Frequency-domain considerations

The frequency domain can be used for

- A better understanding of time-domain system identification methods
  - A time-domain fit is equal to a weighed frequency-domain fit
- Fitting a model to frequency-domain measurements
  - Requires time consuming measurements, but simple calculations

Resumé - Frequency-domain considerations

A least squares fit in the time domain is equal to a weighed least squares fit of the frequency function. The frequency weighting factor is

$$Q(\omega) = |U_N(\omega)|^2$$

that is, the fit is best in the frequency range, where the input signal power is high.

The fit can be further weighted by filtering the signals u(k) and y(k) by a so called prefilter L(q), giving a weighting factor

$$Q(\omega) = |L(\omega)|^2 |U_N(\omega)|^2$$

The model parameters can alternatively be estimated by fitting the model to a measured frequency function, using a frequency-domain performance function of the type

$$P_f(\theta) = (1/2N) \sum | G_{of}(j\omega_k) - G_f(j\omega_k, \theta) |^2$$

Again a frequency weighting can be obtained by choosing different input sine amplitudes.

Input signal design

Rules of thumb

Linear systems:

The input signal shall have most of its power in the frequency range, where the accuracy of the model is most important

Nonlinear systems:

The amplitude range of the input signal shall correspond to the amplitude range, where the accuracy of the model is most important

where the accuracy of the model is most important

Procedure

Design an input signal optimizing sensitivity measures

Procedure for input design

1. Obtain approximative parameter estimates or acquire à priori parameter values.

2. Choose a class of preliminary input signals - shall depend on few (preferably just one) input signal parameters. One parameter, at least, shall control the frequency spectrum; if the model is nonlinear, an additional input signal parameter shall control the amplitude

3. Optimize the input signal for best possible sensitivity measures (simulation). Calculate and plot some of the characteristic sensitivity measures as a function of input signal parameters, and choose best values of these

4. Use the determined input signal on the real system.
   If necessary, repeat the procedure with the improved parameter values.

The Senstools program for optimal input design is called maininp.m

Examples

Example 17

Optimal input square wave for linear system

Example 18

Optimal input square rampe for non-linear system

Which sensitivity measure shall be optimized ?

Input design - resumé

- A procedure for design of an optimal input signal within a ceartain class was described
- For linear systems the class was square wave signals
- For non-linear systems the class was square rampe signals
- The fundamental frequency and the amplitude distribution (respectively) minimizing the sensitivity ratio R was chosen as optimal

- In many cases common sense and experience is sufficient for determination of a good input signal

Diverse

- Praktiske forhold ved eksperimenter
  - Måleopstilling med ’Grue’-filtre
  - Input startende med 10 nuller og kompenser for offset
- DCmotorDemo: udfra virkelige måledata bestemmes
  - Lineær model (simdcml)
  - Ulineær model (dcmn)

Evaluering af kurset

Spørgeskemaundersøgelse

- Svar venligst på såvel spørgeskema 1 som 2. Brug samme navn (må godt være alias)
- Links til begge fra kursets hjemmeside http://www.control.auc.dk/~mk/ExpMod/
- Spørgeskema 2 evaluering af kurset http://mii.auc.dk/mk/pr6-5/
- To fordele ved at besvare spørgeskema 2
  - Du giver et bidrag til et pædagogisk forskningsprojekt, som kan medvirke til at forbedre undervisningen på AAU
  - Du får et bedre overblik over kurset

Foretrukne læringsstile, middelværdi af 18 svar:

1. Informationskanal:

Visuel: figurer, diagrammer, billeder **7.1**

Verbal: ord i tekst eller tale 0.5

2. Informationsbehandling:

Aktiv: lærer ved at bruge informationen f. eks. i opgaver, projekter eller disk. 2.7

Reflekterende: tænker og prøver at opnå forståelse 1.3

3. Opfattelse:

Sansning: konkrete data og facts 3.4

Intuition: teorier og fortolkninger af information 2.1

4. Forståelse:

Sekventiel: forståelsen opbygges skridt for skridt 0.7

Global: ønsker overblik/overordnet forståelse inden detaljerne (top-down) **4.3**