



Erfaringer, mm4:

101028/OKJ, rev. 101031/OKJ

- Målinger

Emner, mm5:

- Principper for forvrængningsmåling
- Egenskaber for NI-PCI-4461-kortet
- Introduktion til
 - "Swept Sine FRF VI"
 - "Amplitude Swept THD VI"
- Måling på "universalforstærker", CE-Re
 - Frekvensafhængig forstærkning og forvrængning
 - Spændingsafhængig forvrængning
 - Indgangsimpedans
- Måling på den hemmelige impedans



Erfaringer, mm4:

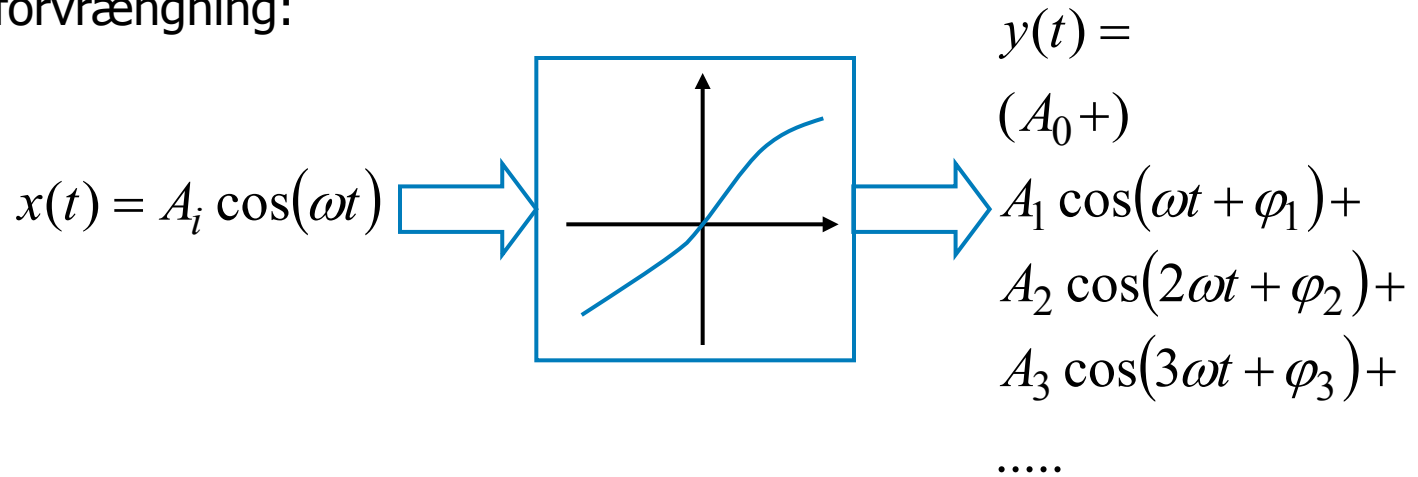
- Målinger plaget af støj (50 Hz brum + højfrekvensstøj fra switch-mode forsyninger)

Løsninger:

- Skærmet kredsløb
- Signaler i coax
- Frekvensselektivt måleudstyr
 - Oscilloskop: DC – xx MHz
 - Voltmeter: xx Hz – xx kHz
 - NI-4461: Frekvensselektiv



Harmonisk forvrængning:



Mål for forvrængning

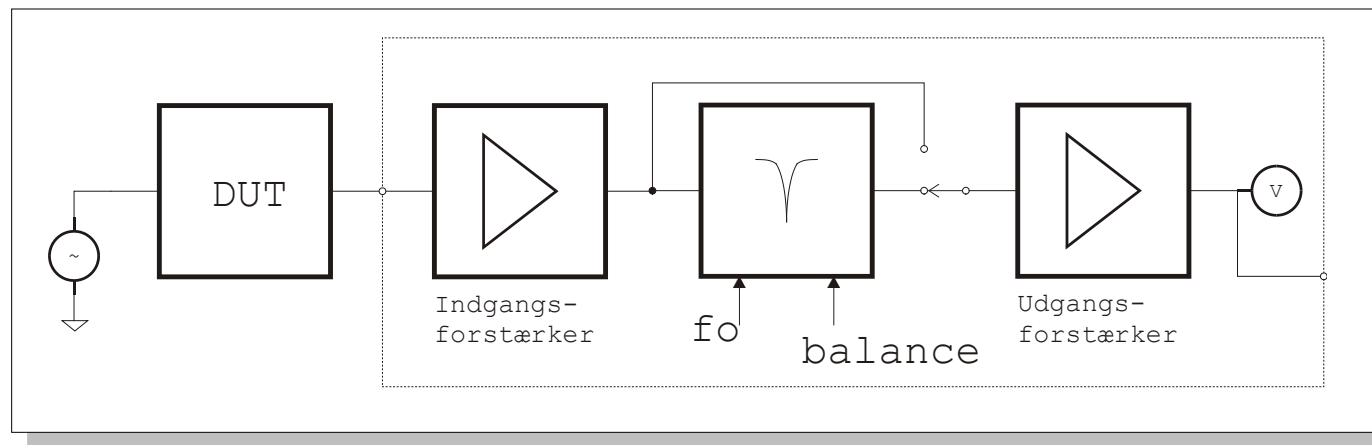
- THD
- Klirfaktor

$$THD = \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \dots}{A_1^2}}$$

$$K = \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \dots}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + \dots}}$$

De enkelte forvrængningsprodukter adderes på "effektbasis"

Måleprincipper:



© JHM

Princip:

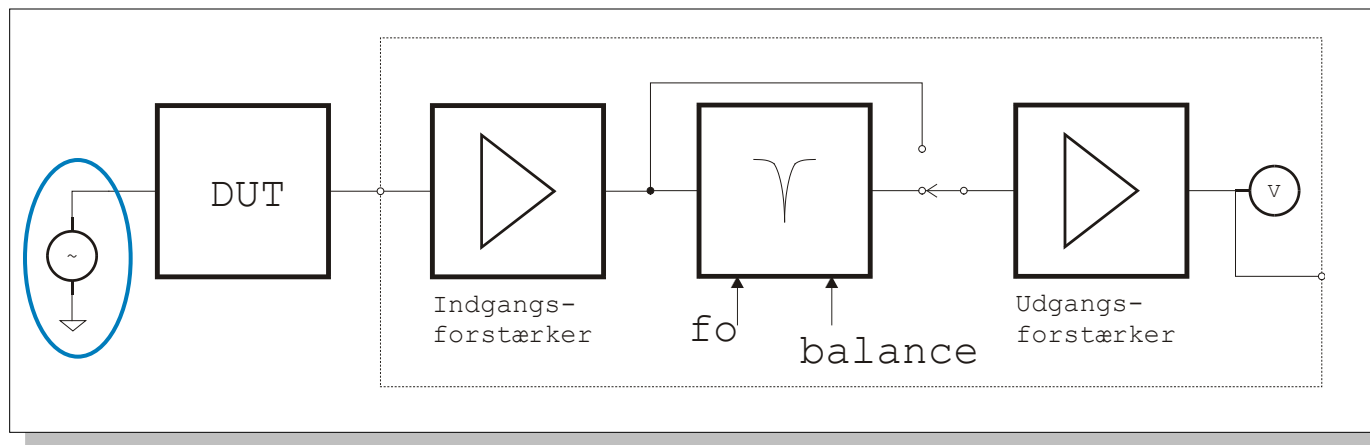
- Måling af det samlede signal fra DUT'en
- Frafiltrering af grundtonen
- Måling af resten
- Beregning af forhold
- Nogle instrumenter måler THD, andre klirfaktor
- Følsom for støj (brum)

$$THD = \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \dots}{A_1^2}}$$

$$K = \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \dots}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + \dots}}$$

Måleprincipper:

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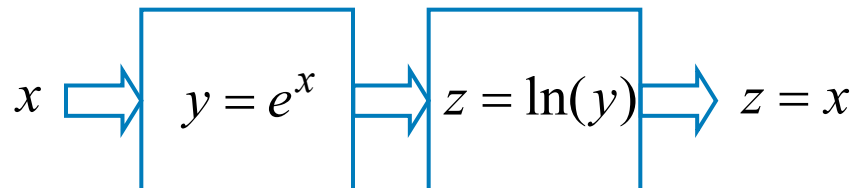


Husk:

- Kvaliteten af generatoren er meget vigtig (B&O TG7 ☺, Philips PM5131 ☹)
- Generatorens forvrængning kan måles for sig og medtages som fejlkilde
- Man må **ikke** trække generatorens forvrængning fra resultatet

PS:

- 2 typer forvrængning kan (teoretisk) ophæve hinanden:





Måleprincipper:

$$y(t) =$$

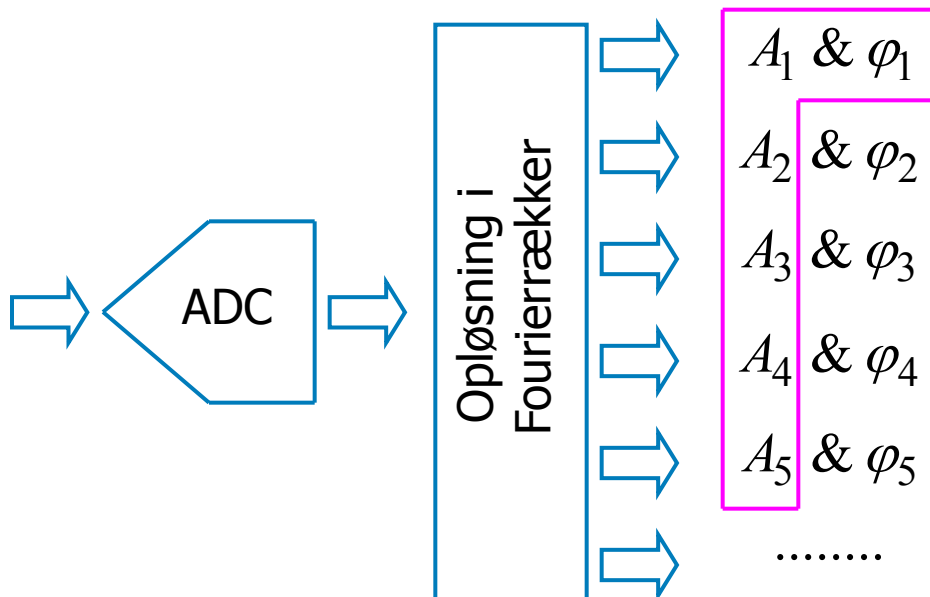
$$(A_0 +)$$

$$A_1 \cos(\omega t + \varphi_1) +$$

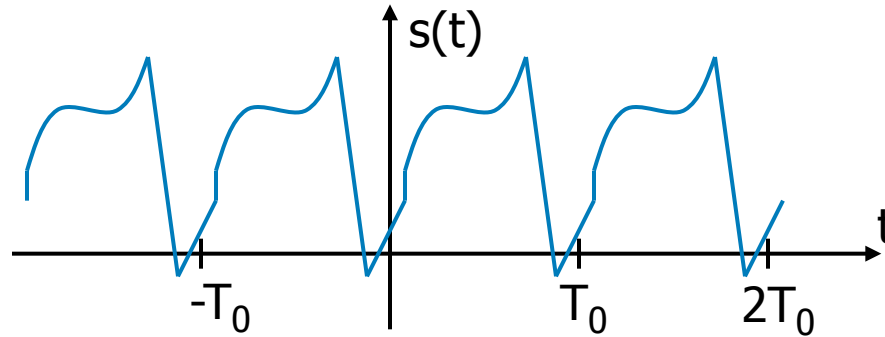
$$A_2 \cos(2\omega t + \varphi_2) +$$

$$A_3 \cos(3\omega t + \varphi_3) +$$

.....



- Anvendes i **NI-4461** systemet
- Mindre følsom for støj
- Kræver en god ADC



$$\omega_0 = \frac{2\pi}{T_0}$$

$$y(t) = a_0 + \sum_{n=1}^{\infty} \{a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t)\}$$

$$y(t) = a_0 + \sum_{n=1}^{\infty} A_n \cos(n\omega_0 t + \varphi_n)$$

Bestemmelse af Fourier-koefficienter:

$$a_n = \frac{2}{T_0} \int_{t_1}^{t_1+T_0} s(t) \cos(n\omega_0 t) dt \quad b_n = \frac{2}{T_0} \int_{t_1}^{t_1+T_0} s(t) \sin(n\omega_0 t) dt$$

$$A_n = \sqrt{a_n^2 + b_n^2} \quad \varphi_n = -\arctg \frac{b_n}{a_n}$$



BKF6 Distortion Meter – Radiometer

Manuel indstilling af notch-filteret (kræver oscilloskop tilslutning!!)

Angiver resultatet som en KLIR-faktor

$$K = \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \dots}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + \dots}}$$

© JHM



- Fremstillet da jeg gik i 5. klasse
- 4 stk E80CF (triode & pentode)
- Brug høreværn når I bruger trykknapperne
- Men det kan faktisk lave brugbare målinger



Tektronix AA501A Distortion Analyzer

- Automatisk indstilling af notch-filteret
- Har egen signal generator
- Angiver resultatet som en THD-værdi
- Kun én frekvens ad gangen

$$THD = \sqrt{\frac{A_2^2 + A_3^2 + A_4^2 + \dots}{A_1^2}}$$





NI-PCI-4461

Hardware:

- Generator
- Analysator

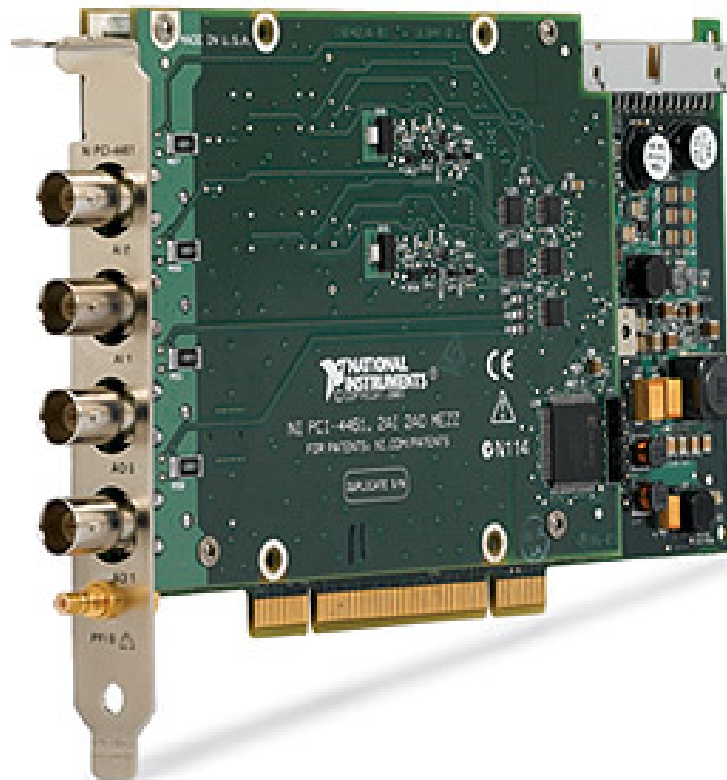
"Swept Sine FRF VI"

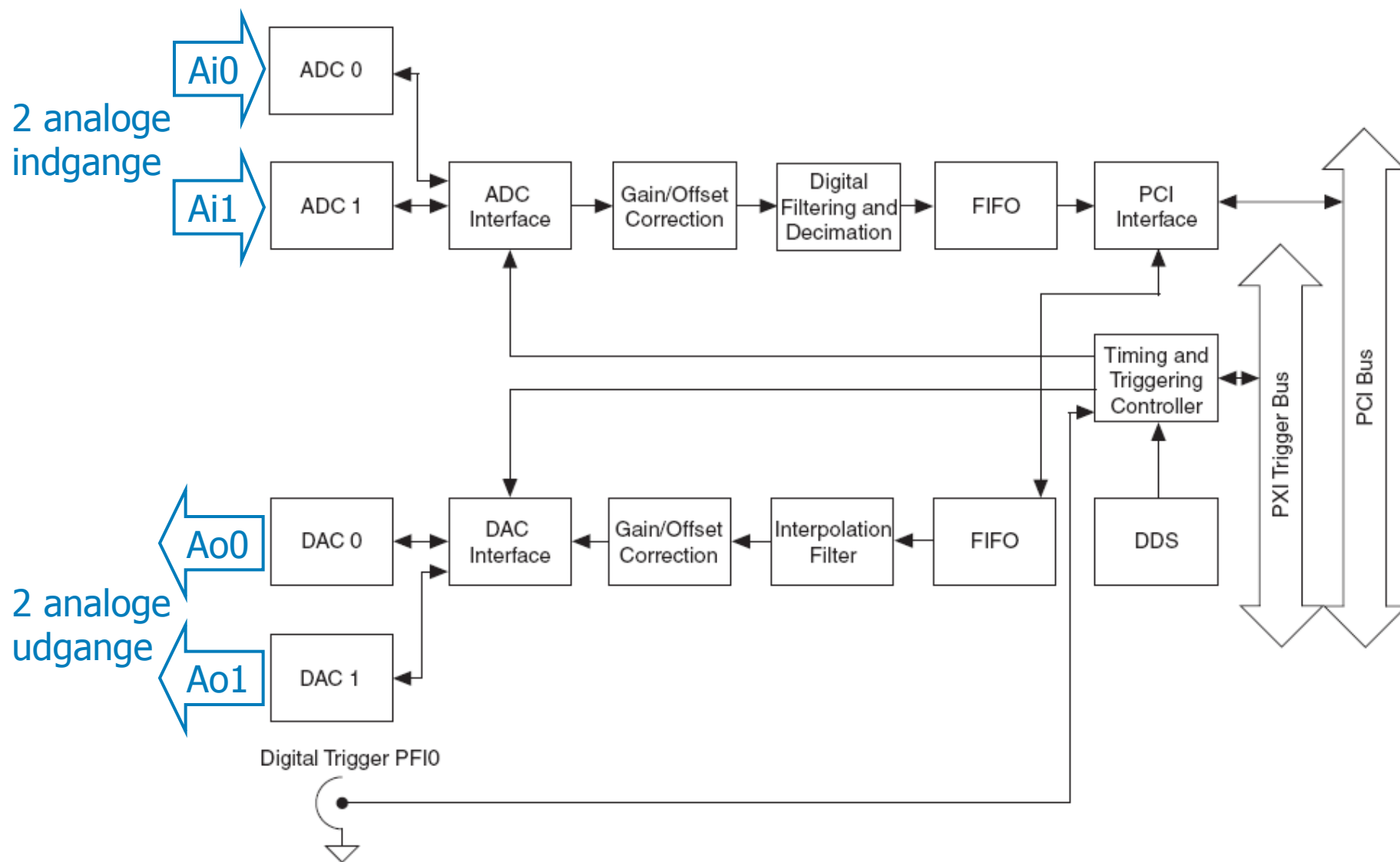
- Tilslutning
- "Swept Sine" princip
- Indstillinger

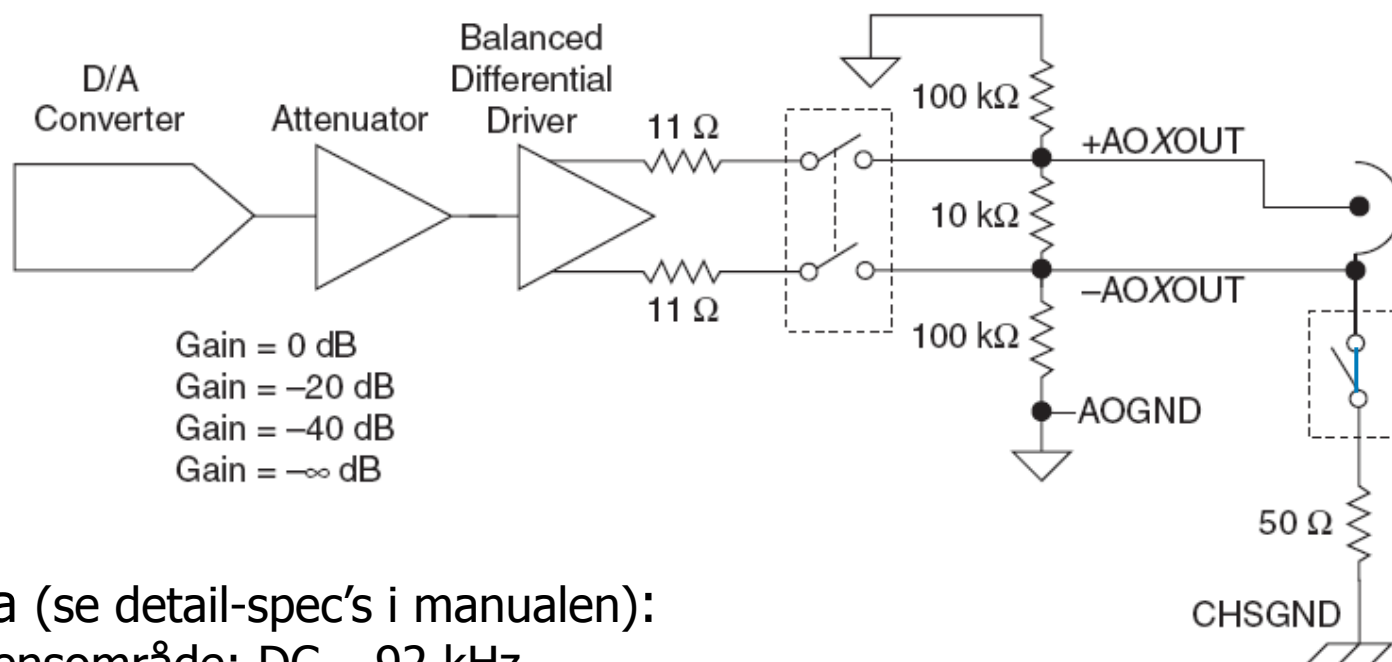
"Amplitude Swept THD VI"

- Tilslutning
- Indstillinger

Måling af indgangsimpedans med "Swept Sine FRF VI"

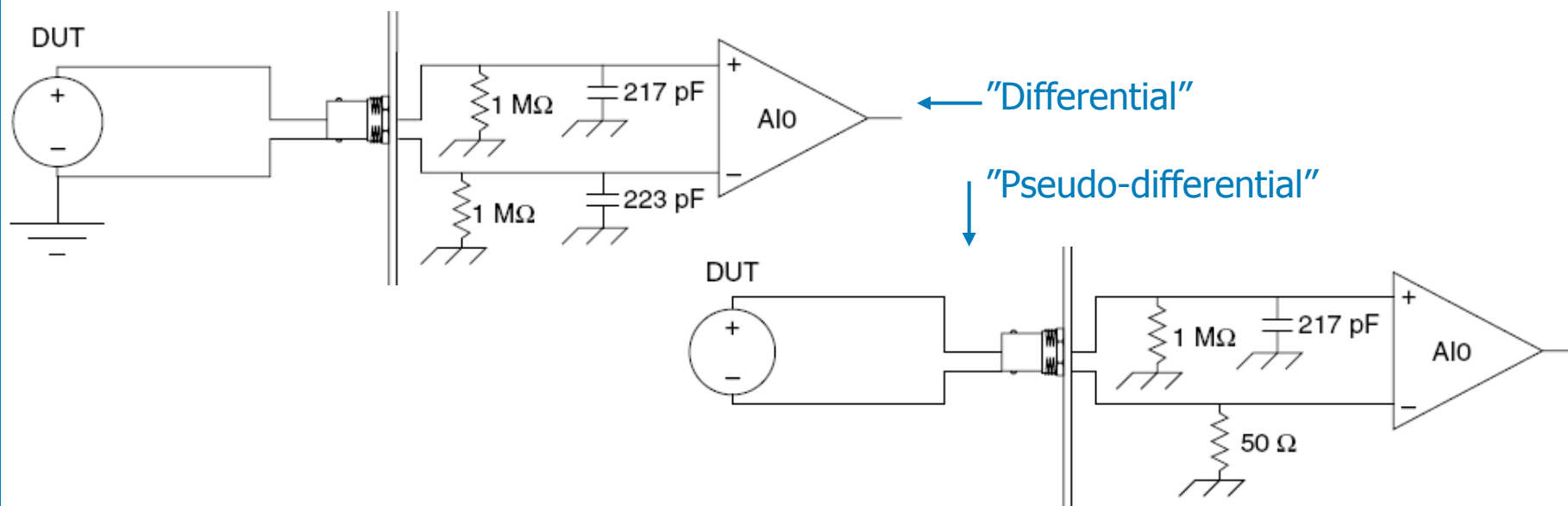






Nøgledata (se detail-spec's i manualen):

- Frekvensområde: DC – 92 kHz
- 204,8 ks/s & udglatningsfiltre (anti-aliasing, analog/digital))
- 24 bit opløsning
- Fuld-skala områder: ± 10 V, ± 1 V, $\pm 0,1$ V NB: Det er peak-værdier
- "Pseudo-differentiel" eller "single-ended"
- THD < -97 dB $\sim 0,0014\%$ @ $f < 20$ kHz, (betingelser = ?)
- Frekvensgang: $\pm 0,008$ dB @ 20 Hz-20 kHz
- Frekvensgang: $\pm 0,1$ dB @ 20 Hz-92 kHz
- Eks: Amplitude = 1,01 V $\Rightarrow \pm 10$ V "full-scale" ~ 20 bits



Nøgledata (se detail-spec's i manualen):

- Frekvensområde: DC – 92 kHz
- 204,8 ks/s & "anti-aliasing"-filtre (analog/digital)
- 24 bit opløsning
- Fuld-skala områder: $\pm 42,4$ V, $\pm 31,6$ V, ± 10 V, $\pm 3,16$ V, ± 1 V, $\pm 0,316$ V
- DC/AC-kobling; AC: 3 dB @ 3,4 Hz
- THD < -107 dB $\sim 0,0004\%$ @ $f < 20$ kHz, (-91 dB - -109 dB)
- Frekvensgang: $\pm 0,08$ dB @ 20 Hz-92 kHz (typ. $\pm 42,4$ V, $\pm 31,6$ V, ± 10 V, $\pm 3,16$ V)
- Kanalforskel: $\pm 0,003$ dB - $\pm 0,04$ dB @ 20 Hz-20 kHz
- Eks: Amplitude = 1,01 V $\Rightarrow \pm 3,16$ V "full-scale" ~ 22 bits



LabVIEW Sound and Vibration Toolbox inkluderer bl.a. de 2 VI's:

- SVXMPL_Swept Sine FRF (DAQmx).vi
- SVXMPL_Amplitude Swept THD (DAQmx).vi

De dækker vores behov 😊, men kan ikke gemme måledata i en fil 😞??

Knud Larsen, I21/SMI har rettet et par fejl og har udvidet de 2 VI's, så de kan gemme data 😊😊😊

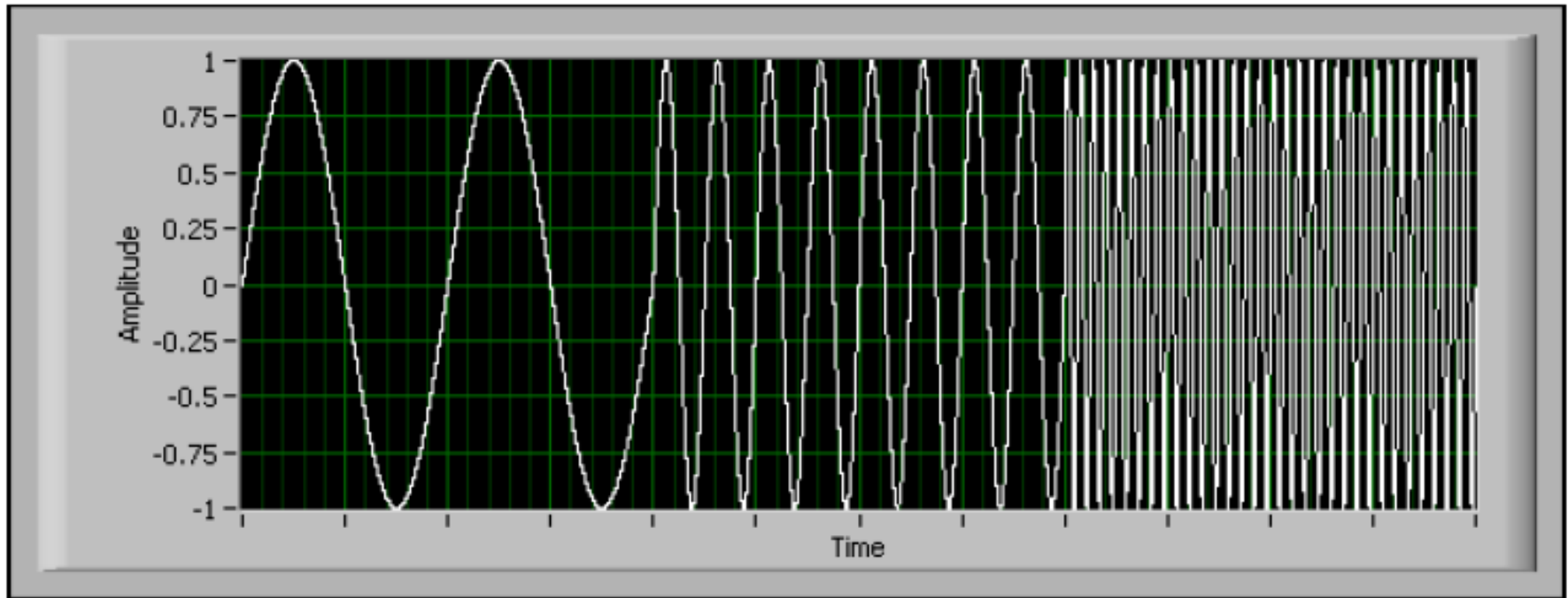
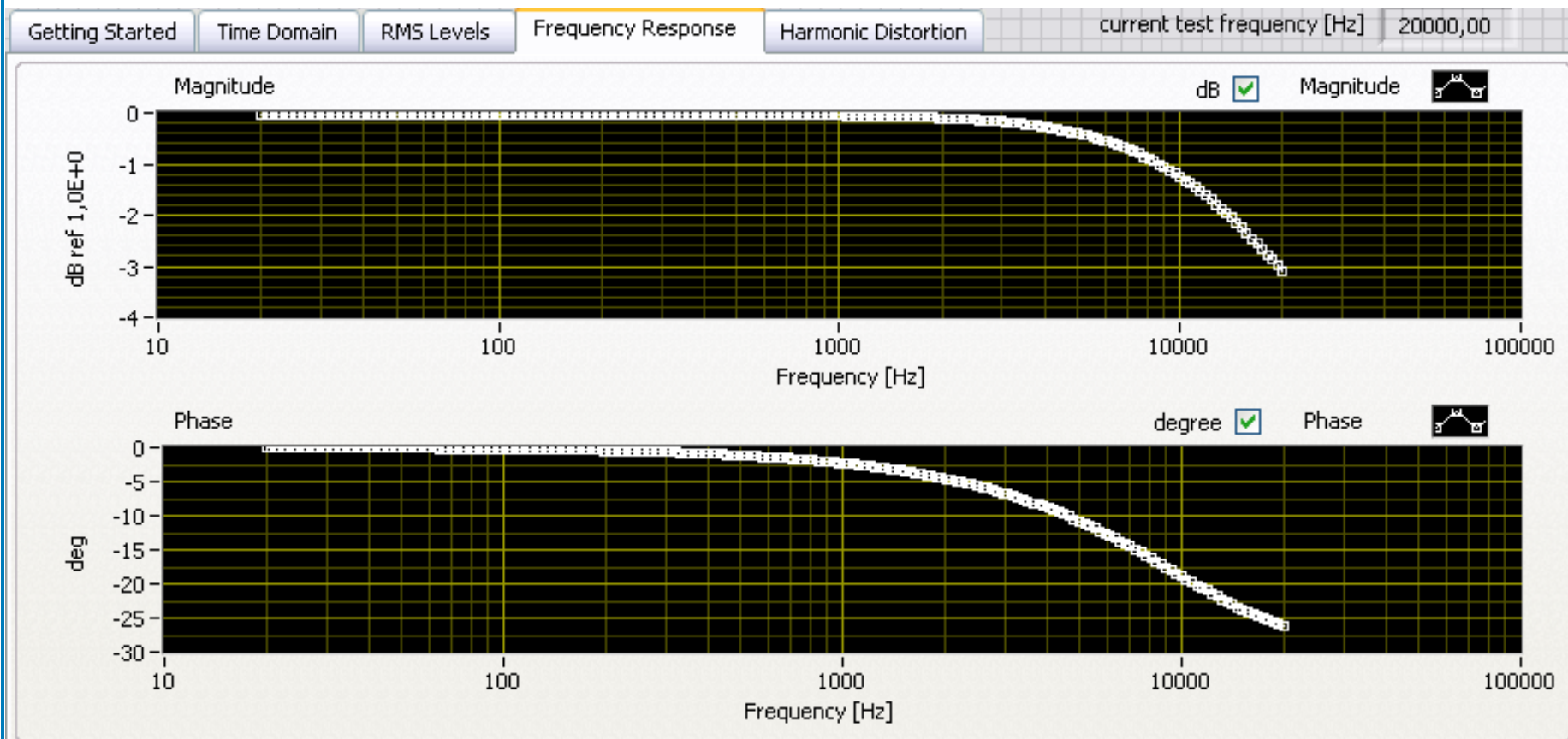


Figure 13-3. Stepping Swept Sine Example

"Stepped swept sine analysis"

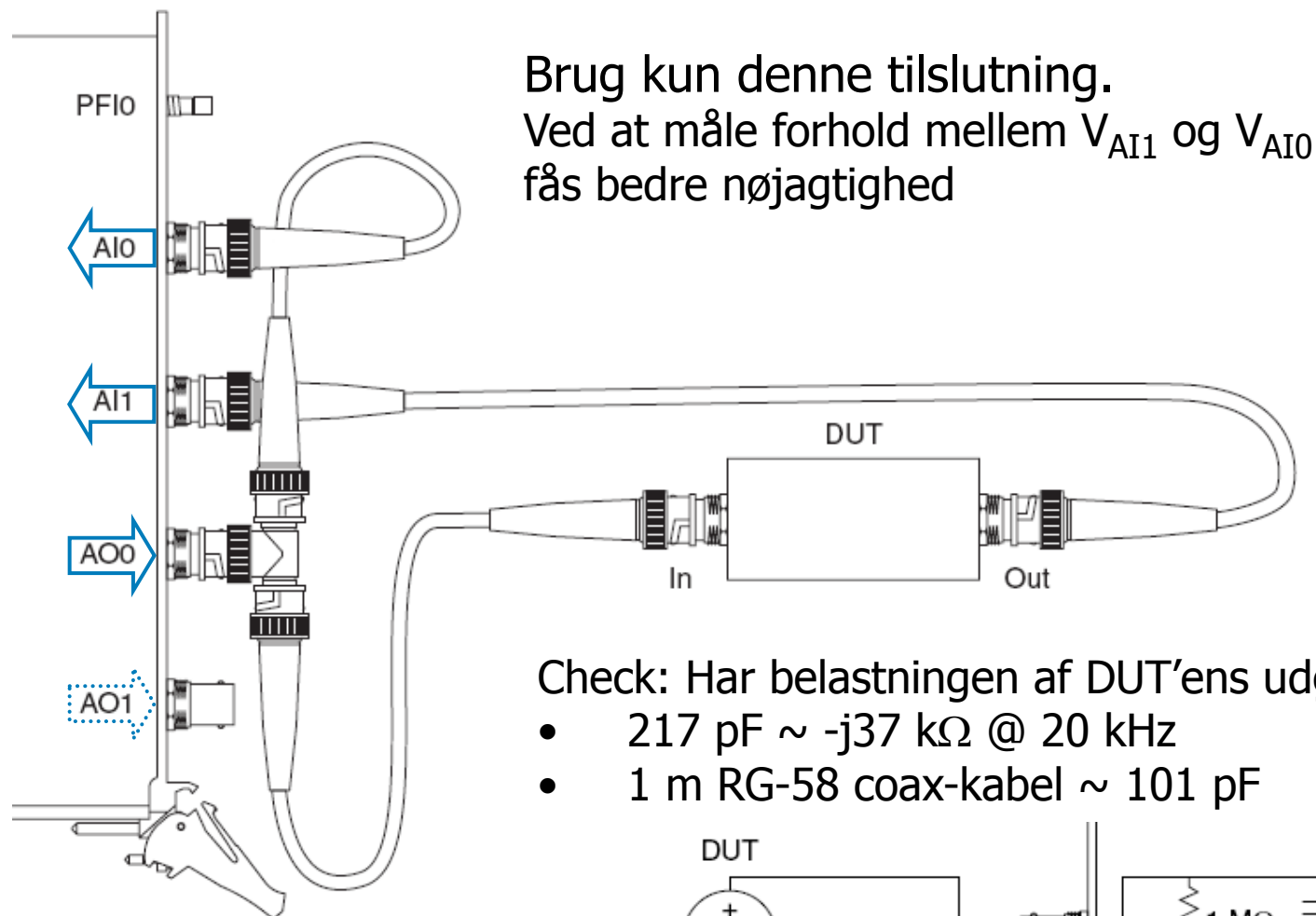
- Frekvens-"sweep" med analyse ved at antal frekvenser
- Ved at måle over et helt antal perioder og lave en Fourier-opløsning kan man måle størrelse og fase af grundtonen og harmoniske i samme sweep
- Husk: Indsvingningstid af testobjektet, hvis det er "en stemmegaffel"

"Swept Sine FRF VI" – forstærkning & fase



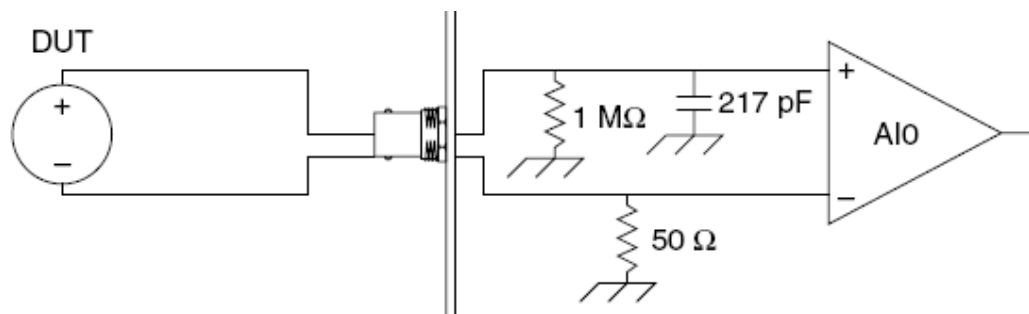


Forbindelse ved "Swept Sine" måling:



Check: Har belastningen af DUT'ens udgang betydning?

- $217 \text{ pF} \sim -j37 \text{ k}\Omega @ 20 \text{ kHz}$
- $1 \text{ m RG-58 coax-kabel} \sim 101 \text{ pF}$





"Swept Sine FRF VI" – Opsætning

Dobbeltklik
på Swept
Sine FRF
-genvejen



Swept Sine - Linear Response and Harmonic Distortion (DAQmx)

Getting Started | Time Domain | RMS Levels | Frequency Response | Harmonic Distortion | **Exit**

GETTING STARTED

This VI measures the frequency response of the device under test (DUT) with a swept sine technique. The example generates a tone for the excitation signal and measures the root-mean-square (RMS) levels of the stimulus and response channels, the frequency response (magnitude and phase), and the total harmonic distortion (THD) (including contributions from individual harmonics) of the DUT. The measurements are performed at each test frequency, one frequency at a time.

Refer to the wiring diagram to physically connect the DSA or DAQ device to the DUT. This example uses two analog input channels and one analog output channel. Note that the analog output is connected to both the DUT input and to the first analog input channel on the measurement device.

The wiring diagram assumes that you use the default channel settings. If you change the channel settings in the VI front panel you should adjust the physical connections appropriately.

NI strongly recommends that you take precautions to limit the effects of out-of-band aliasing in your frequency domain measurements. DSA devices use transparent digital and

DAQ Configuration | Source Settings | Processing Settings | THD Settings | Engineering Units | current test frequency [Hz] NaN

AO excitation channel terminal configuration
1/0 Dev1/ao0 Pseudodifferential

block duration [ms] 100 sampling frequency [Hz] 50000,00 propagation delay [samples] 1

AI stimulus channel AI range coupling terminal configuration
1/0 Dev1/ai0 ±10.0V (0dB) AC Pseudodifferential

AI response channel AI range coupling terminal configuration
1/0 Dev1/ai1 ±42.4V (-20dB) AC Pseudodifferential

Start **Stop** % **Save**

F5 Esc Data File F12



"Swept Sine FRF VI" – Opsætning

DAQ Configuration | Source Settings | Processing Settings | THD Settings | Engineering Units | current test frequency [Hz] NaN

AO excitation channel: Dev1/ao0 | terminal configuration: Pseudodifferential

AI stimulus channel: Dev1/ai0 | AI range: ±10.0V (0dB) | coupling: AC | terminal configuration: Pseudodifferential

AI response channel: Dev1/ai1 | AI range: ±42.4V (-20dB) | coupling: AC | terminal configuration: Pseudodifferential

block duration [ms]: 100 | sampling frequency [Hz]: 50000,00 | propagation delay [samples]: 1

Start (F5) | Stop (Esc) | Data File | Save (F12)

Generator:

- Port: Ao0
- Max. value indstilles via Source Settings
- Samplingsfrekvens >> max. målefrekvens (gerne høj ved THD-måling)

Indgange:

- Porte: Ai0 (stimulus) og Ai1 (response = udgang af DUT)
- Max. value (Range: ±42,4 V, ±31,6 V, ±10 V, ±3,16 V, ±1 V, ±0,316 V)
- Vælg DC eller AC kobling



"Swept Sine FRF VI" – Opsætning

Generator:

- Amplitude
- (DC-offset)
- Startfrekvens
- Stopfrekvens
- Antal frekvenspunkter
- Log/lin-sweep

DAQ Configuration | **Source Settings** | Processing Settings | THD Settings | Engineering Units | current test frequency [Hz]

DC offset [V] 0,00 amplitude [V] 1,00

sweep frequencies [Hz]

start frequency	stop frequency	number of steps
100,00	10000,00	100

frequency spacing logarithmic

Start Stop Data File

F5 Esc

DAQ Configuration | Source Settings | **Processing Settings** | THD Settings | Engineering Units | current test frequency [Hz] NaN

settling

settle time [s]	settle cycles
25,00m	5

integration

integration time [s]	integration cycles
25,00m	5

Processing Settings:

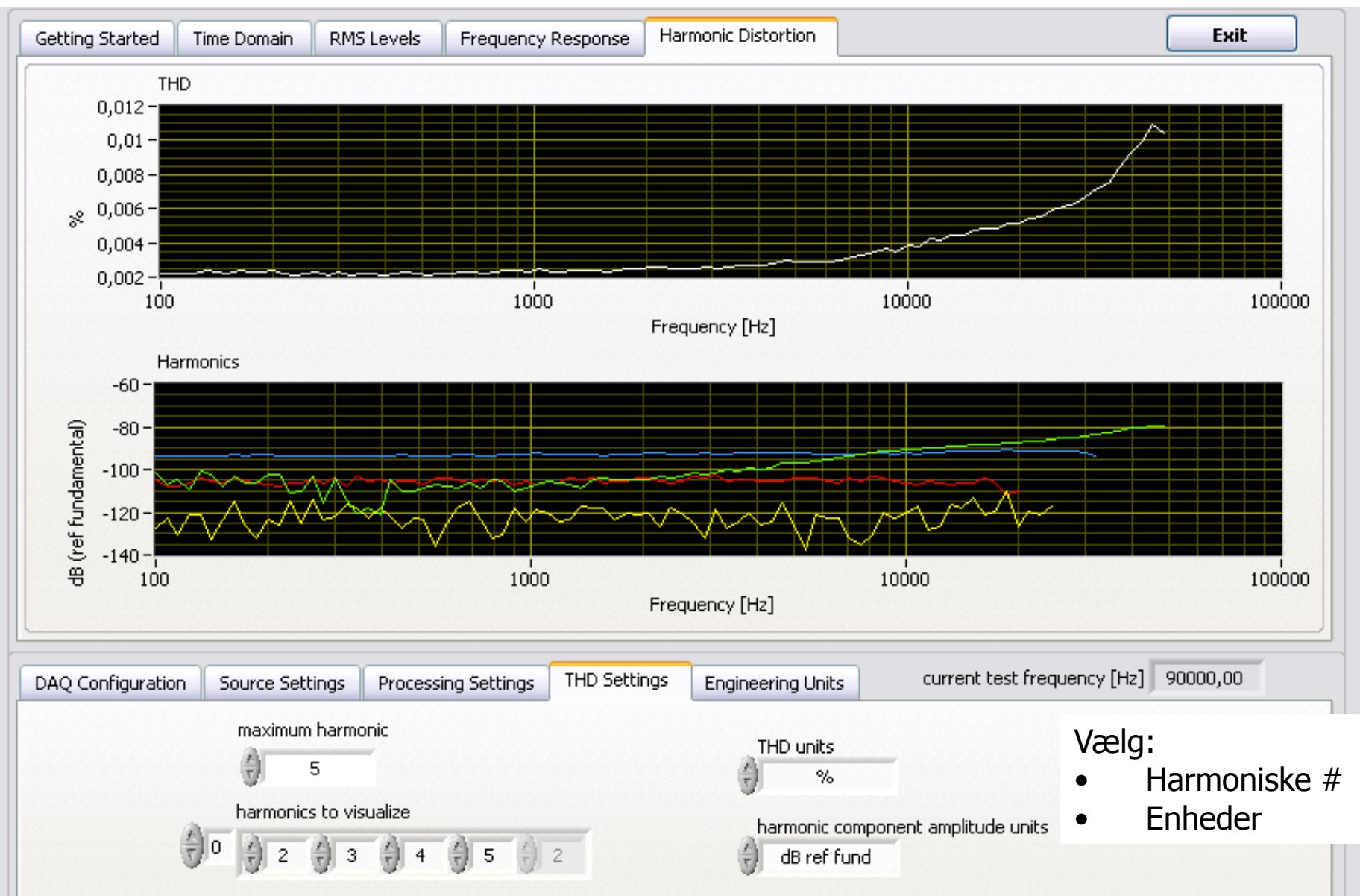
- Høj værdi af "settle-" og "integration-cycles", m, ved lav THD
- Settle time = ?

$$a_n = \frac{2}{mT_0} \int_{t_1}^{t_1 + mT_0} s(t) \cos(n\omega_0 t) dt$$

$$b_n = \frac{2}{mT_0} \int_{t_1}^{t_1 + mT_0} s(t) \sin(n\omega_0 t) dt$$



"Swept Sine FRF VI" – Opsætning





"Swept Sine FRF VI" – Knuds knap

DAQ Configuration | Source Settings | Processing Settings | THD Settings | Engineering Units | current test frequency [Hz] NaN

AO excitation channel: Dev1/ao0 | terminal configuration: Pseudodifferential

AI stimulus channel: Dev1/ai0 | AI range: ±10.0V (0dB) | coupling: AC | terminal configuration: Pseudodifferential

block duration [ms]: 100 | sampling frequency [Hz]: 50000.00 | propagation delay [samples]: 1

AI response channel: Dev1/ai1 | AI range: ±42.4V (-20dB) | coupling: AC | terminal configuration: Pseudodifferential

Start | Stop | Save

- Start (single)
- Stop
- Save



"Swept Sine FRF VI" – Datafil

%	Date: 2007-11-30	Time:	10:37:46					
%	Sampling frequency	[Hz]:	50000					
%	Generator amplitude	[V]:	2.0000					
%	Settle time	[s]:	0.025000					
%	Settle cycles:		5					
%	Integration time	[s]:	0.025000					
%	Integration cycles:		5					
%	Freq.	Amplitude	Phase	THD	HD 2	HD 3	HD 4	HD 5
%	[Hz]	[dB]	[deg]	[dB]	[dB ref fund]	[dB ref fund]	[dB ref fund]	[dB ref fund]
	2.0000E+1	-8.5395E-2	-2.5950E-1	-1.0128E+2	-1.0428E+2	-1.0514E+2	-1.1568E+2	-1.1418E+2
	2.0706E+1	-8.5411E-2	-2.6871E-1	-9.9864E+1	-1.0302E+2	-1.0380E+2	-1.1287E+2	-1.1188E+2
	2.1438E+1	-8.5415E-2	-2.7816E-1	-1.0132E+2	-1.0470E+2	-1.0480E+2	-1.1436E+2	-1.1512E+2
.								
	1.8022E+4	-7.3666E+0	-2.1150E+1	NaN	NaN	NaN	NaN	NaN
	1.8659E+4	-7.4047E+0	-2.1154E+1	NaN	NaN	NaN	NaN	NaN
	1.9318E+4	-7.4419E+0	-2.1175E+1	NaN	NaN	NaN	NaN	NaN
	2.0000E+4	-7.4781E+0	-2.1214E+1	NaN	NaN	NaN	NaN	NaN

NB:

- **Hold øje med enheder - de afhænger af indstillingerne på skærmen**

NB2: Hvis grundtonen sweepes op til f_{\max} vises:

- HD2 for grundtonefrekvenser op til $f_{\max}/2$
- HD3 for grundtonefrekvenser op til $f_{\max}/3$
- HD4 for grundtonefrekvenser op til $f_{\max}/4$
- HD5 for grundtonefrekvenser op til $f_{\max}/5$
- Herover står der NaN i filen



```
% SweptSine.m
% NI-4461 & Swept Sine FRF VI
clear;
```

% READ MEASURED DATA

% txt-file with 9 header lines and 8 columns:

% Freq[Hz], Ampl[dB], Phase[deg], THD[%], HD2[dBc], HD3[dBc], HD4[dBc], HD5[dBc]

```
[FileA,PathA]=uigetfile('*.txt','Select measured frequency response file');
```

```
FullFileA = fullfile(PathA,FileA);
```

```
[Freq dBfund degFund THDpct HD2dB HD3dB HD4dB
```

```
HD5dB]=textread(FullFileA,'%f%f%f%f%f%f%f%f','headerlines',9);
```

% Data format conversions:

Vfund = 10.^(dBfund/20).*exp(j*degFund/180*pi); % Complex voltage of
fundamental **Vai1/Vai0**

```
HD2pct = 100*10.^(HD2dB/20); % HD2 in %
```

```
HD3pct = 100*10.^(HD3dB/20); HD4pct = 100*10.^(HD4dB/20); HD5pct = 100*10.^(HD5dB/20);
```

```
figure(1)
```

```
loglog(Freq,THDpct,Freq,HD2pct,Freq,HD3pct,Freq,HD4pct,Freq,HD5pct);
```

```
xlabel('Frequency [Hz]'); ylabel('Distortion [%]');
```

```
grid;
```

```
figure(2);
```

```
subplot(2,1,1);
```

```
semilogx(Freq,dBfund);
```

```
xlabel('Frequency [Hz]'); ylabel('Gain [dB]');
```

```
grid;
```

```
title('Frequency response');
```

```
subplot(2,1,2);
```

```
semilogx(Freq,degFund);
```

```
xlabel('Frequency [Hz]'); ylabel('Phase [deg]');
```

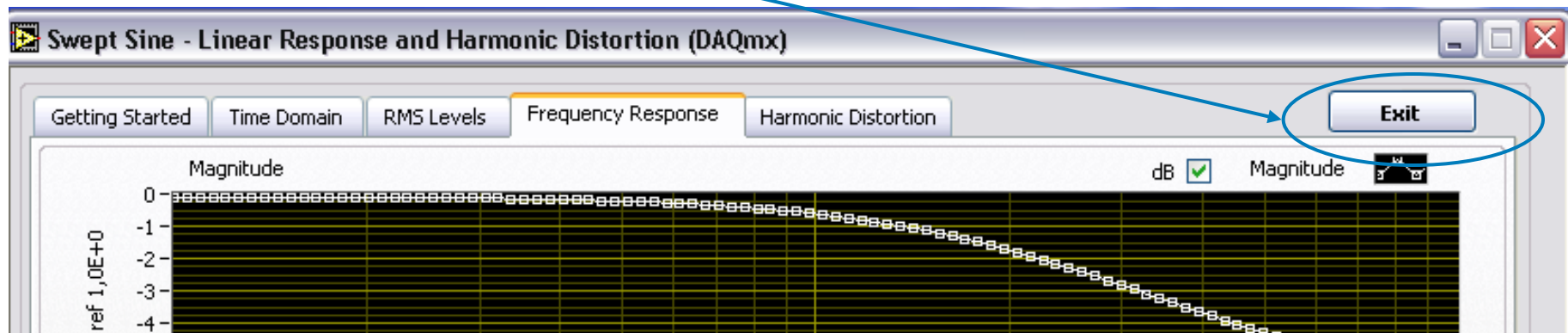
```
grid;
```

Hold øje med
enheder

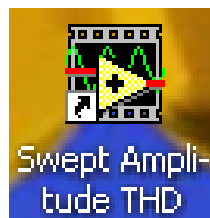


"Swept Sine FRF VI" → "Amplitude Swept THD VI"

Luk "Swept Sine FRF VI":



Dobbeltklik på "Swept Amplitude THD":





Swept Amplitude THD VI



Amplitude Swept THD (DAQmx)

Getting Started | Time Record | THD vs Input Level | **Exit**

GETTING STARTED

This VI measures the total harmonic distortion (THD) of a device under test (DUT). THD quantifies harmonics produced from excitation at a single frequency. THD is defined as the ratio of the RMS sum of powers in the harmonics to the power in the fundamental frequency. This test sweeps the single tone excitation through several amplitude levels. Such an amplitude sweep adds value in distortion measurements because THD is often strongly dependent on DUT input amplitude.

Refer to the wiring diagram to physically connect the DSA or DAQ device to the DUT. This example uses one analog input channel and one analog output channel.

The wiring diagram assumes that you use the default channel settings. If you change the channel settings in the VI front panel you should adjust the physical connections appropriately.

NI strongly recommends that you take precautions to limit the effects of out-of-band aliasing in your frequency domain measurements. DSA devices use transparent digital and analog hardware filtering to eliminate aliased input and output frequencies. Multifunction DAQ devices are more susceptible to the effects of aliased frequencies. If you are using a non-DSA measurement device, we recommend addressing potential aliasing through high sampling rates, built-in analog filters on S Series devices, and/or external analog filters.

Wiring Diagram:

The diagram shows a DUT (Device Under Test) with an IN port and an OUT port. The IN port is connected to the Output Chan 0 of the DSA / DAQ Device. The OUT port is connected to the Input Chan 1 of the DSA / DAQ Device.

DAQ Configuration:

Measurement Settings | Source Settings | actual sample rate: NaN [Hz] | measurements per second: NaN

Output channel: Dev1/ao0 | Terminal Configuration: Differential

Input channel: Dev1/ai1 | Range: ±42.4V (-20dB) | Coupling: AC | Terminal Configuration: Pseudodifferential | device propagation delay [samples]: 1

Start | **Stop** | **Save**



Swept Amplitude THD VI

The screenshot shows the 'Measurement Settings' tab of the 'Swept Amplitude THD VI' interface. At the top, there are tabs for 'DAQ Configuration', 'Measurement Settings' (which is selected), and 'Source Settings'. To the right of these tabs, there are two status fields: 'actual sample rate' with a value of 'NaN' and units '[Hz]', and 'measurements per second' with a value of 'NaN'. The main area contains four control groups, each with a slider icon and a text box: 'maximum harmonic' set to '5', 'THD units' set to 'dB', 'settling' (which includes 'settle time' at '100,00m' and 'settle cycles' at '10'), and 'integration' (which includes 'integration time' at '100,00m' and 'integration cycles' at '20'). At the bottom, there are three buttons: 'Start', 'Stop', and 'Save'.

Measurement Settings:

- Høj værdi af "settle-" og "integration-cycles" ved lav THD

The screenshot shows the 'Source Settings' tab of the 'Swept Amplitude THD VI' interface. At the top, there are tabs for 'DAQ Configuration', 'Measurement Settings', and 'Source Settings' (which is selected). To the right of these tabs, there are two status fields: 'actual sample rate' with a value of '12500,00' and units '[Hz]', and 'measurements per second' with a value of '4,99'. The main area contains four control groups, each with a slider icon and a text box: 'frequency [Hz]' set to '1000,00', 'min amplitude [V]' set to '0,10', 'max amplitude [V]' set to '2,00', and '# of steps' set to '20'. At the bottom, there are three buttons: 'Start', 'Stop', and 'Save'.

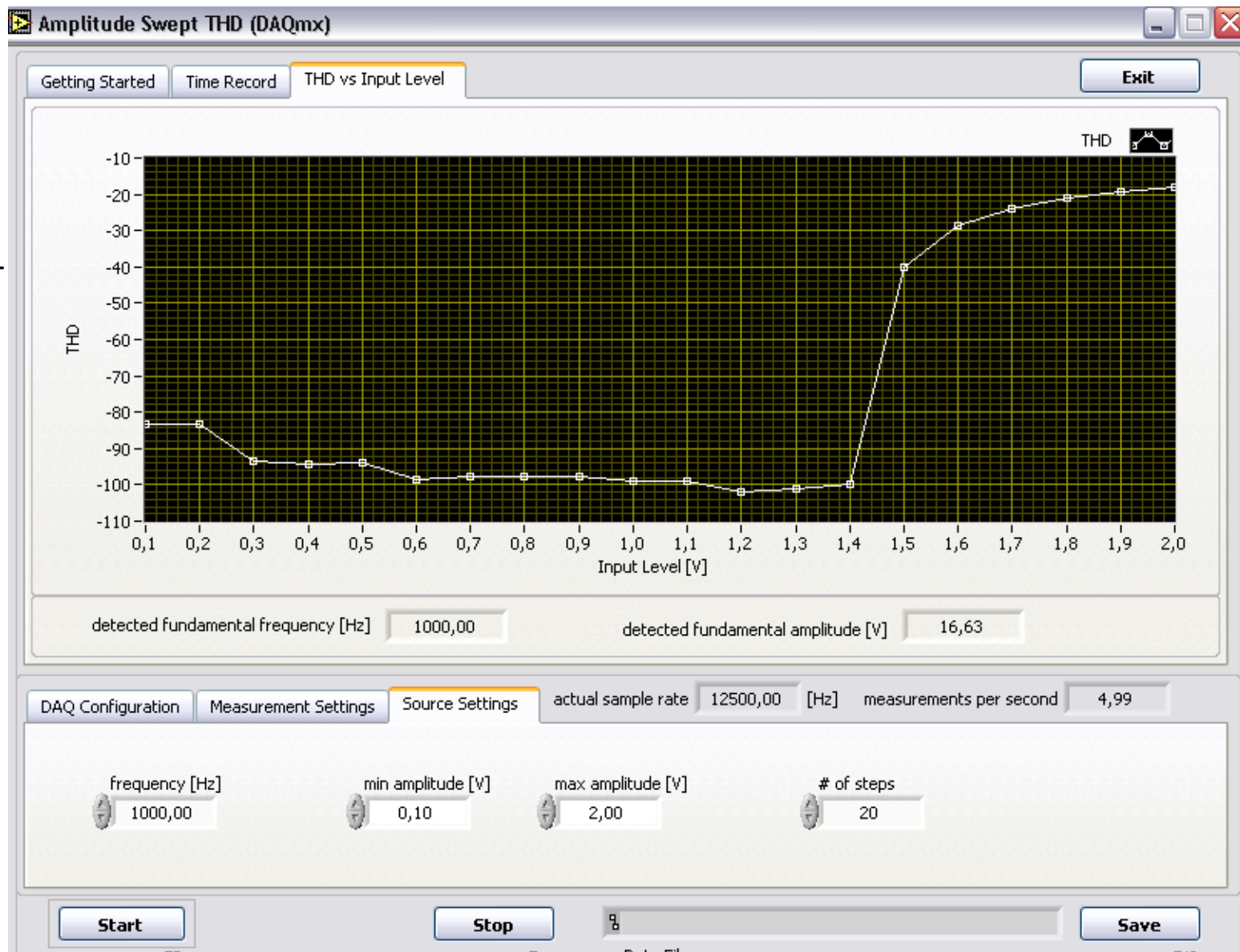
Source Settings: Frekvens, min-/max-amplitude, antal steps
(Sample rate vælges af programmet)



Swept Amplitude THD VI

Vælg optimal "Range Setting" for at få lavest mulig forvrængning fra instrumentet.

-80 dB ~
0,01 %





%	Date:	2007-11-30	Time:	10:46:17
%	Generator frequency	[Hz]:	5000.0	
%	Actual sample rate	[Hz]:	62500	
%	Max. number of harmonics:		5	
%	Settle time	[s]:	0.10000	
%	Settle cycles:		10	
%	Integration time	[s]:	0.10000	
%	Integration cycles:		20	
%	S. ampl.	Fund. ampl.	THD	
%	[V]	[V]	[dB]	
	1.0000E-1	6.0805E-2	-8.2038E+1	
	1.1005E-1	6.6913E-2	-8.0681E+1	
	1.2011E-1	7.3027E-2	-8.3610E+1	
	1.3016E-1	7.9139E-2	-8.7510E+1.	
	.			
	1.9799E+0	1.1795E+0	-2.3316E+1	
	1.9899E+0	1.1854E+0	-2.3275E+1	
	2.0000E+0	1.1913E+0	-2.3235E+1	

NB:

- Enhederne i filen (THD) kan afhænge af indstillingerne på skærmen

```
% AmplSweptTHD.m                                071130/OKJ;
% NI-4461 & Amplitude Swept THD VI
clear;

% READ MEASURED DATA
% txt-file with 10 header lines and 3 columns:
% Source amplitude[V], Fundamental amplitude[V] & THD[dB]
[FileA,PathA]=uigetfile('*.txt','Select measured amplitude sweep file');
FullFileA = fullfile(PathA,FileA);
[Vsource Vfund THDdB]=textread(FullFileA,'%f%f%f','headerlines',10);

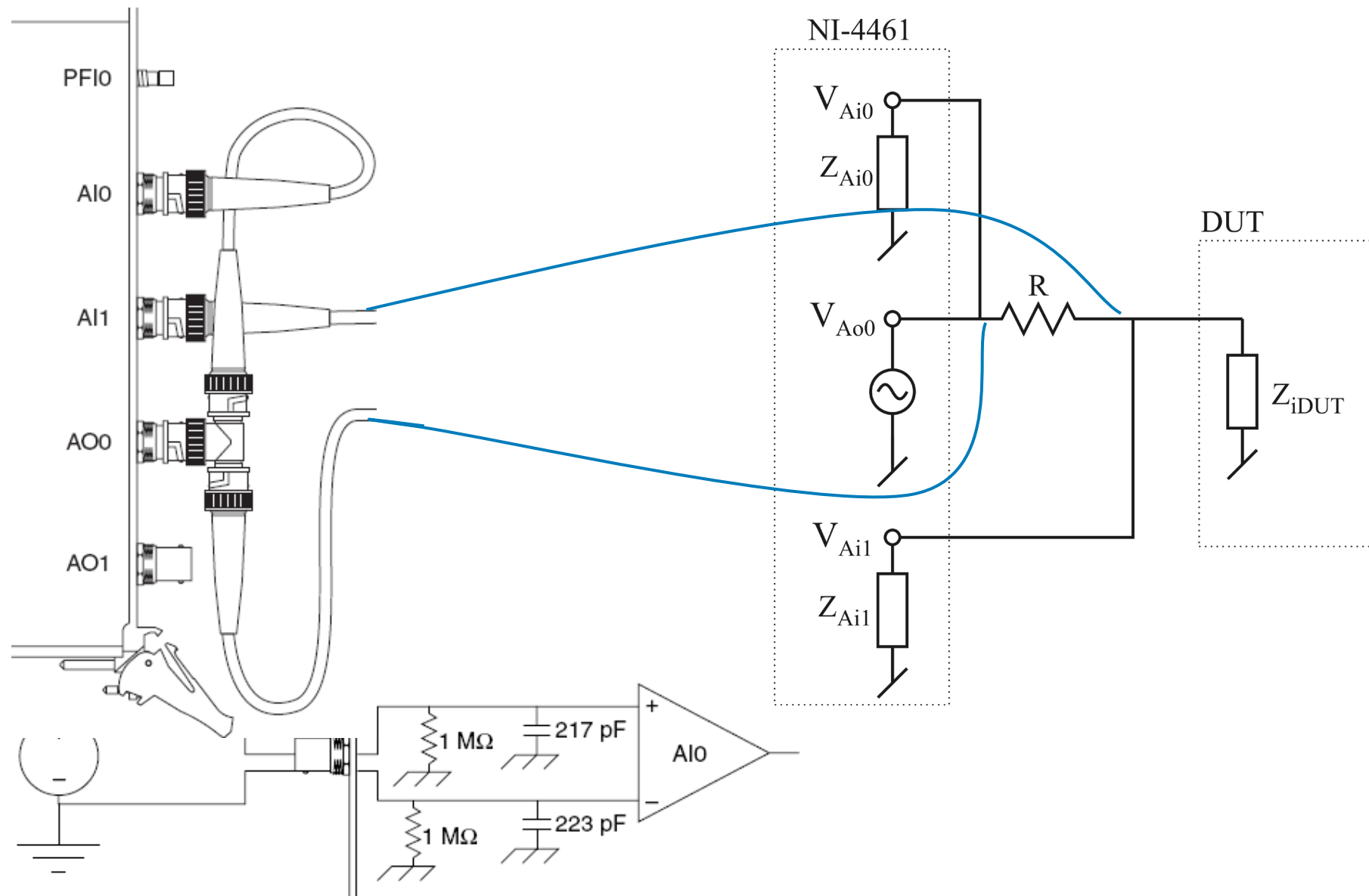
THDpct = 100*10.^(THDdB/20);

figure(1)
loglog(Vsource,Vfund./Vsource,Vsource,THDpct);
xlabel('Source amplitude [V]');
ylabel('Fundamental gain[-] & Distortion [%]');
grid;
```

Hold øje med
enheder



Måling af indgangsimpedans med "Swept Sine FRF VI"





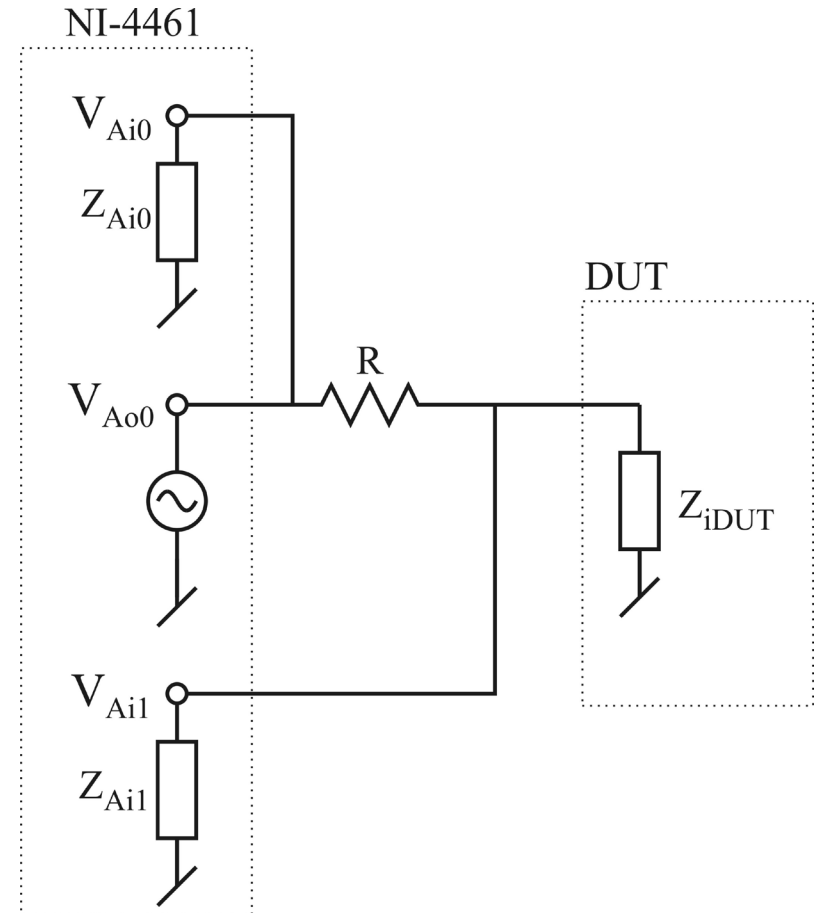
Måling med DUT:

$$\frac{V_{Ai1}}{V_{Ai0}} = \frac{Z_{iDUT} \parallel Z_{Ai1}}{R + Z_{iDUT} \parallel Z_{Ai1}}$$

$$R \frac{V_{Ai1}}{V_{Ai0}} = Z_{iDUT} \parallel Z_{Ai1} \left(1 - \frac{V_{Ai1}}{V_{Ai0}} \right)$$

$$Z_{iDUT} \parallel Z_{Ai1} = R \frac{\frac{V_{Ai1}}{V_{Ai0}}}{1 - \frac{V_{Ai1}}{V_{Ai0}}}$$

Måles som et
komplekst forhold
v.h.a.
"Swept Sine FRF VI"





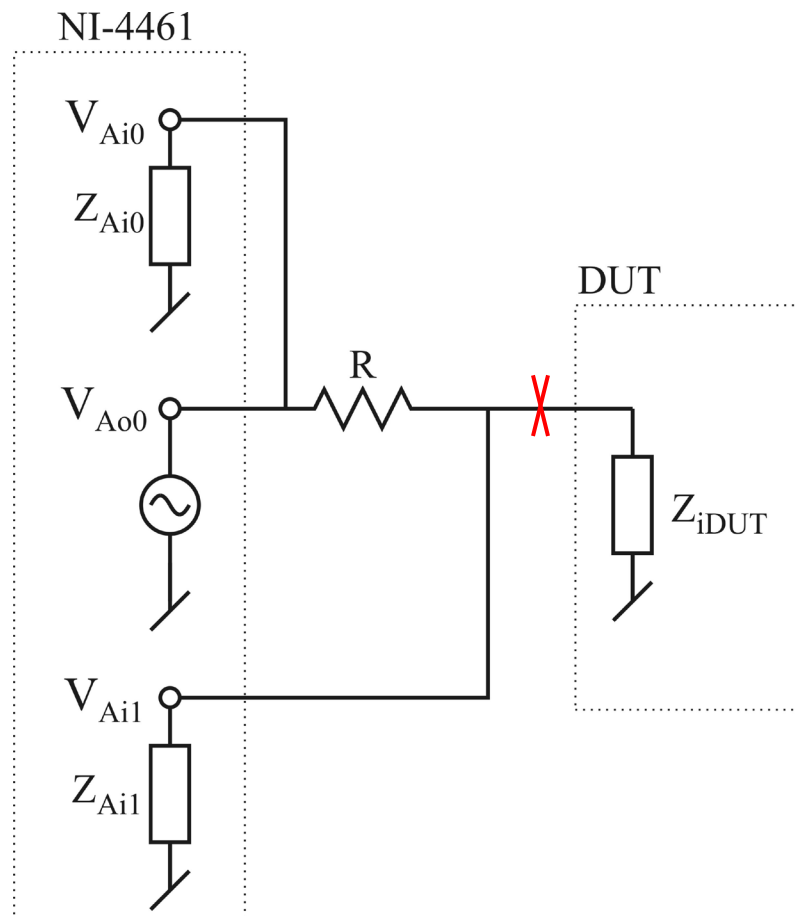
Måling uden DUT:

$$Z_{Ai1} = R \frac{\frac{V'_{Ai1}}{V'_{Ai0}}}{1 - \frac{V'_{Ai1}}{V'_{Ai0}}}$$

Måles som et
komplekst forhold
v.h.a.
"Swept Sine FRF VI"

Opdeling af parallellforbindelsen:

$$Z_{iDUT} = \left((Z_{iDUT} \parallel Z_{Ai1})^{-1} - Z_{Ai1}^{-1} \right)^{-1}$$





Måling af indgangsimpedans med "Swept Sine FRF VI"

```
% SweptSineImp.m                                071130/OKJ;  
% NI-4461 & Swept Sine FRF VI  
% Measurement of input impedance  
clear;
```

R = 10e3; % Series resistor – insert correct value

% READ MEASURED DATA with DUT connected

```
% txt-file with 9 header lines and 8 columns:  
% Freq[Hz], Ampl[dB], Phase[deg], THD[%], HD2[dBc], HD3[dBc], HD4[dBc], HD5[dBc]  
[FileA,PathA]=uigetfile('*.txt','Select measured frequency response file with DUT connected');  
FullFileA = fullfile(PathA,FileA);  
[Freq dBfund degFund dummy1 dummy2 dummy3 dummy4 dummy5]=textread(FullFileA,'%f%f%f%f%f%f%f%f','headerlines',9);
```

Vratio = 10.^(dBfund/20).*exp(j*degFund/180*pi); % Complex voltage ratio of Vai1/Vai0
Zboth = R*Vratio./(1-Vratio);

% READ MEASURED DATA without DUT connected

```
% txt-file with 9 header lines and 8 columns:  
% Freq[Hz], Ampl[dB], Phase[deg], THD[%], HD2[dBc], HD3[dBc], HD4[dBc], HD5[dBc]  
[FileA,PathA]=uigetfile('*.txt','Select measured frequency response file without DUT connected');  
FullFileA = fullfile(PathA,FileA);  
[Freq dBfund degFund dummy1 dummy2 dummy3 dummy4 dummy5]=textread(FullFileA,'%f%f%f%f%f%f%f%f','headerlines',9);
```

Vratio = 10.^(dBfund/20).*exp(j*degFund/180*pi); % Complex voltage ratio of Vai1/Vai0
Zai1 = R*Vratio./(1-Vratio);

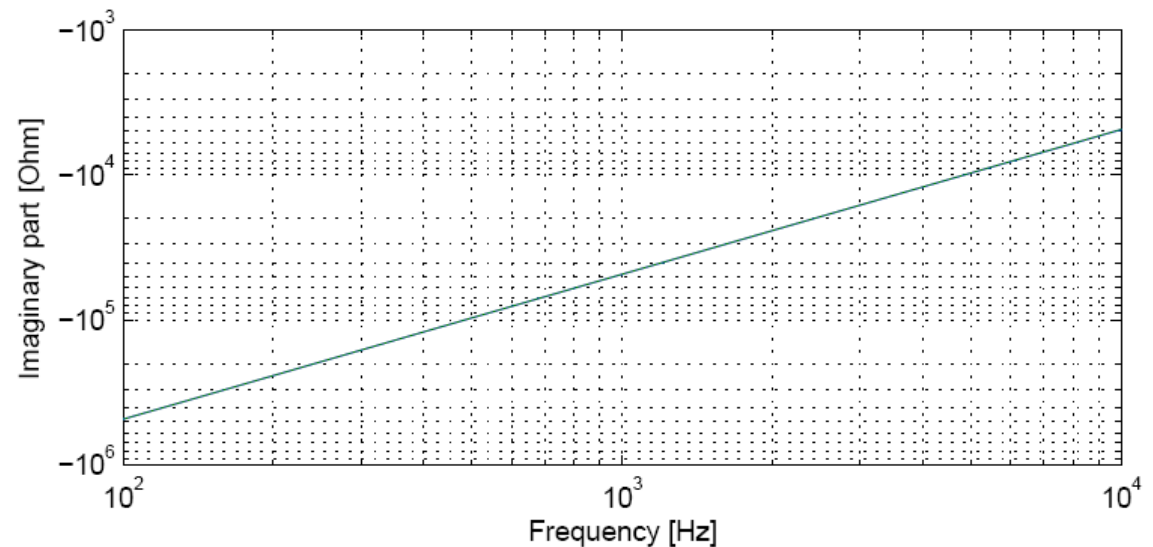
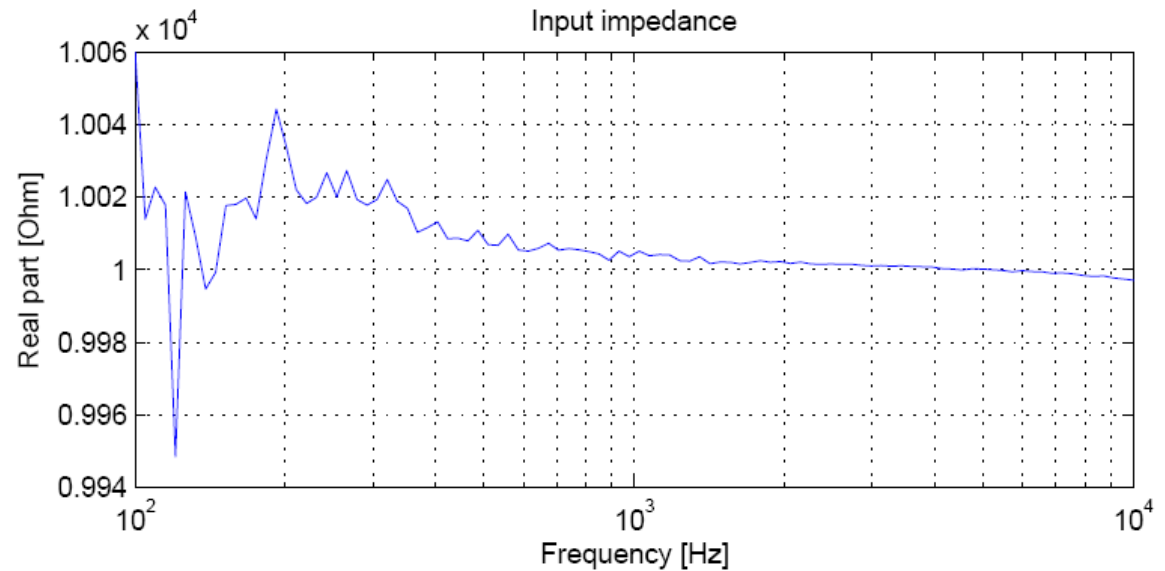
ZiDUT = 1./(1./Zboth - 1./Zai1);



Måling af indgangsimpedans med "Swept Sine FRF VI"

Eksempel på impedans-
måling:

10 k Ω i serie med
3,3 nF



Og det virker 😊



NI-4461 datablad

- <http://www.ni.com/pdf/products/us/pxi4461.pdf>

NI-4461 Detailed specifications

- <http://www.ni.com/pdf/manuals/373770g.pdf>
- <http://www.ni.com/pdf/manuals/373770j.pdf>

LabVIEW Sound and Vibration Toolkit User Manual

- <http://www.ni.com/pdf/manuals/322194c.pdf>

Øvelser:

- 310 & 311: Mandag 10:00-11:00
- 312 & 313: Mandag 11:00-12:00
- 314 & 315: Onsdag 15:00-16:00
(eller evt. fredag 12:30-13:30)

Plan B:

- 310 & 311: Mandag 9:30 – 10:30
- 312 & 313: Mandag 10:30 – 11:30
- 314 & 315: Mandag 11:30 – 12:30

I “mellemtiden”

- Målinger fra mm4. (f_H , f_L CE_{Re})

Læs øvelsesvejledningen inden I går i lab (nej, det har I vel allerede gjort?)