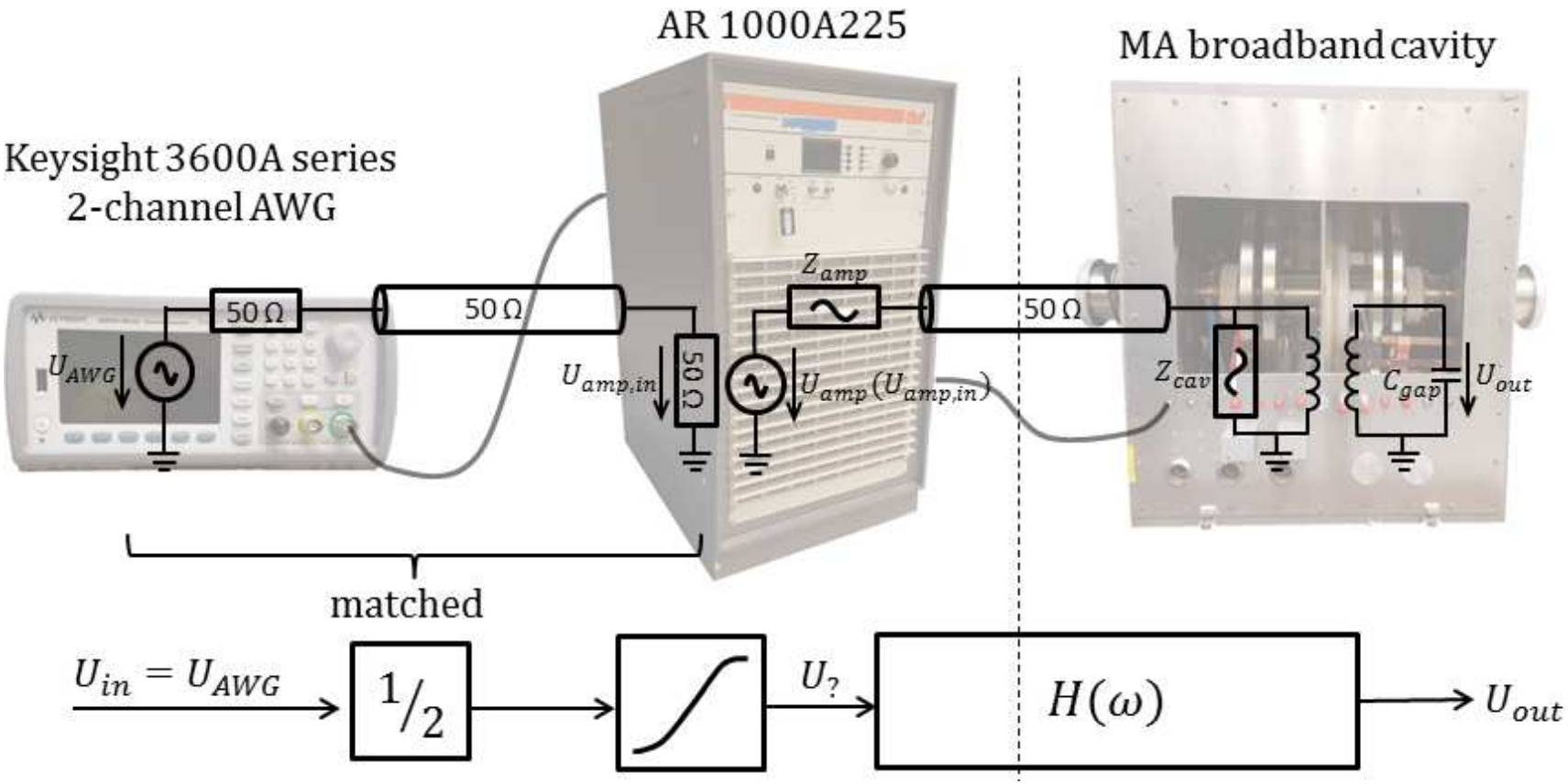
  - Kommunikation mit Oszilloskop von anderem Laptop
  - Laufzeit: Status-Abfrage der Geräte mit `BUSY?` oder `*WAI`
  - Anpassung der Auflösung des DSO

Code: Das Design



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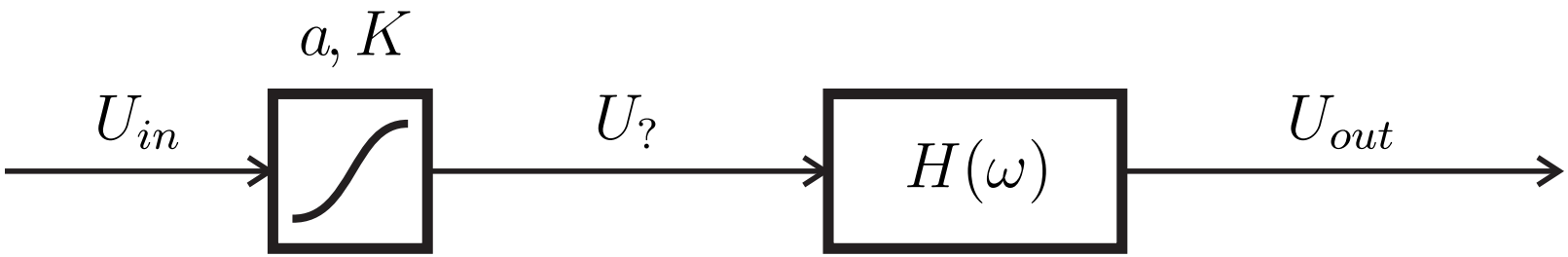

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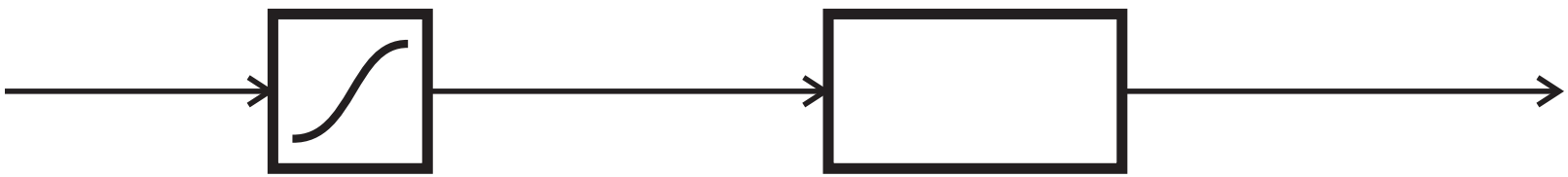

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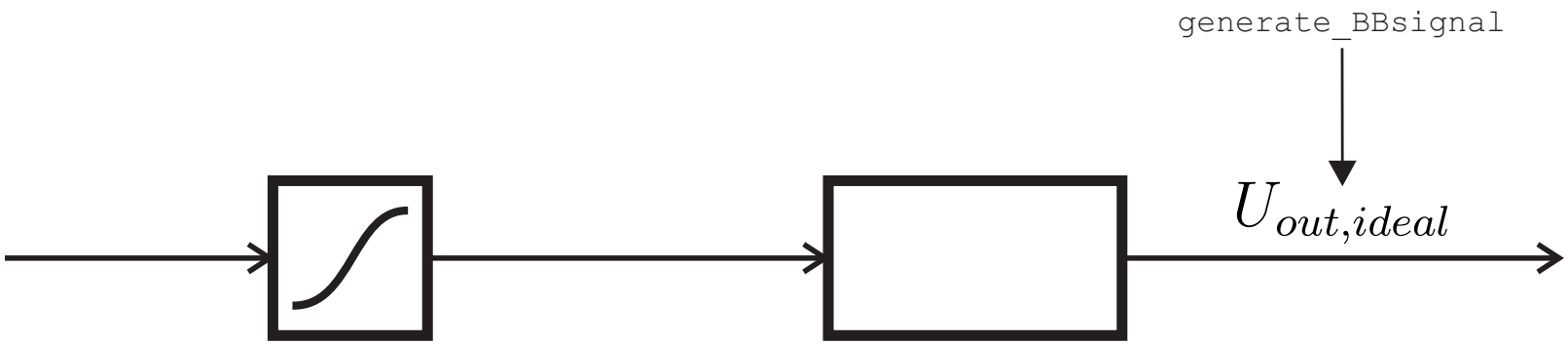


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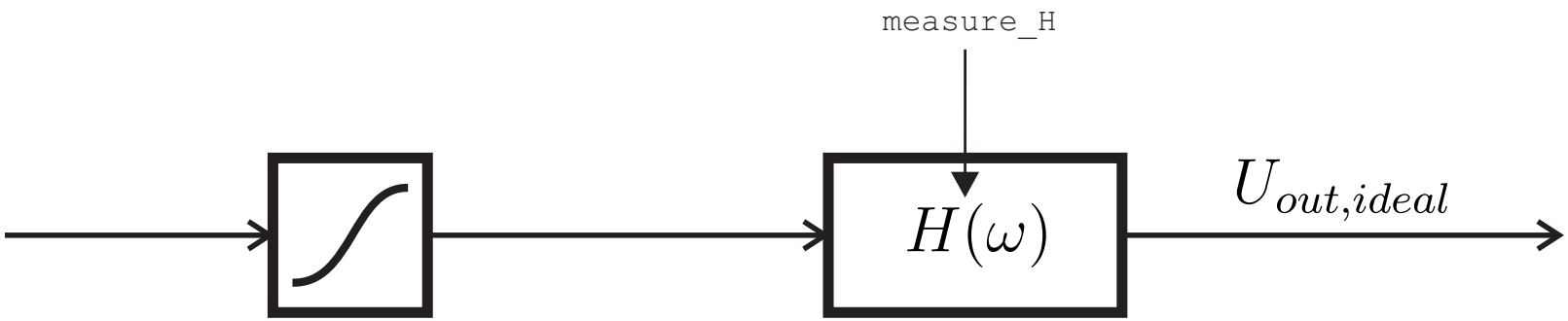


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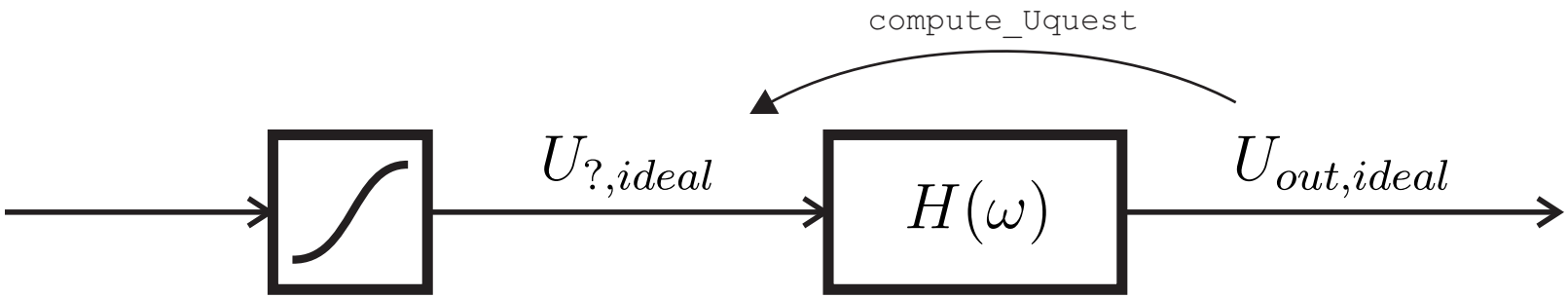


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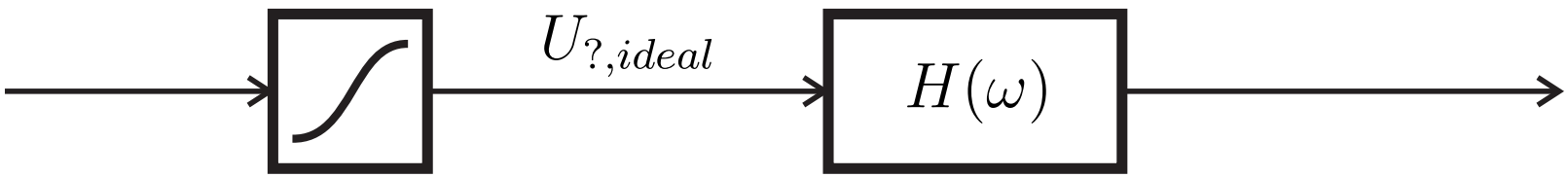


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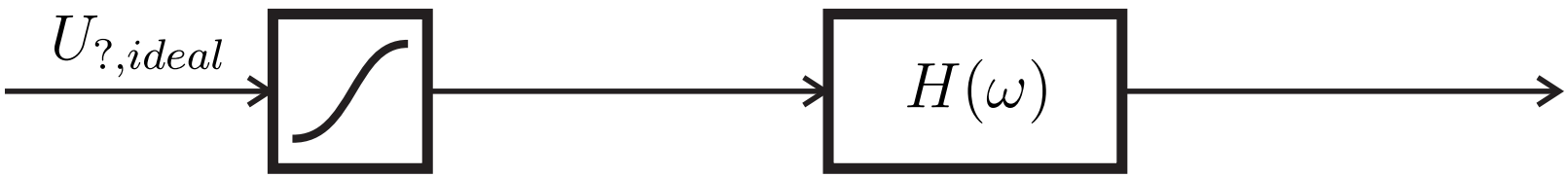


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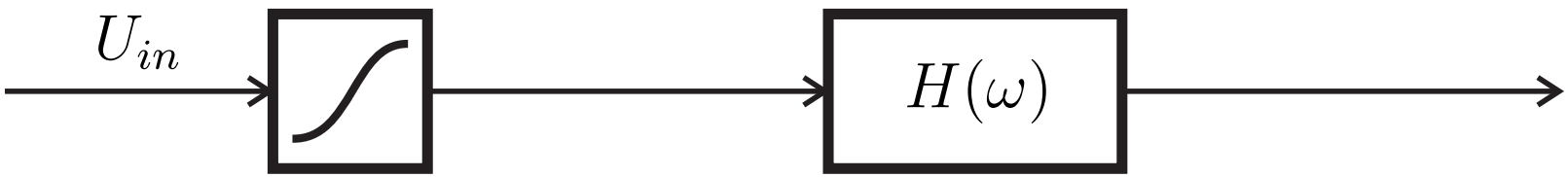


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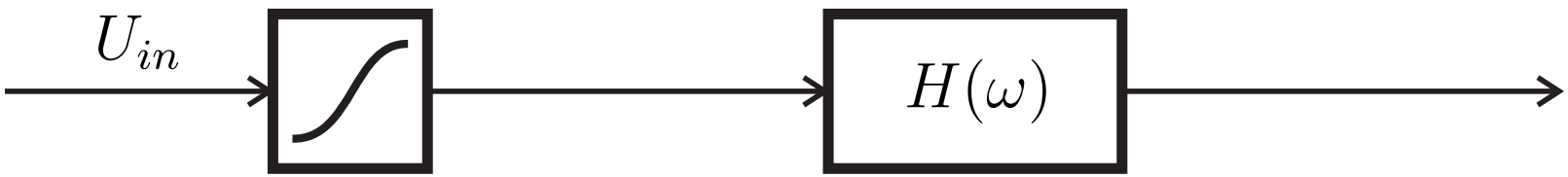


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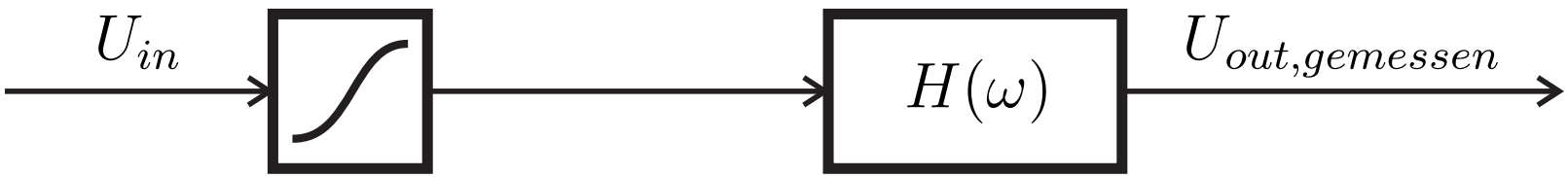


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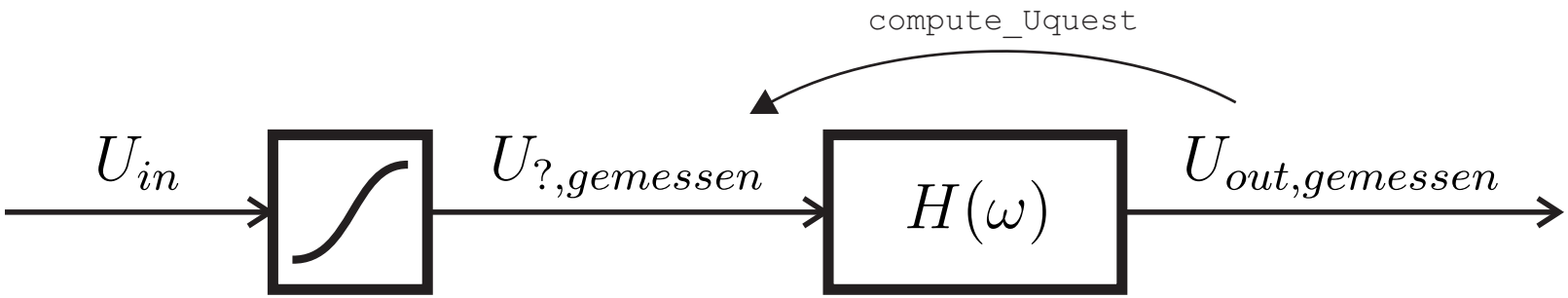


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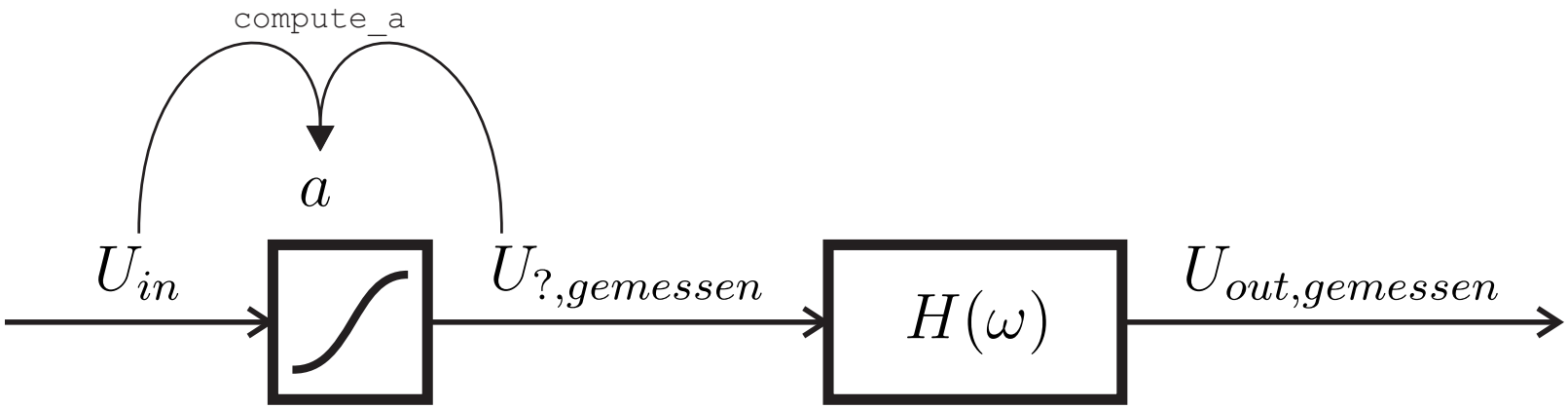


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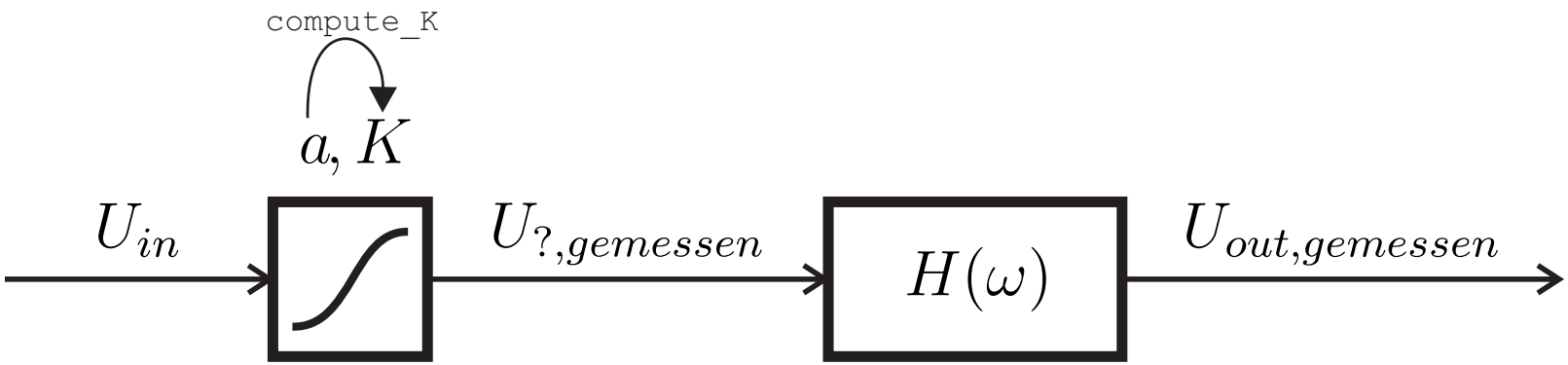


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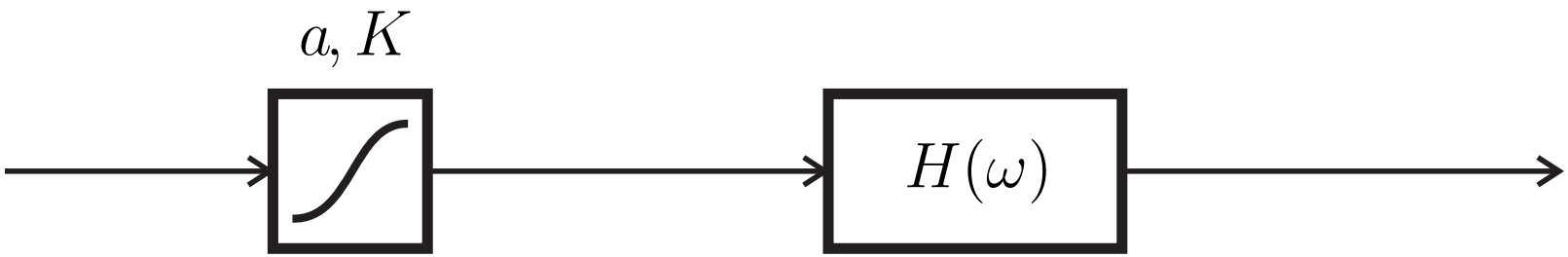


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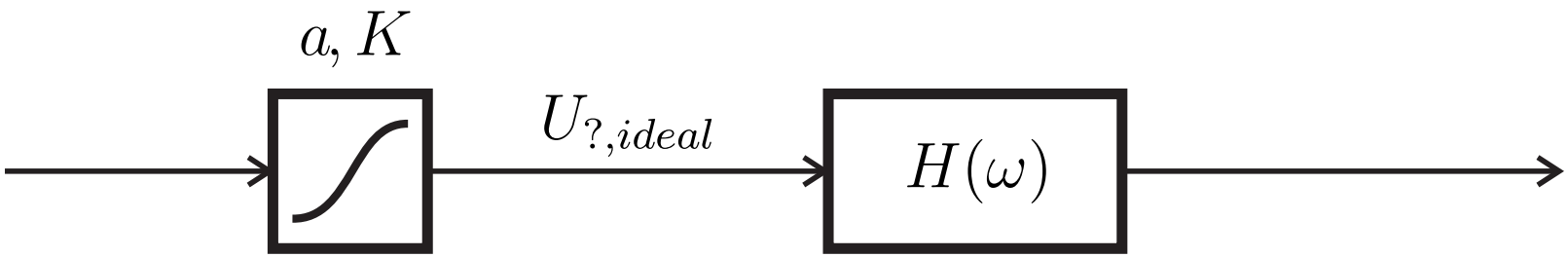


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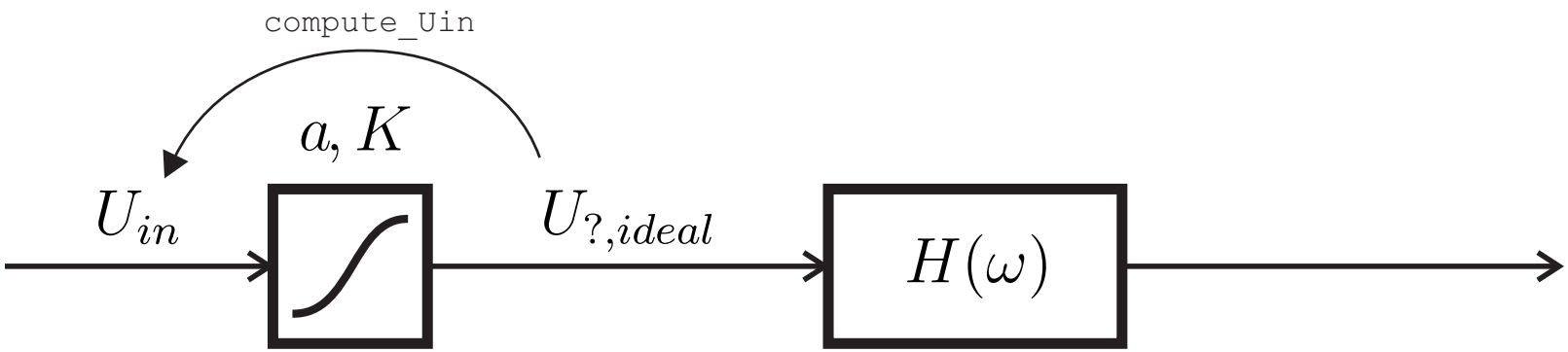


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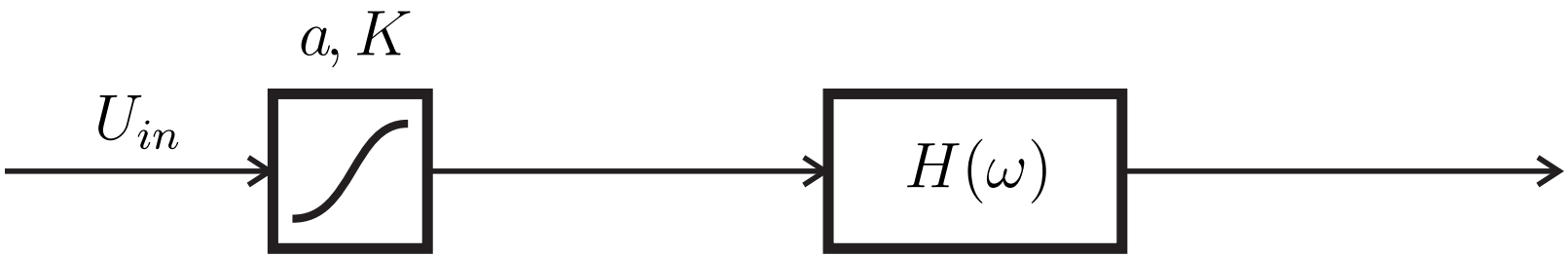


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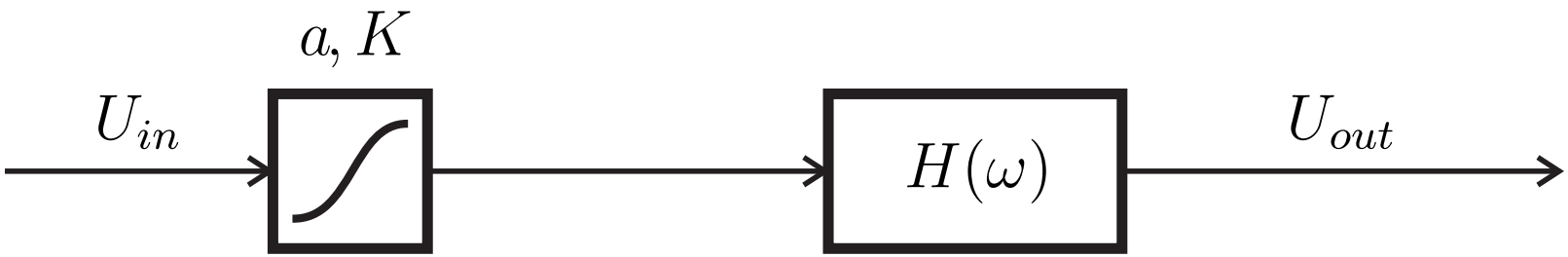


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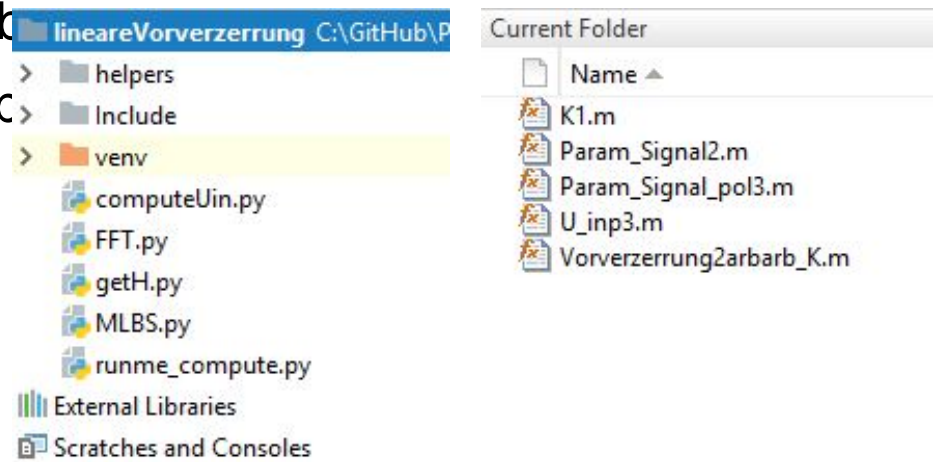

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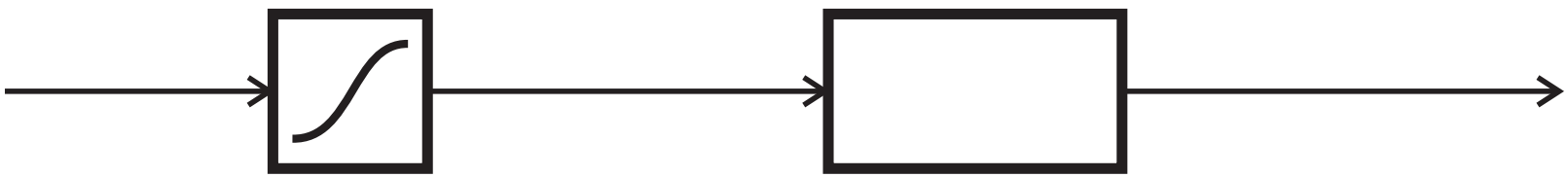
- Maximale Vorbereitung der Funktionen ohne Messaufbau dank **TDD**
  - Nur zum Testen von `measure_Uout` sind Geräte notwendig

Code: Evaluierung



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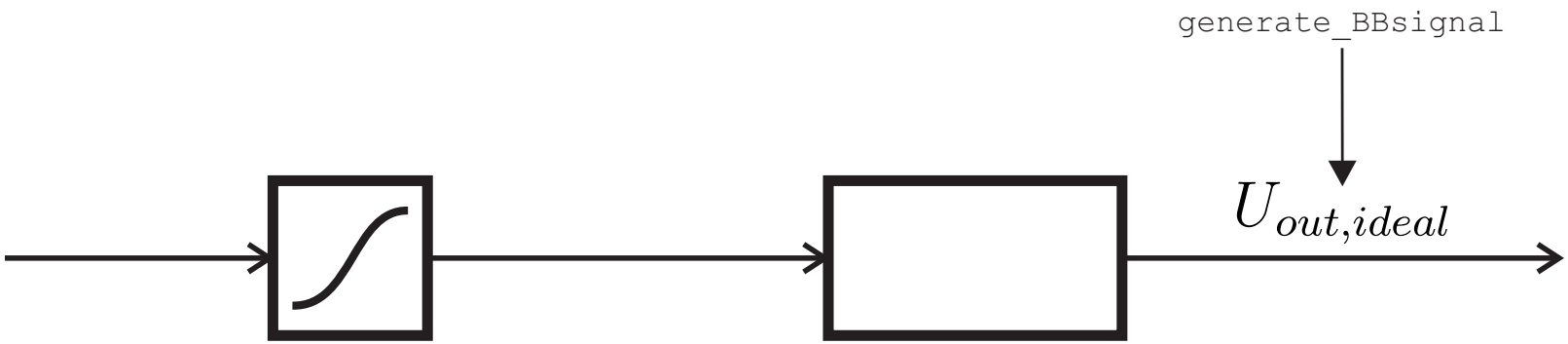


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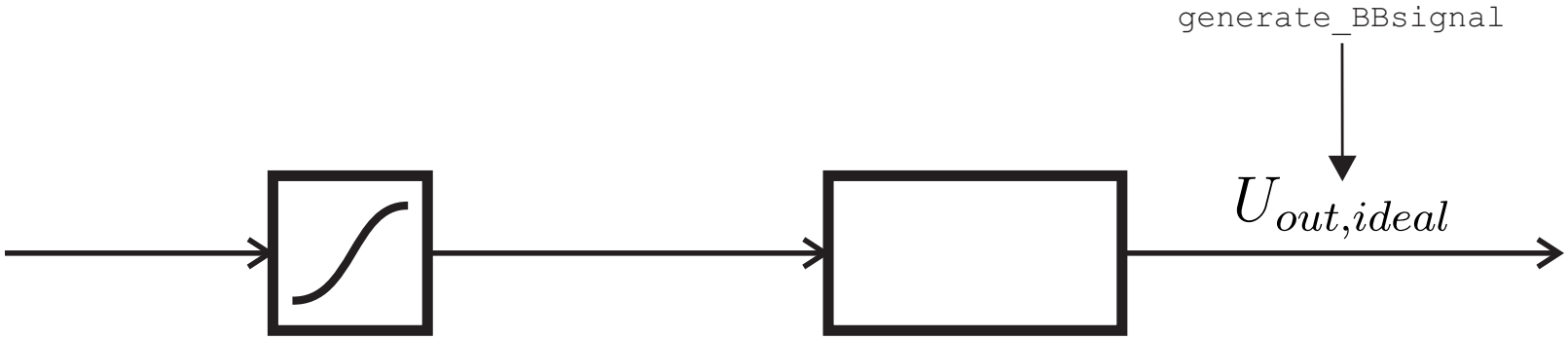


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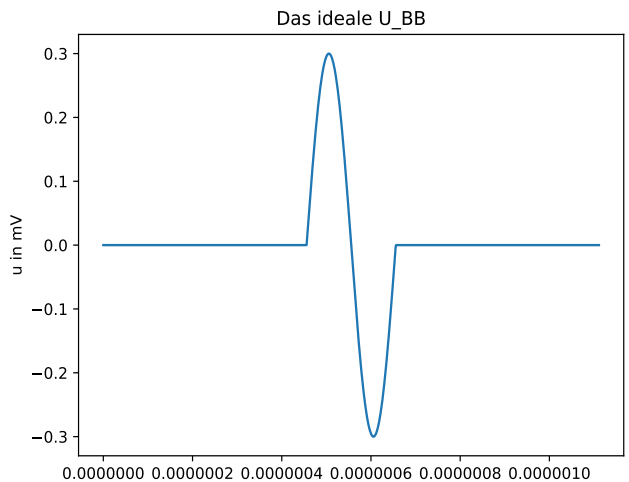
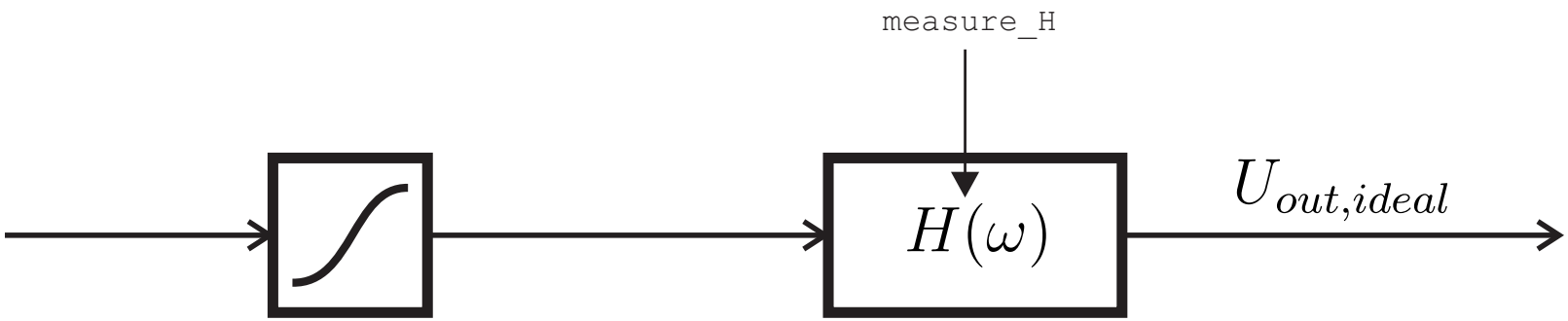
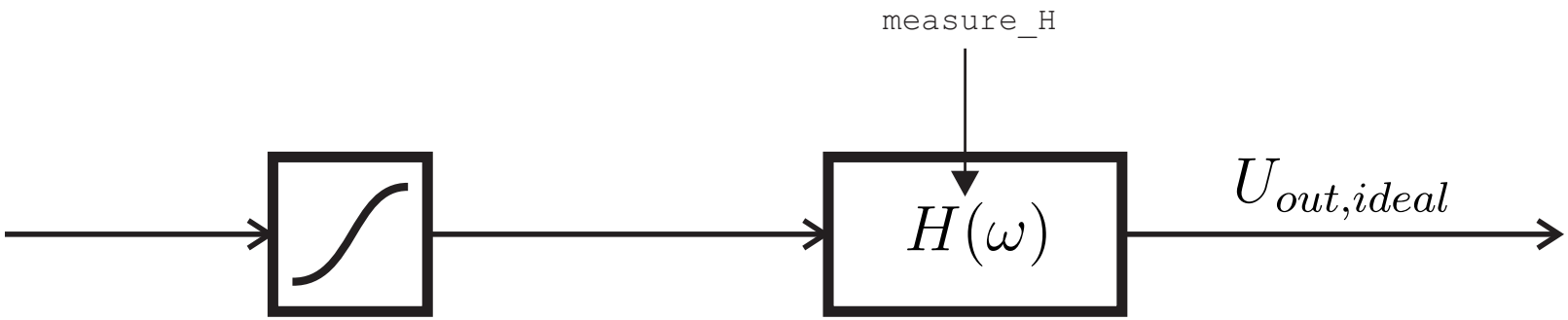


Code: Evaluierung

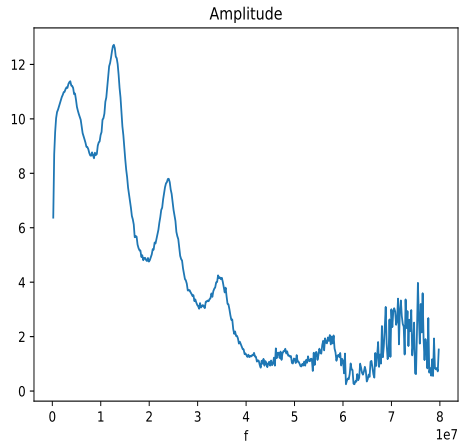


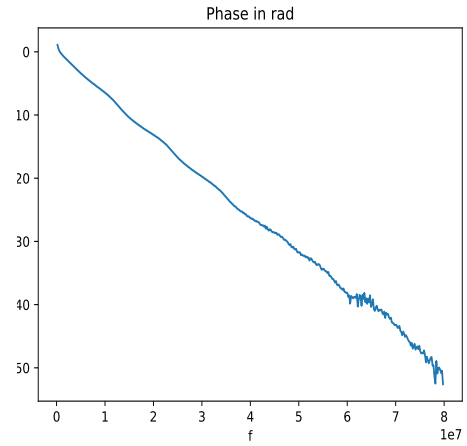

```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
2 H = measure_H ( )
```

Code: Evaluierung

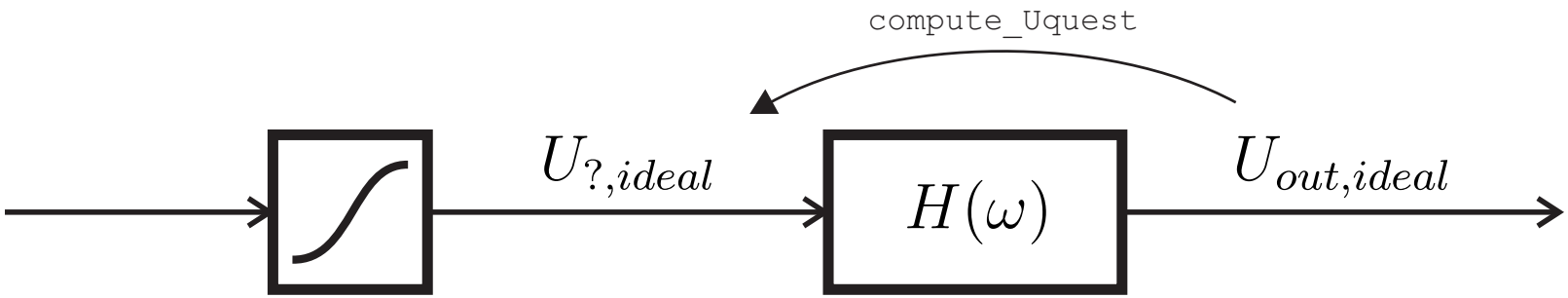



```
1 Uout_ideal = generate_BBsignal ( fq_rep ,
2 H = measure_H ( )
```



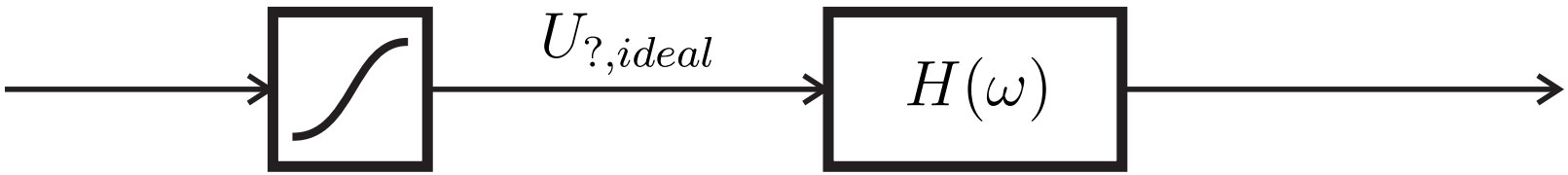


Code: Evaluierung




```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
2 H = measure_H ( )
3 Uquest_ideal = compute_Uquest ( Uout_ideal, H )
```

Code: Evaluierung

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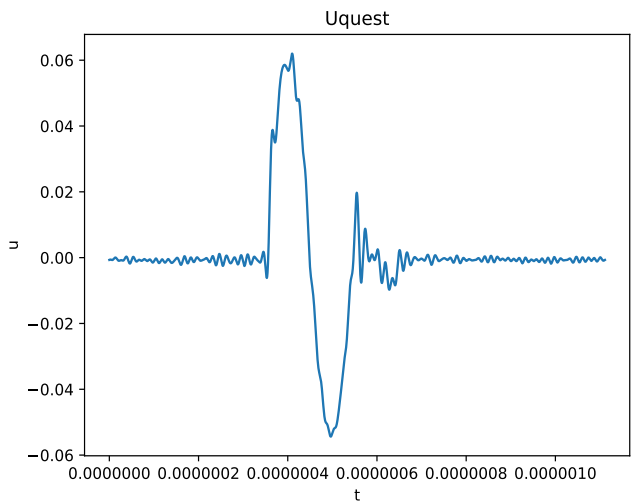
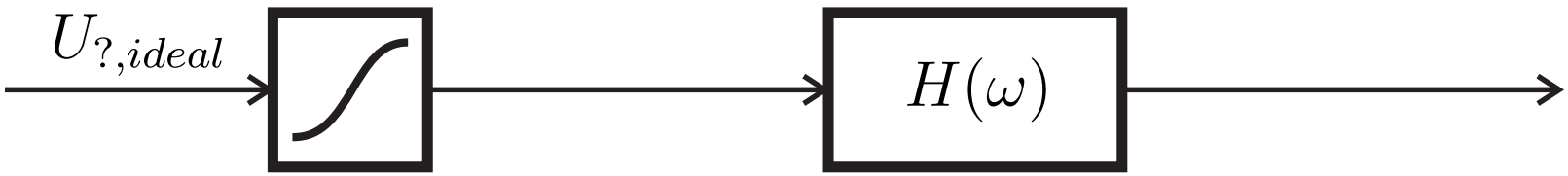


Code: Evaluierung

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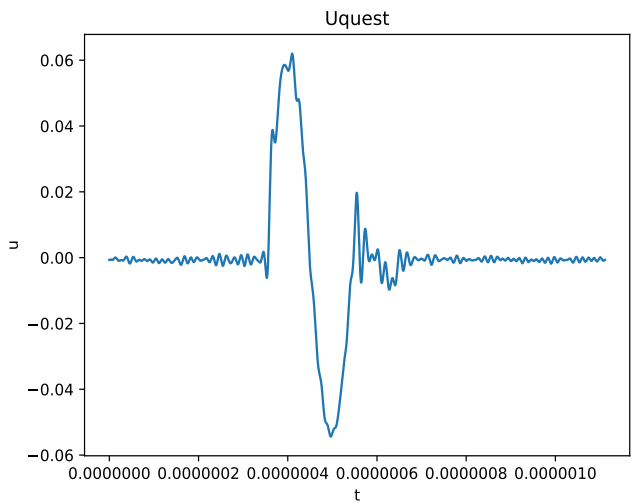
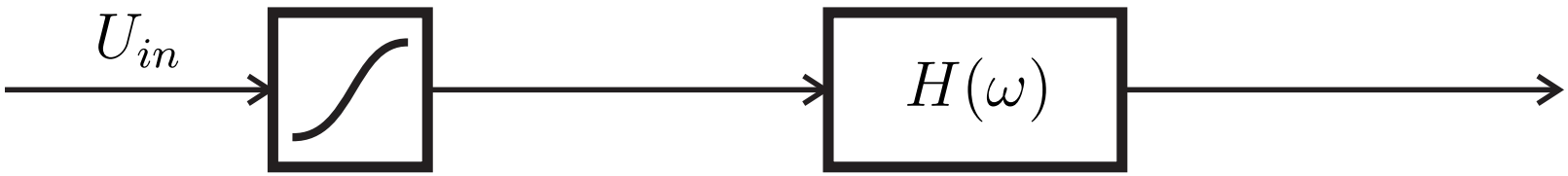
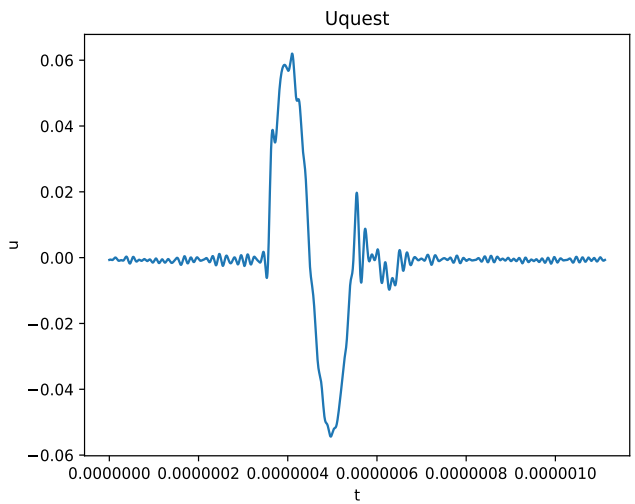


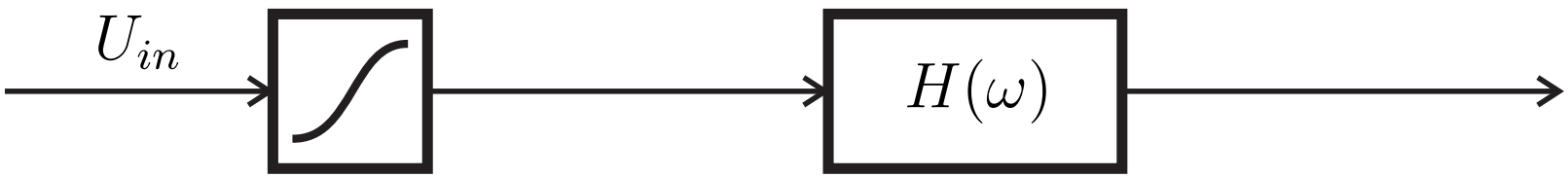
Code: Evaluierung




```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
2 H = measure_H ( )
3 Uquest_ideal = compute_Uquest ( Uout_ideal, H )
4 Uin = Uquest_ideal
```

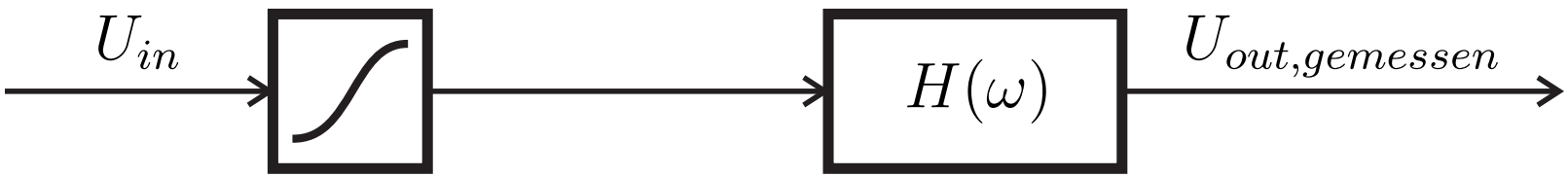


Code: Evaluierung




```
Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
H = measure_H ( )
Uquest_ideal = compute_Uquest ( Uout_ideal, H )
Uin = Uquest_ideal
Uout_measured = measure_Uout ( Uin )
```

Code: Evaluierung




```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
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4 Uin = Uquest_ideal
5 Uout_measured = measure_Uout ( Uin )
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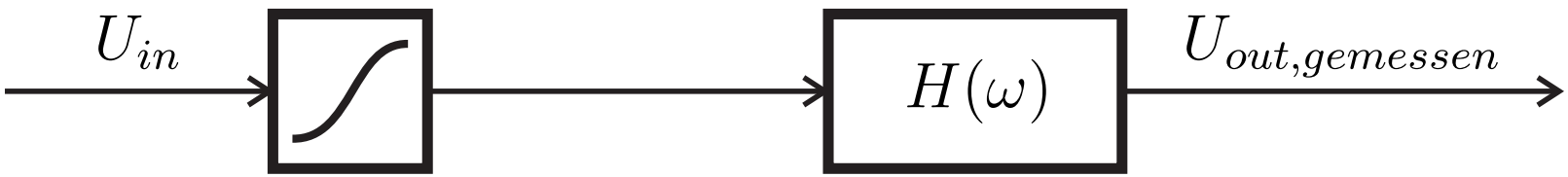
Code: Evaluierung

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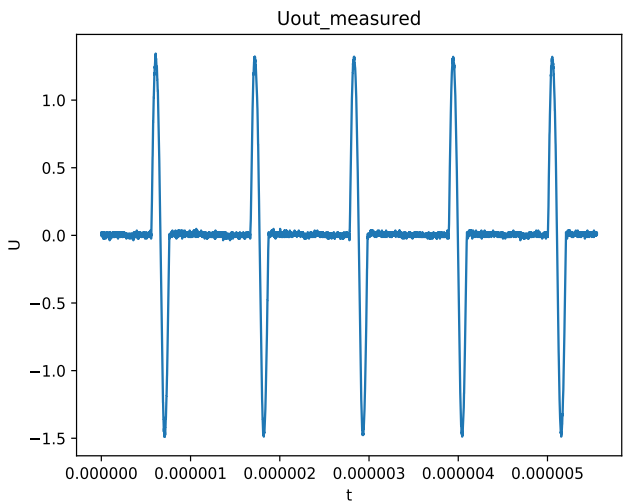
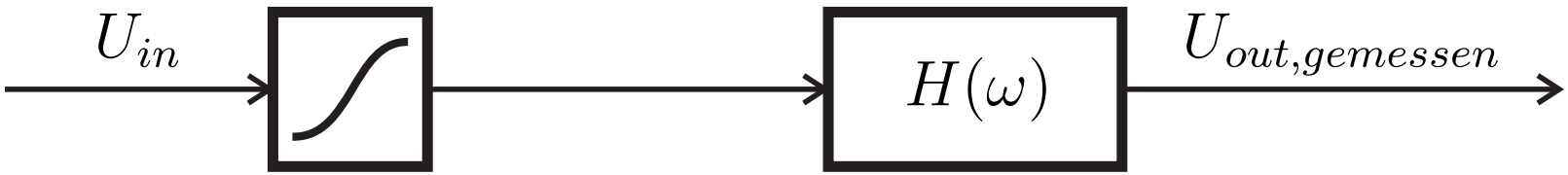


Code: Evaluierung

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1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
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5 Uout_measured = measure_Uout ( Uin )
```
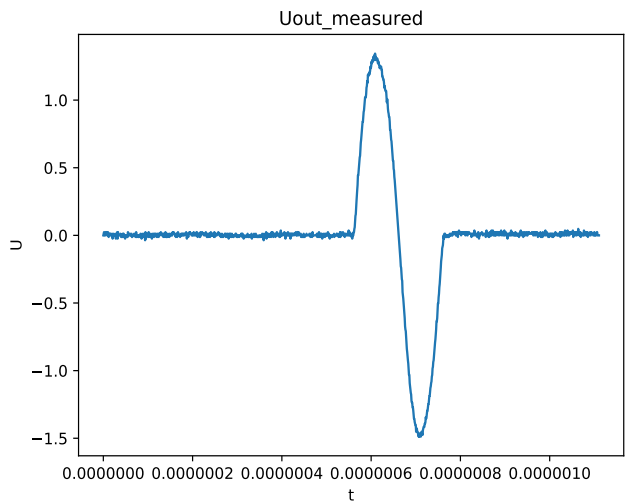
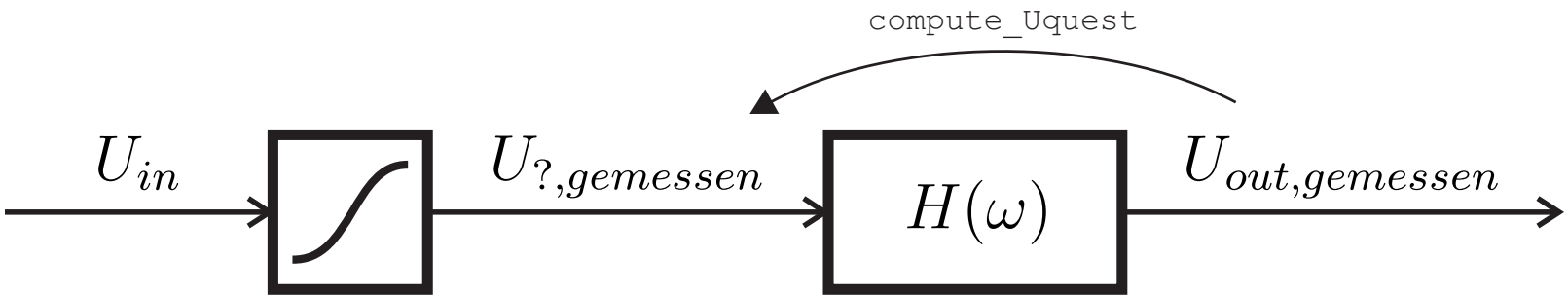
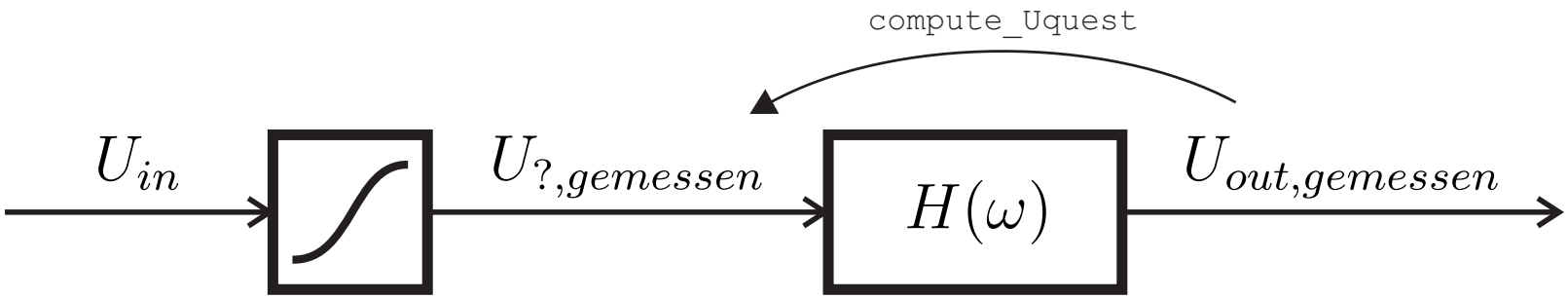



Code: Evaluierung




```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
2 H = measure_H ( )
3 Uquest_ideal = compute_Uquest ( Uout_ideal, H )
4 Uin = Uquest_ideal
5 Uout_measured = measure_Uout ( Uin )
6 Uquest_measured = compute_Uquest ( Uout_measured, H )
```

Code: Evaluierung

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1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
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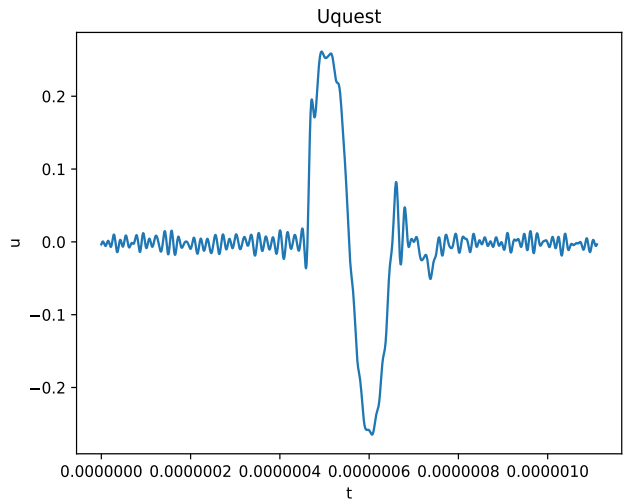
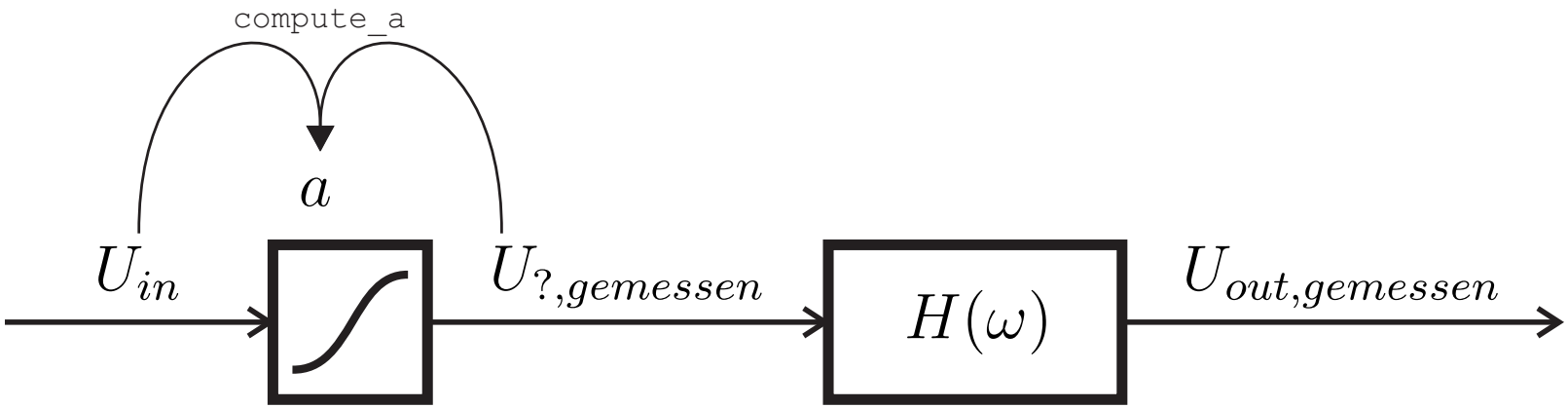
5 Uout_measured = measure_Uout ( Uin )
6 Uquest_measured = compute_Uquest ( Uout_measured, H )
```

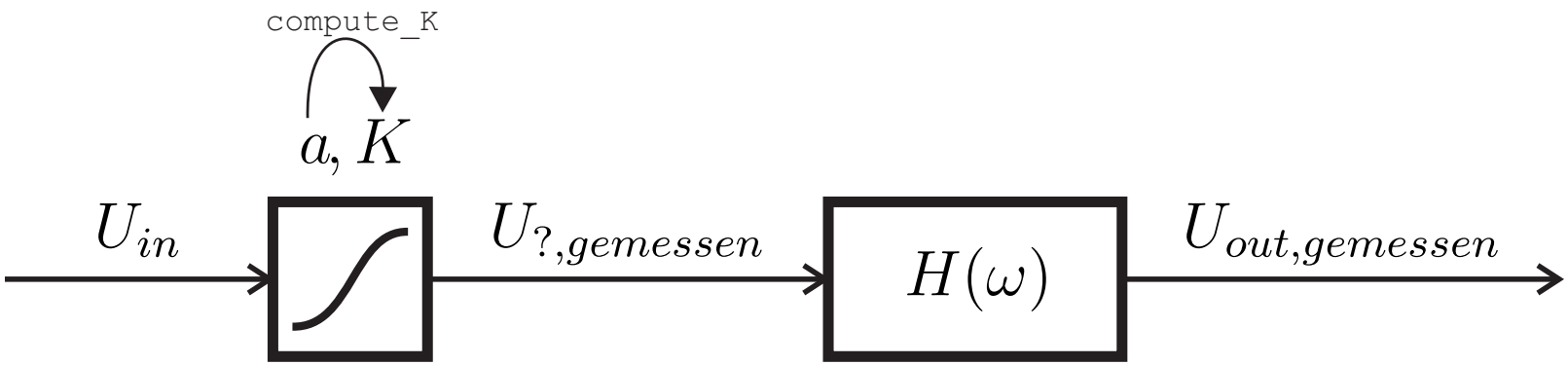


Code: Evaluierung



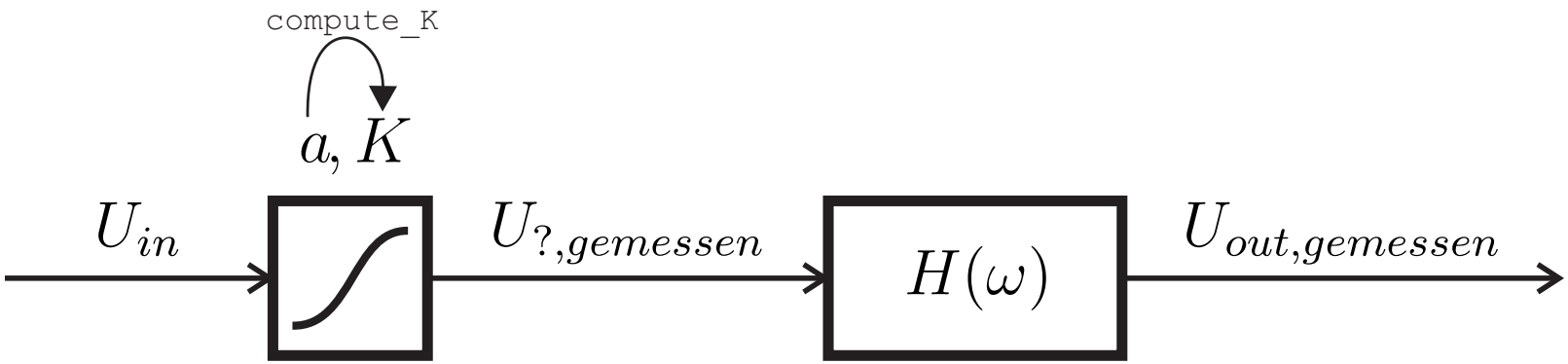

```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
2 H = measure_H ( )
3 Uquest_ideal = compute_Uquest ( Uout_ideal, H )
4 Uin = Uquest_ideal
5 Uout_measured = measure_Uout ( Uin )
6 Uquest_measured = compute_Uquest ( Uout_measured, H )
7 a = compute_a ( Uin, Uquest_measured, N )
```

Code: Evaluierung




```
1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
2 H = measure_H ( )
3 Uquest_ideal = compute_Uquest ( Uout_ideal, H )
4 Uin = Uquest_ideal
5 Uout_measured = measure_Uout ( Uin )
6 Uquest_measured = compute_Uquest ( Uout_measured, H )
7 a = compute_a ( Uin, Uquest_measured, N )
8 K = compute_K ( a )
```

Code: Evaluierung

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1 Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
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7 a = compute_a ( Uin, Uquest_measured, N )
8 K = compute_K ( a )
```
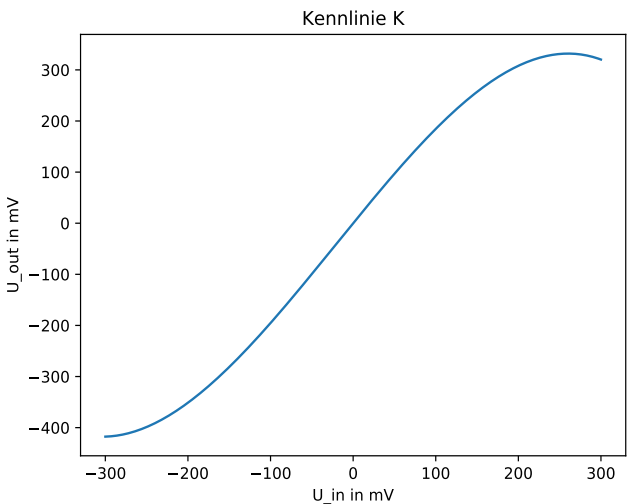
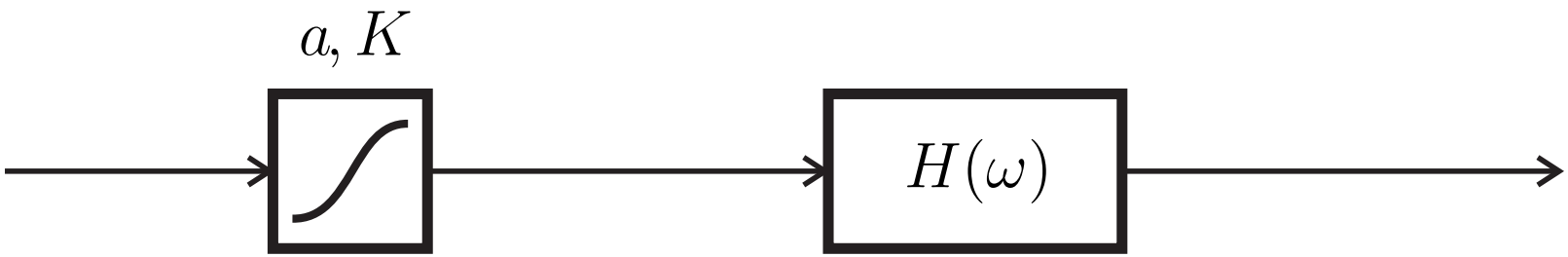
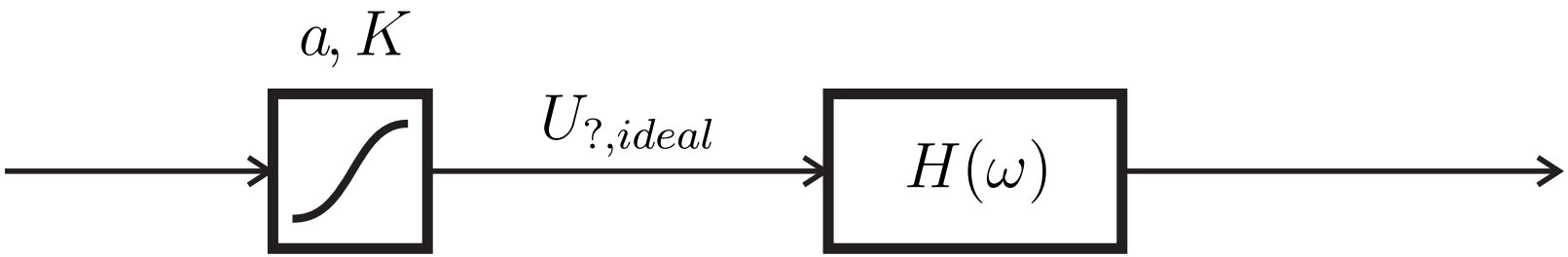



Code: Evaluierung




```
Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
H = measure_H ( )
Uquest_ideal = compute_Uquest ( Uout_ideal, H )
Uin = Uquest_ideal
Uout_measured = measure_Uout ( Uin )
Uquest_measured = compute_Uquest ( Uout_measured, H )
a = compute_a ( Uin, Uquest_measured, N )
K = compute_K ( a )
```

Code: Evaluierung

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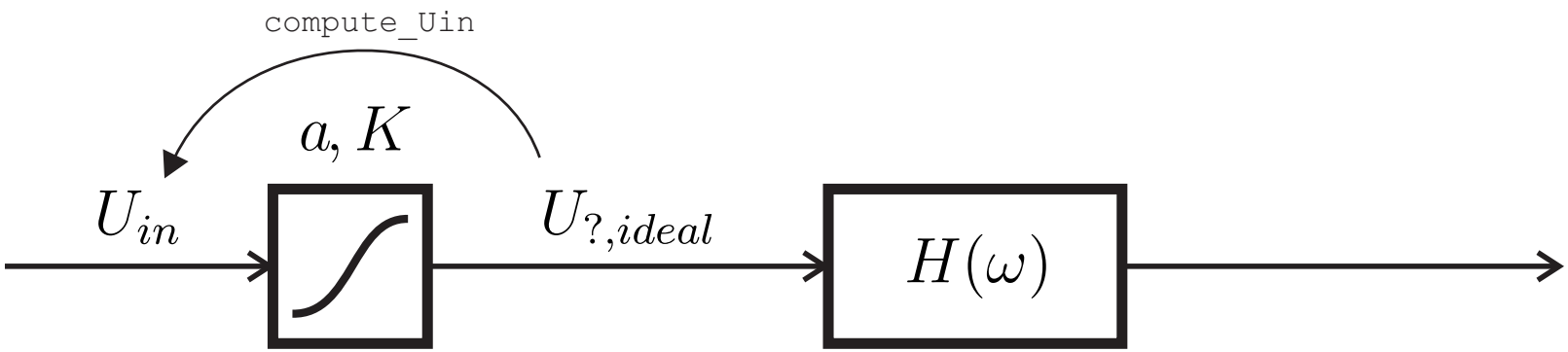
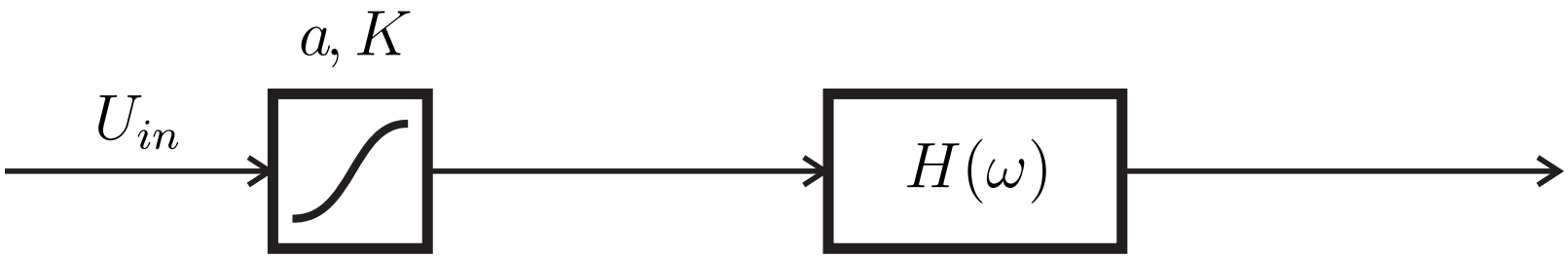
Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
H = measure_H ( )
Uquest_ideal = compute_Uquest ( Uout_ideal, H )
Uin = Uquest_ideal
Uout_measured = measure_Uout ( Uin )
Uquest_measured = compute_Uquest ( Uout_measured, H )
a = compute_a ( Uin, Uquest_measured, N )
K = compute_K ( a )
```

Code: Evaluierung



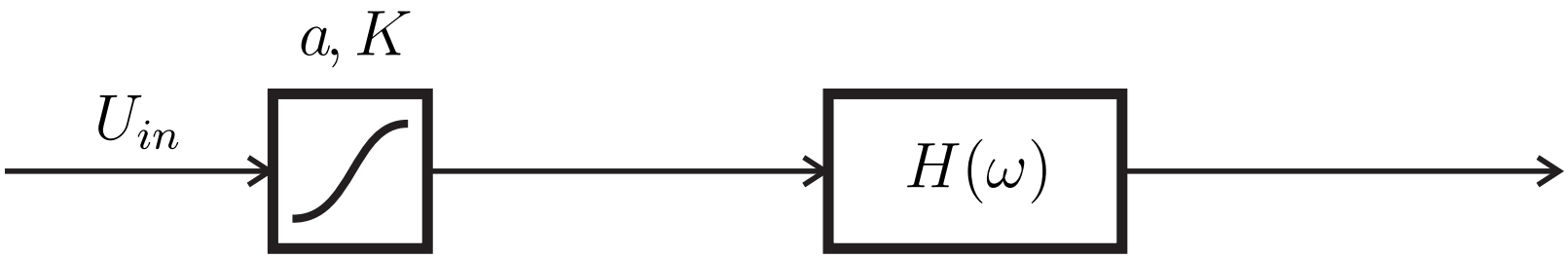

```
Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
H = measure_H ( )
Uquest_ideal = compute_Uquest ( Uout_ideal, H )
Uin = Uquest_ideal
Uout_measured = measure_Uout ( Uin )
Uquest_measured = compute_Uquest ( Uout_measured, H )
a = compute_a ( Uin, Uquest_measured, N )
K = compute_K ( a )
Uin = compute_Uin ( Uquest_ideal, K )
```

Code: Evaluierung




```
Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
H = measure_H ( )
Uquest_ideal = compute_Uquest ( Uout_ideal, H )
Uin = Uquest_ideal
Uout_measured = measure_Uout ( Uin )
Uquest_measured = compute_Uquest ( Uout_measured, H )
a = compute_a ( Uin, Uquest_measured, N )
K = compute_K ( a )
Uin = compute_Uin ( Uquest_ideal, K )
```

Code: Evaluierung

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6 Uquest_measured = compute_Uquest ( Uout_measured, H )
7 a = compute_a ( Uin, Uquest_measured, N )
8 K = compute_K ( a )
9 Uin = compute_Uin ( Uquest_ideal, K )
```
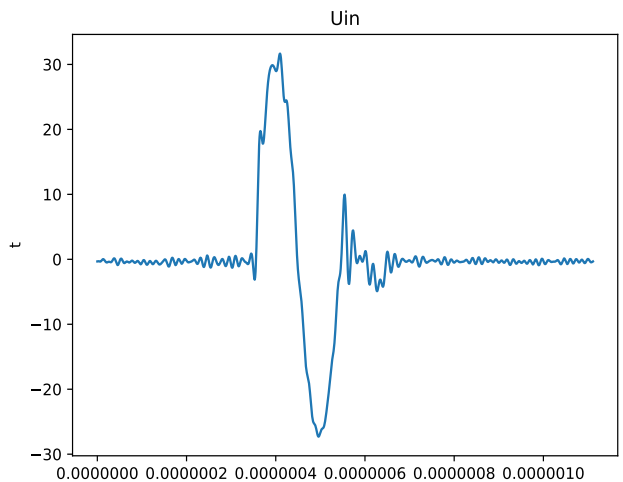
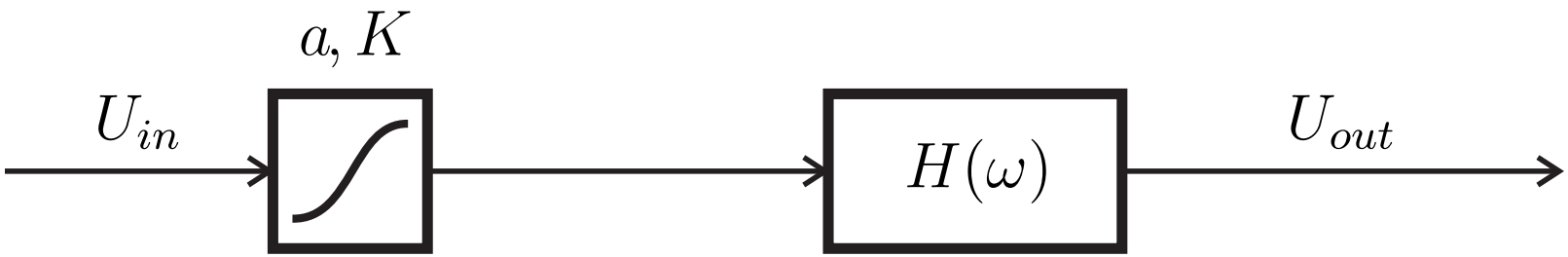



Code: Evaluierung



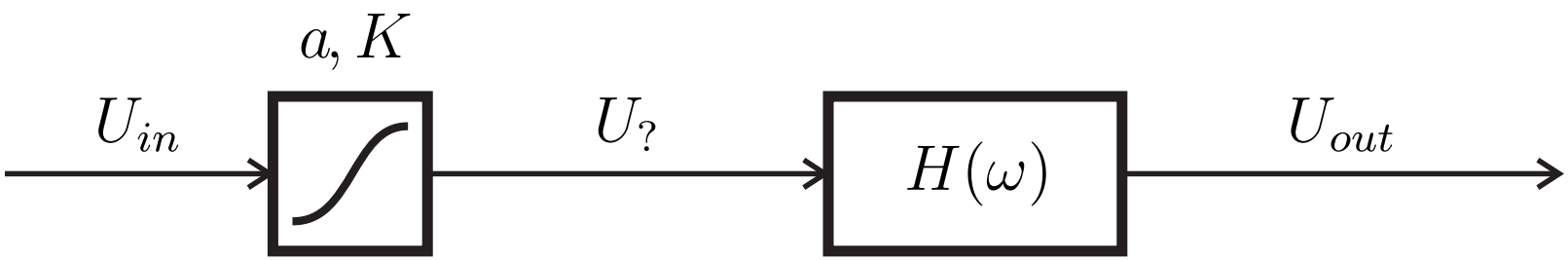

```
Uout_ideal = generate_BBsignal ( fq_rep, fq_bb, vpp )
H = measure_H ( )
Uquest_ideal = compute_Uquest ( Uout_ideal, H )
Uin = Uquest_ideal
Uout_measured = measure_Uout ( Uin )
Uquest_measured = compute_Uquest ( Uout_measured, H )
a = compute_a ( Uin, Uquest_measured, N )
K = compute_K ( a )
Uin = compute_Uin ( Uquest_ideal, K )
Uout = measure_Uout ( Uin )
```

Ausblick

- Iterative Optimierung der linearen Übertragungsfunktion mittels Auswertung der erwarteten und gemessenen Ausgangssignale U_{out}:

$$\underline{H}^{\text{neu}}(\omega) = \underline{H}^{\text{alt}}(\omega) \cdot \frac{\underline{U}_{out,\text{ideal}}(\omega)}{\underline{U}_{out,\text{mess}}(\omega)} \cdot \sigma_H$$

  mit σ_H als Schrittweite der jeweiligen Iteration

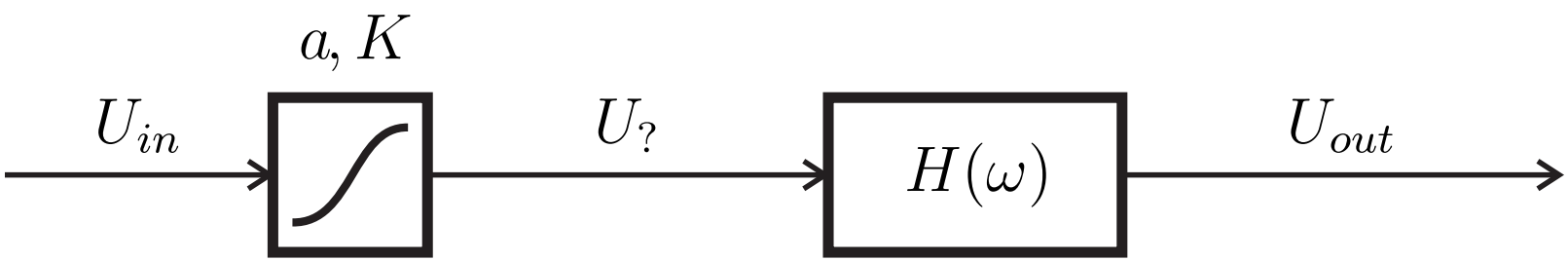


Ausblick

- Optimierung der nichtlinearen Kennlinie mittels Vergleich der Differenz der erwarteten und gemessenen Spannungssignale U_{quest} und der Faktoren a der polynomialen Kennlinie:

$$\Delta U_? = U_{?,\text{mess}} - U_{?,\text{berechnet}} = \sum_n \tilde{a}_n U_{in}^n \qquad a_n^{\text{neu}} = a_n^{\text{alt}} + \sigma_a \cdot \tilde{a}_n$$

  mit σ_a als Schrittweite der jeweiligen Iteration



Offene Fragen

- Reihenfolge der Optimierung: Parallele Iteration $\Leftrightarrow$ alternierende Iteration von H und K
- Einfluss von K auf das Spektrum von $U_?$ und damit auf Optimierung von H durch Oberschwingungen bei Potenzierung des Eingangssignals
- Bewertung der Qualität des Ausgangssignals nach einem Iterationsschritt

Quellen

- Denys Bast, Armin Galetzka, "Projektseminar Beschleunigertechnik", 2017
- Jens Harzheim *et al.*, "Input Signal Generation For Barrier Bucket RF Systems At GSI",
- Kerstin Gross *et al.*, "Test Setup For Automated Barrier Bucket Signal Generation", 2017