

Extra Content for: Rolf Isermann, Marco Münchhof:  
**Identification of Dynamic Systems.**  
Springer. ISBN 978-3-540-78878-2

# Experimental Data of the Three-Mass Oscillator

MATLAB<sup>®</sup> compatible files



# Important Remarks (1/2)

These data **should only be used as companion data for the book Identification of Dynamic Systems**. Using these data without a profound knowledge of the identification methods as described in the book will lead to **useless and/or erroneous results**.

The given measurements of the Three-Mass Oscillator **must be pre-processed** in order to obtain optimal results.

**The measurements have furthermore been sampled with very small sample times** in order to allow the user to downsample the data and hence adjust the sample rate and investigate the influence of the sample time on the results. **Using the data directly with such heavy oversampling can result in numerical problems.**



# Important Remarks (2/2)

Some measurements have been conducted **on purpose** in such a **way that they do not provide useful results** as e.g. the input sequence does not excite the relevant system dynamics.

Please consult the appropriate sections in the book to see detailed discussions of the suitability of the input sequences.

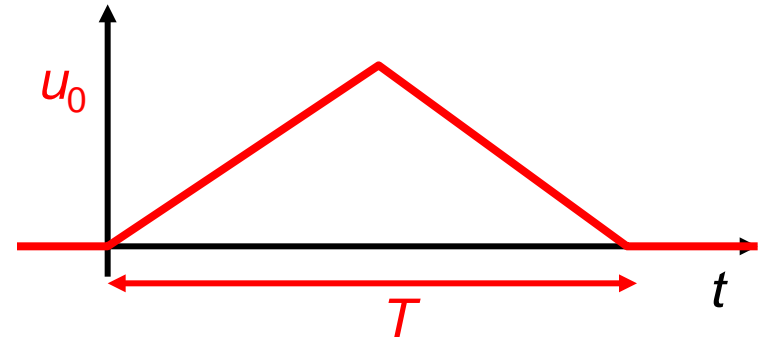
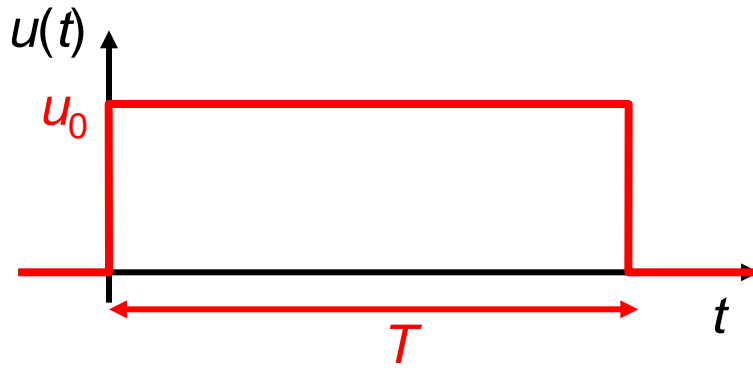


# File Structure

Variable	Name	Variable	Name
Time	time	Motor Torque	MM
$\varphi_1$	phi1	$d\varphi_1 / dt$	dphi1
$\varphi_2$	phi2	$d\varphi_2 / dt$	dphi2
$\varphi_3$	phi3	$d\varphi_3 / dt$	dphi3
Sample Time	T0	Factor $\mu$ for PRBS	mue



# Non-Periodic Test Signals



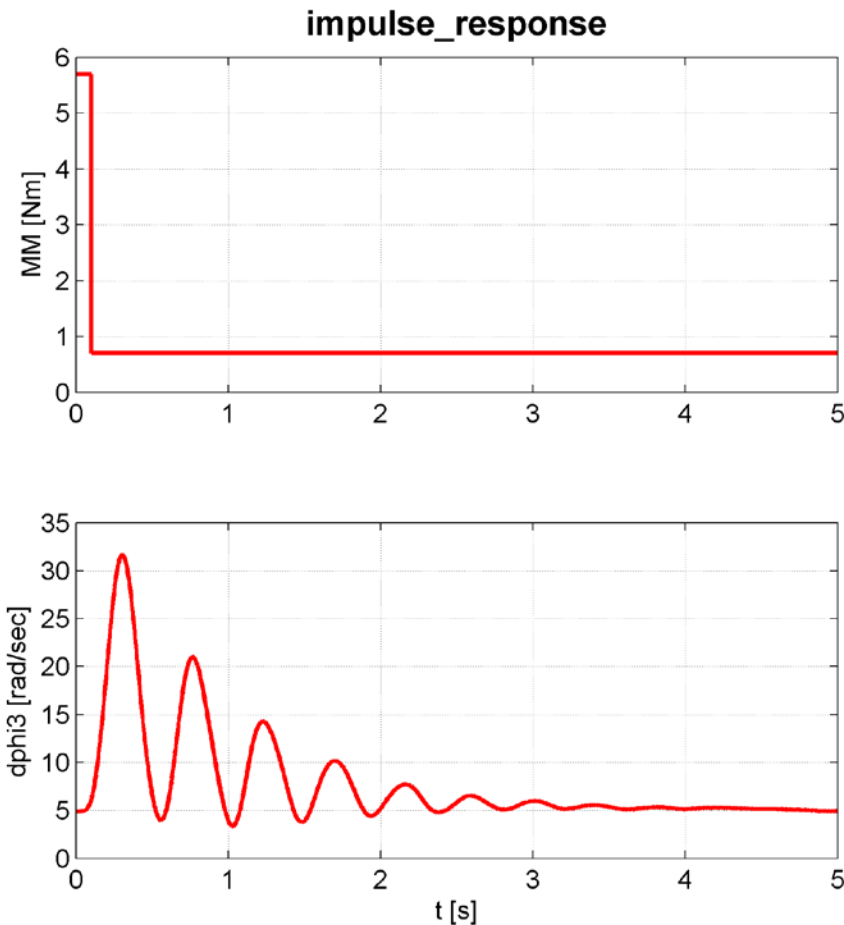
# Impulse

**Excitation:** Impulse, i.e. approximation by a short step of duration 0.1s and height 5 Nm over an offset of 0.7 Nm (total height 5.7 Nm). The impulse response is measured for comparison with methods that provide an impulse response as a model.

**Sample Time:** 0.003 s

**Files:**

- impulse\_response



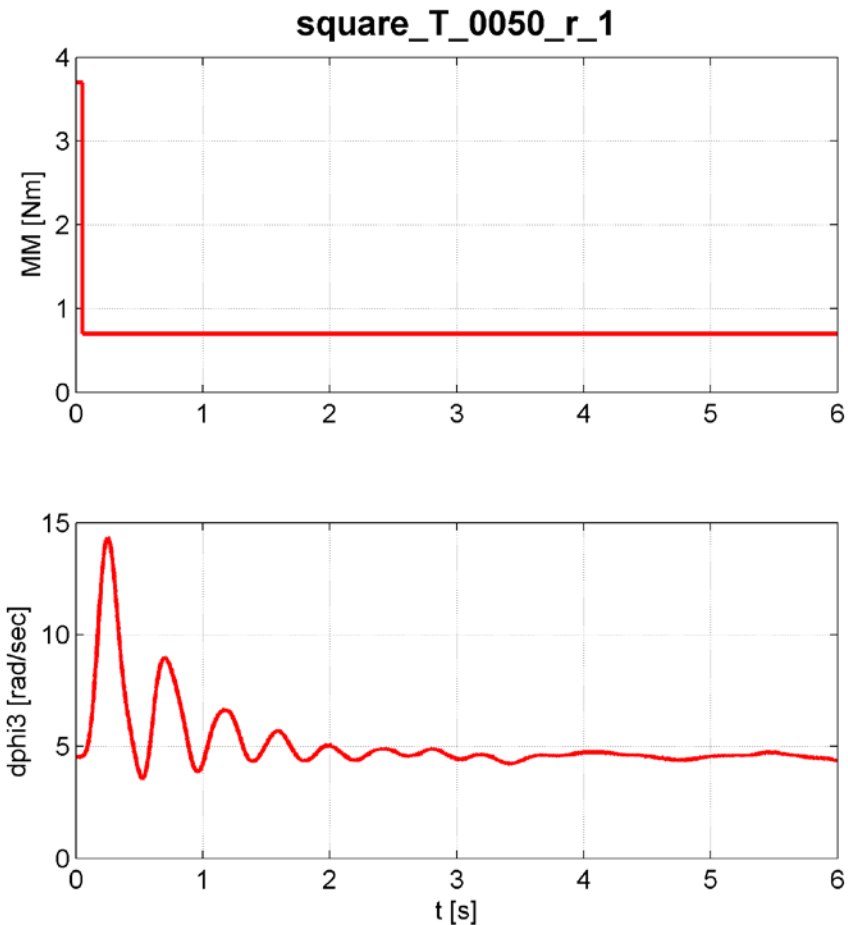
# Square Pulse 0.05 s

**Excitation:** Square pulse of length 0.05 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0050\_r\_1



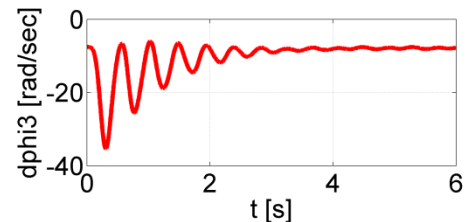
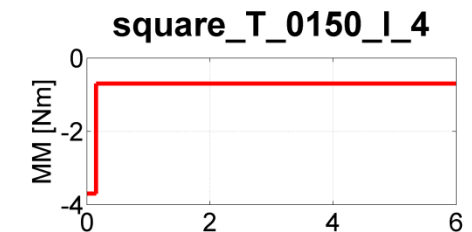
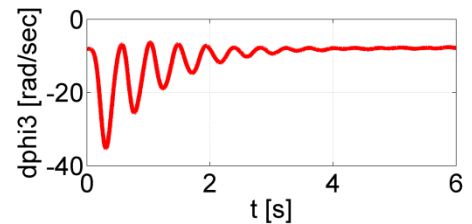
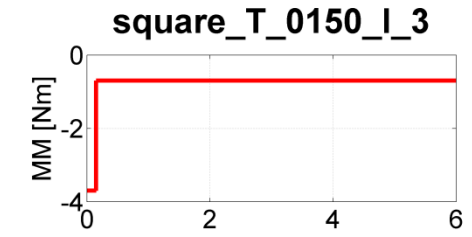
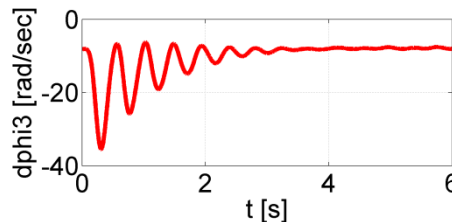
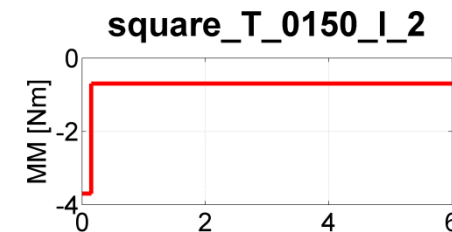
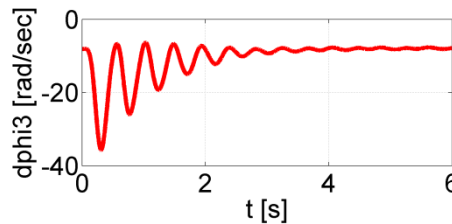
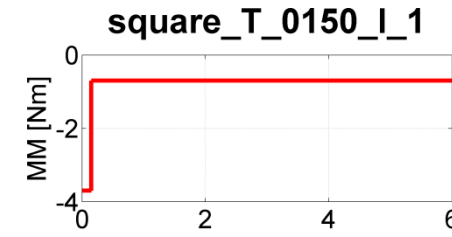
# Negative Square Pulse 0.15 s (1/2)

**Excitation:** Negative square pulse of length 0.15 s and height -3 Nm over an offset of -0.7 Nm (total height -3.7 Nm)

**Sample Time:** 0.003 s

## Files:

- square\_T\_0150\_l\_1
- square\_T\_0150\_l\_2
- square\_T\_0150\_l\_3
- square\_T\_0150\_l\_4





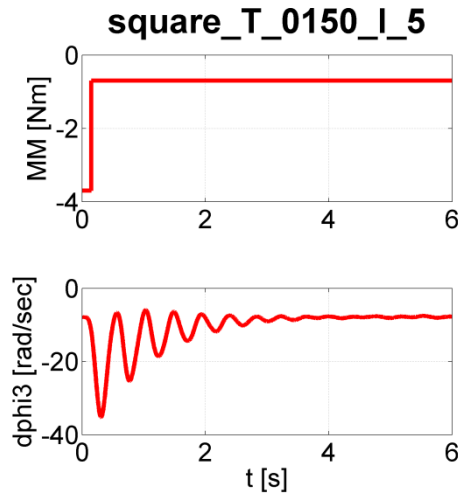
# Negative Square Pulse 0.15 s (2/2)

**Excitation:** Negative square pulse of length 0.15 s and height -3 Nm over an offset of -0.7 Nm (total height -3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0150\_1\_5



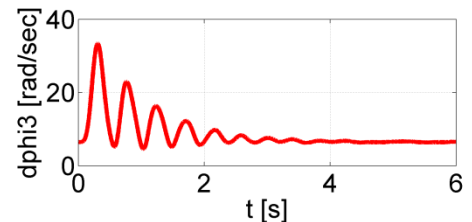
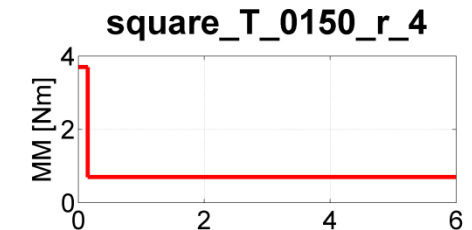
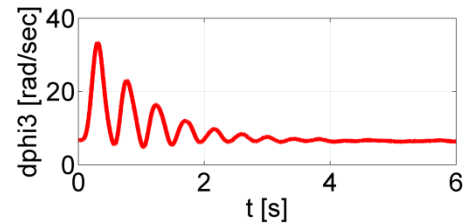
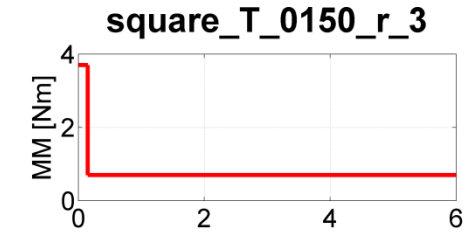
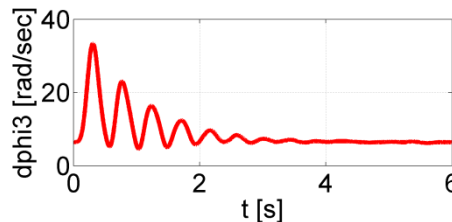
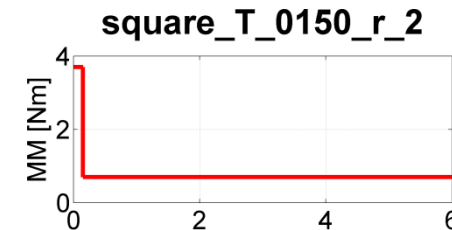
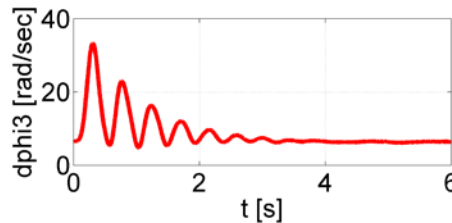
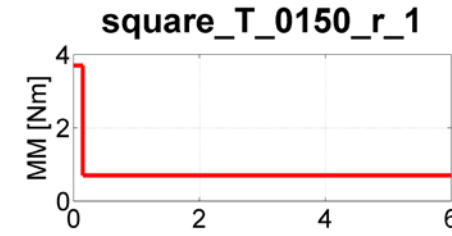
# Square Pulse 0.15 s (1/2)

**Excitation:** Square pulse of length 0.15 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

## Files:

- square\_T\_0150\_r\_1
- square\_T\_0150\_r\_2
- square\_T\_0150\_r\_3
- square\_T\_0150\_r\_4



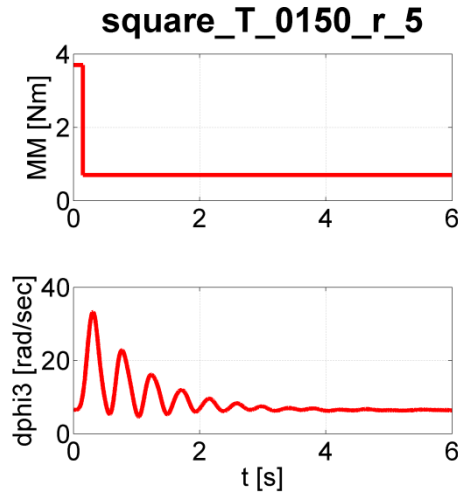
# Square Pulse 0.15 s (2/2)

**Excitation:** Square pulse of length 0.15 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0150\_r\_5



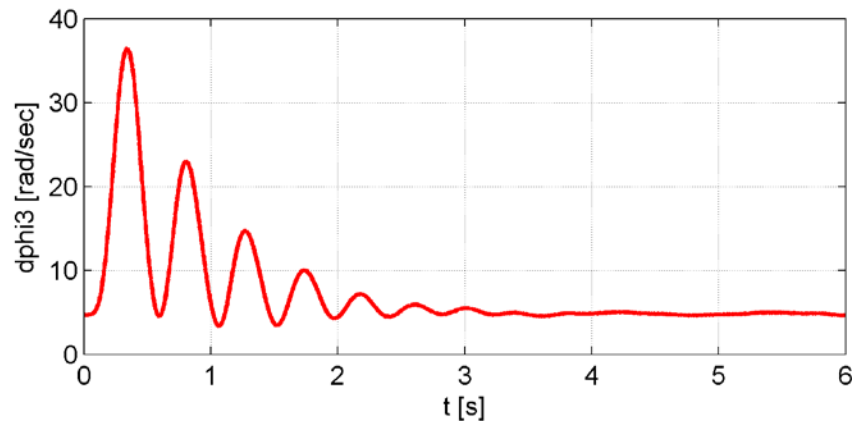
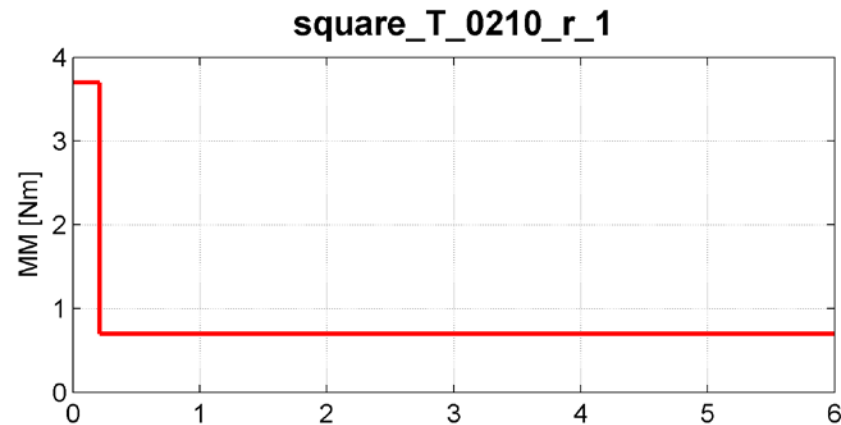
# Square Pulse 0.21 s

**Excitation:** Square pulse of length 0.21 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0210\_r\_1



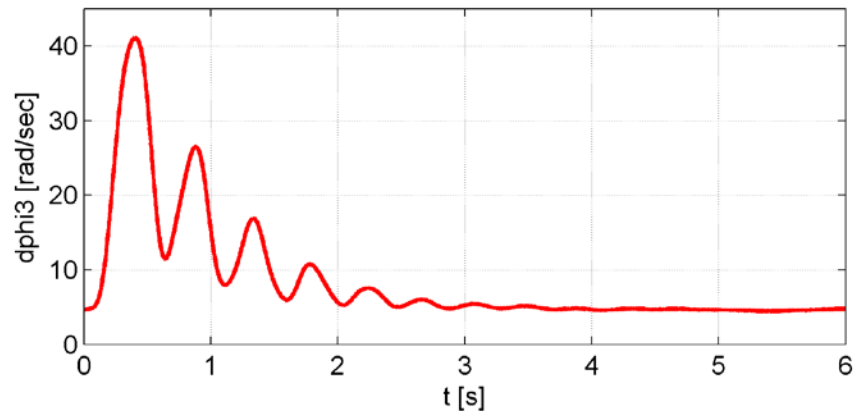
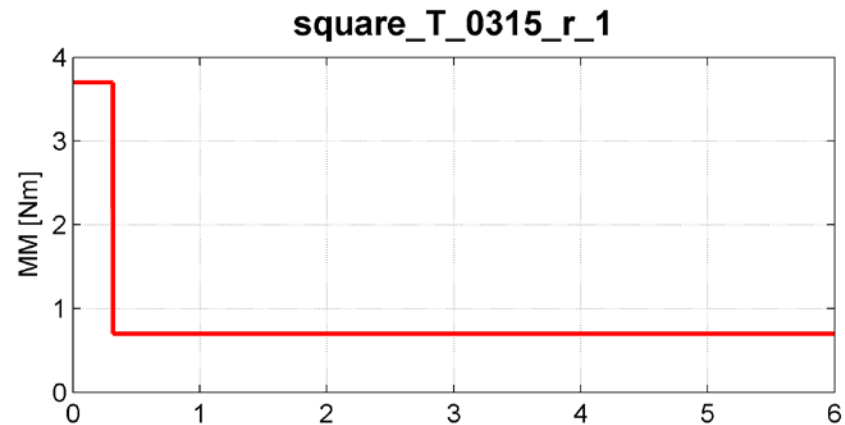
# Square Pulse 0.315 s

**Excitation:** Square pulse of length 0.315 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0315\_r\_1



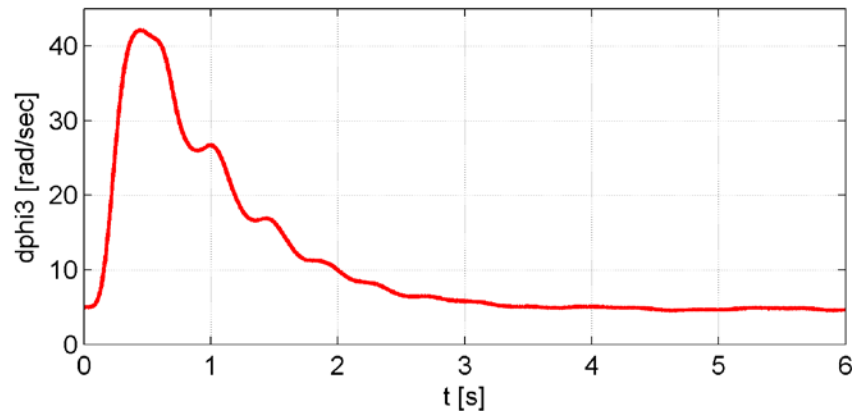
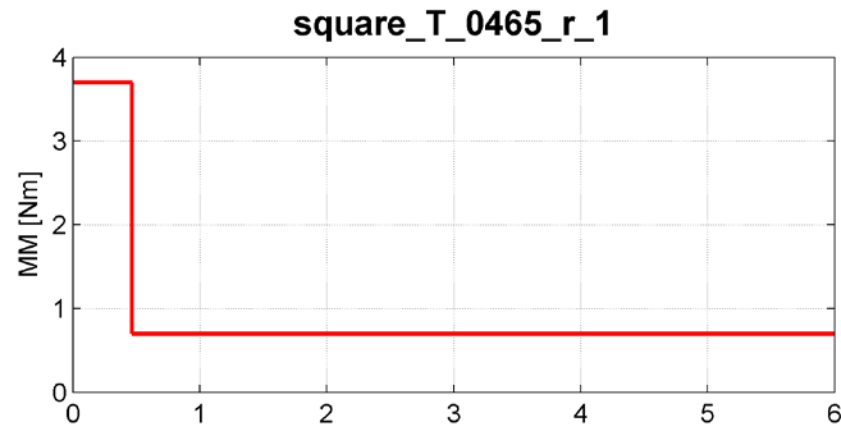
# Square Pulse 0.465 s

**Excitation:** Square pulse of length 0.465 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0465\_r\_1



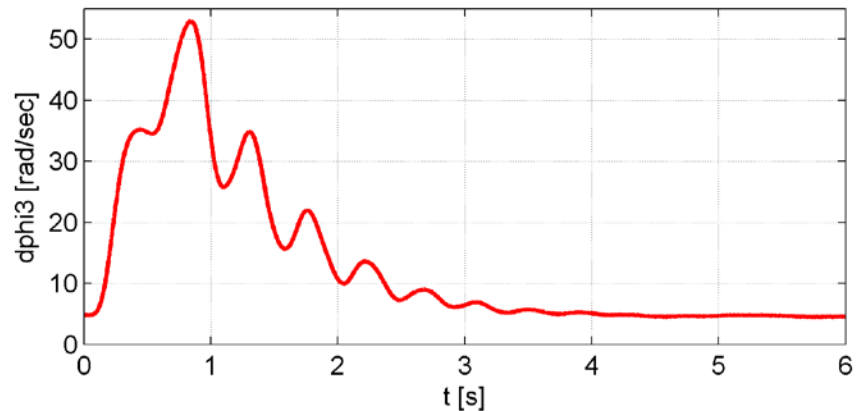
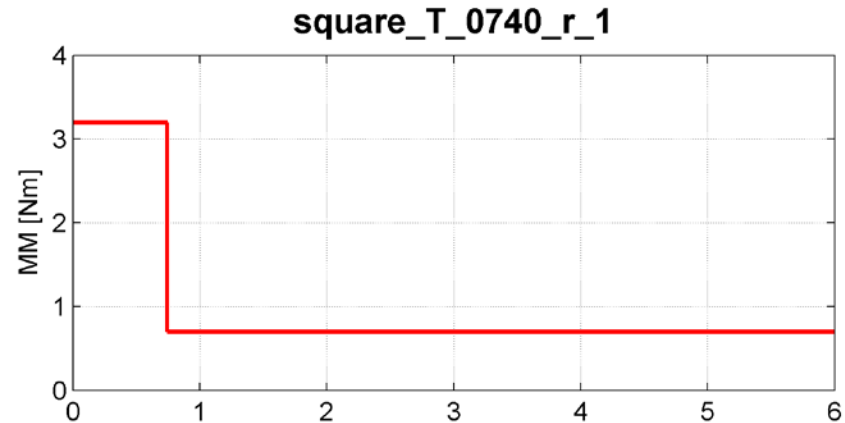
# Square Pulse 0.740 s

**Excitation:** Square pulse of length 0.740 s and height 2.5 Nm over an offset of 0.7 Nm (total height 3.2 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_0740\_r\_1



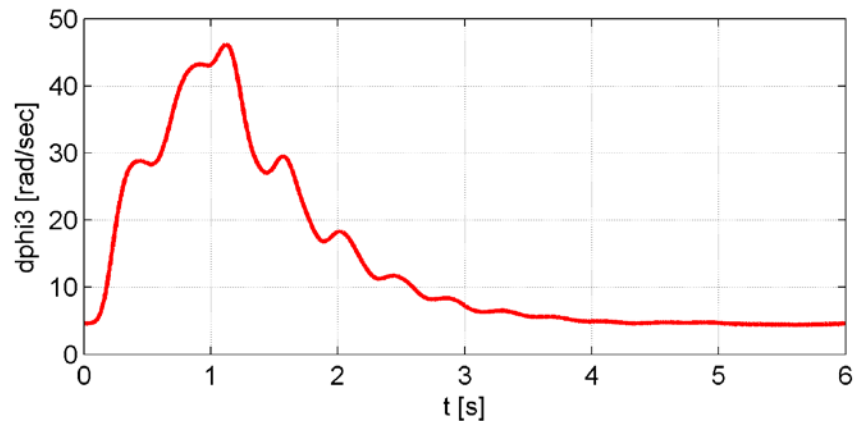
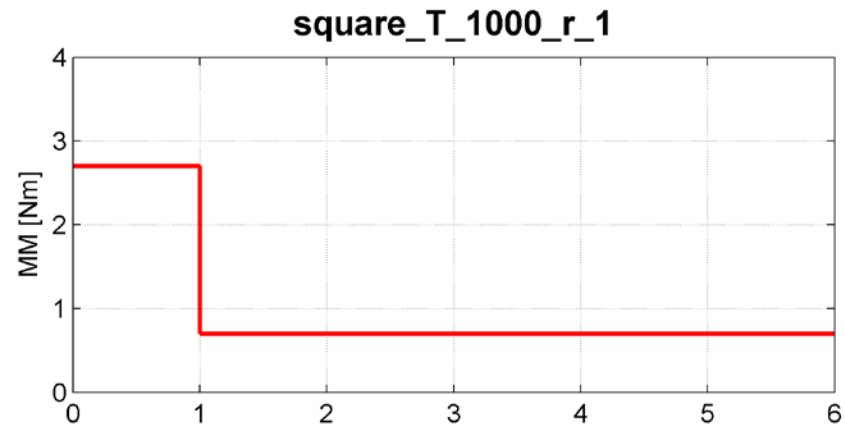
# Square Pulse 1.000 s

**Excitation:** Square pulse of length 1.000 s and height 2 Nm over an offset of 0.7 Nm (total height 2.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- square\_T\_1000\_r\_1





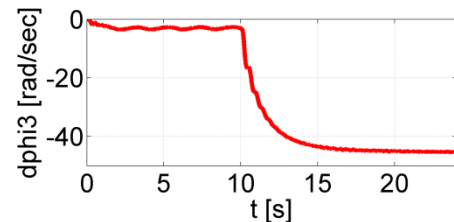
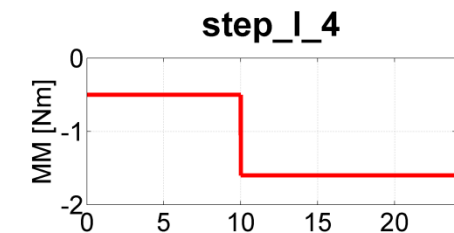
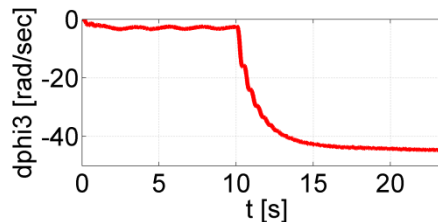
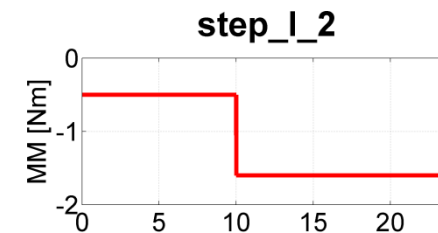
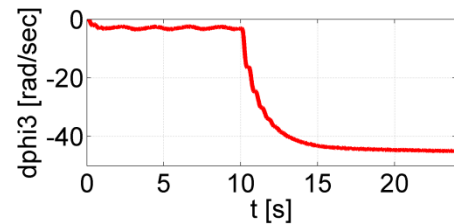
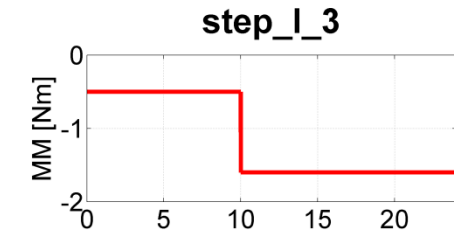
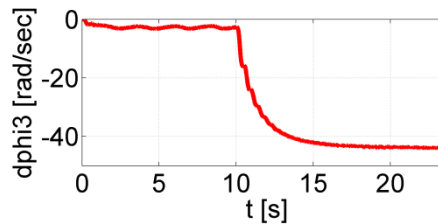
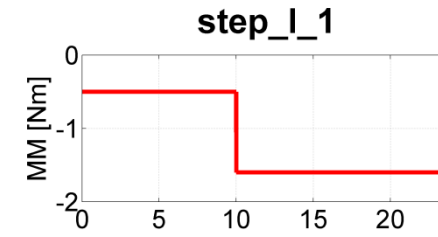
# Negative Step (1/2)

**Excitation:** Negative step at time  $t=10$  s and height  $-1.1$  Nm over an offset of  $-0.5$  Nm (total height  $-1.6$  Nm)

**Sample Time:** 0.003 s

## Files:

- step\_l\_1
- step\_l\_2
- step\_l\_3
- step\_l\_4



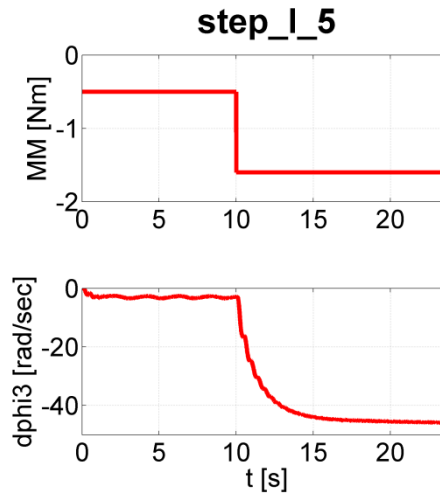
# Negative Step (2/2)

**Excitation:** Negative step at time  $t=10$  s and height  $-1.1$  Nm over an offset of  $-0.5$  Nm (total height  $-1.6$  Nm)

**Sample Time:** 0.003 s

**Files:**

- step\_1\_5



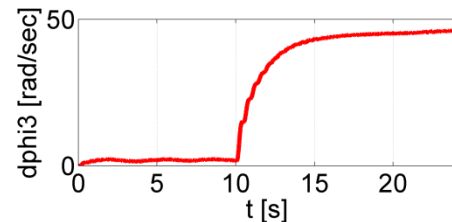
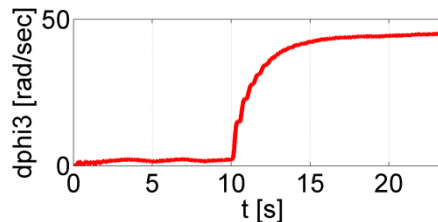
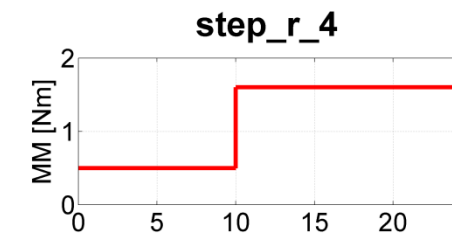
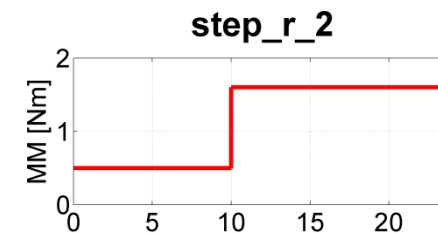
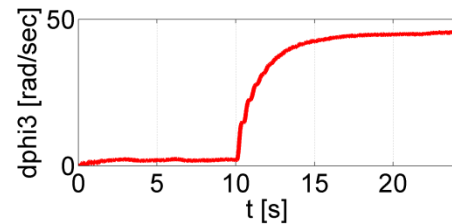
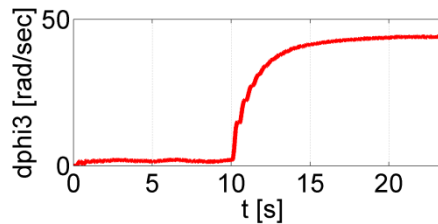
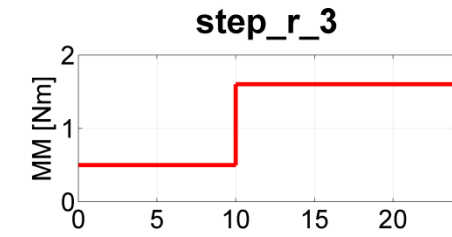
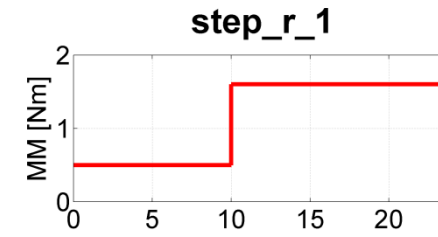
# Step (1/2)

**Excitation:** Negative step at time  $t=10$  s and height 1.1 Nm over an offset of 0.5 Nm (total height 1.6 Nm)

**Sample Time:** 0.003 s

## Files:

- step\_r\_1
- step\_r\_2
- step\_r\_3
- step\_r\_4



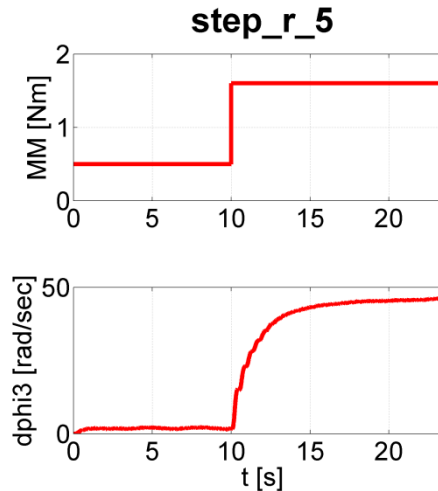
# Step (2/2)

**Excitation:** Step at time  $t=10$  s and height 1.1 Nm over an offset of 0.5 Nm

**Sample Time:** 0.003 s

**Files:**

- step\_r\_5



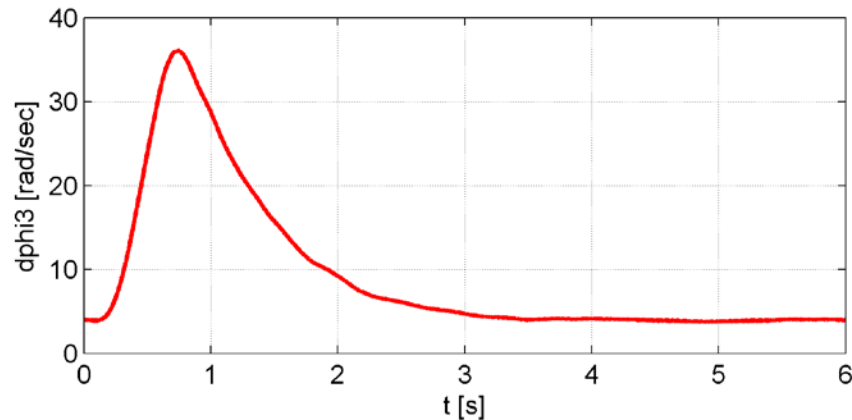
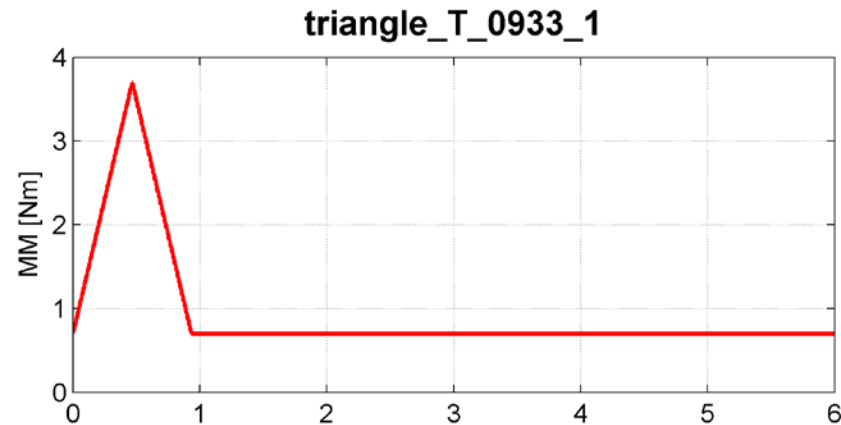
# Triangle 0.933s

**Excitation:** Triangular pulse of length 0.933 s and height 3 Nm over an offset of 0.7 Nm (total height 3.7 Nm)

**Sample Time:** 0.003 s

**Files:**

- triangle\_T\_0933\_1

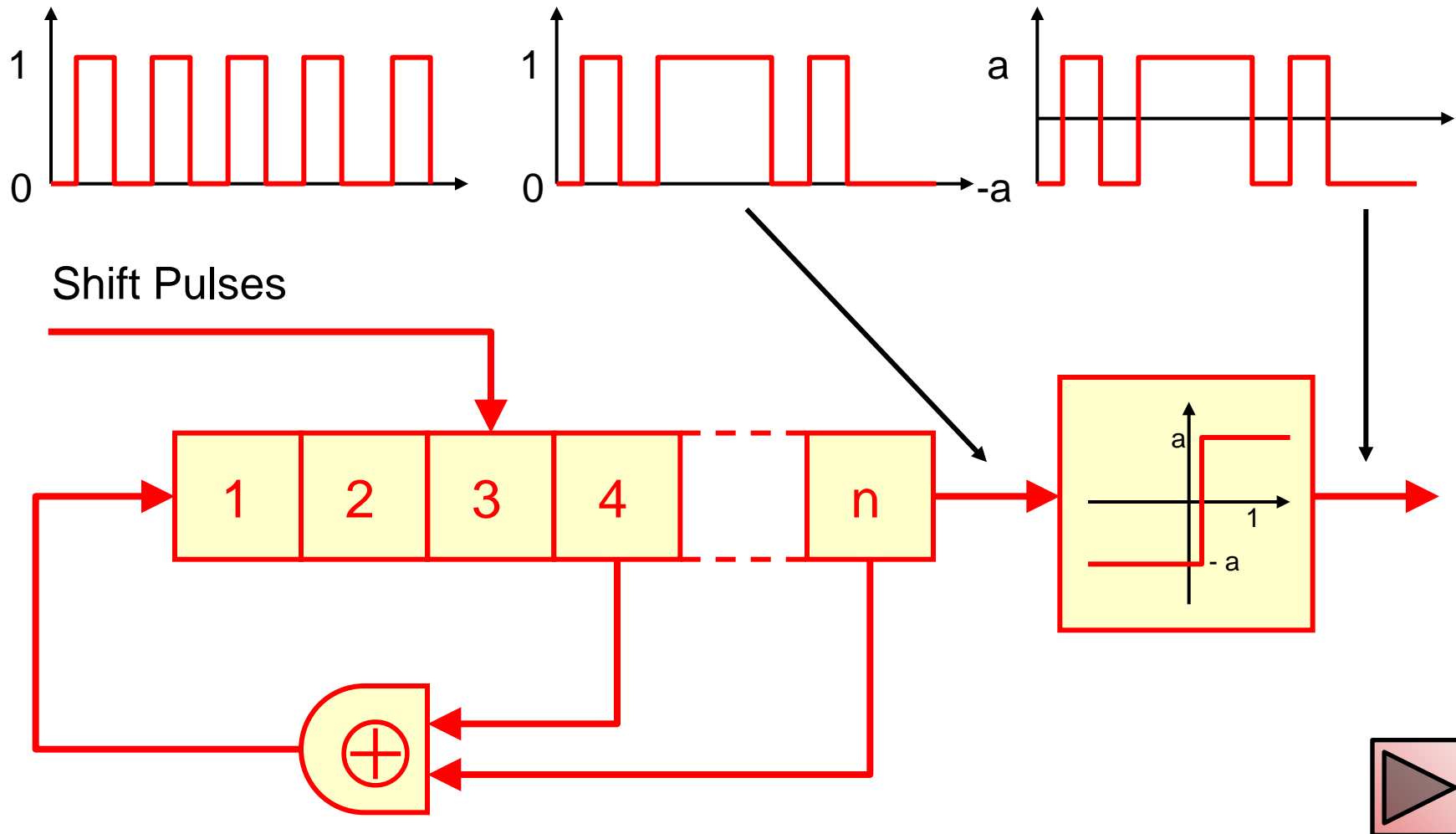


# Evaluation with Fourier Transform

- Use data set `square_T_0150_r_1`
- Subtract the DC values
- Downsampling not necessary
- Warning: The file `triangle_T_0933_1` is totally unsuited as the first zero of the input spectrum coincides with the resonant frequency of the system



# PRBS Signals



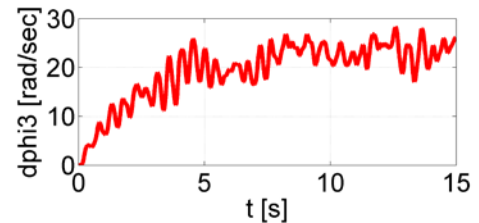
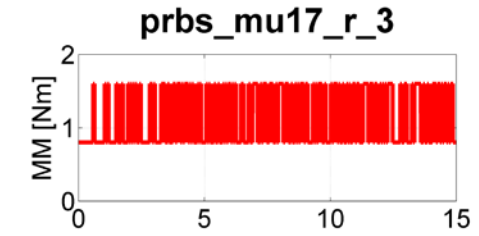
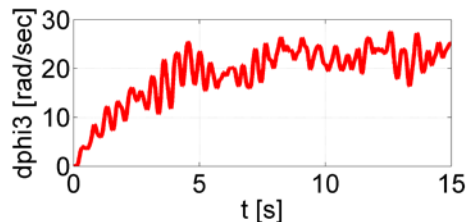
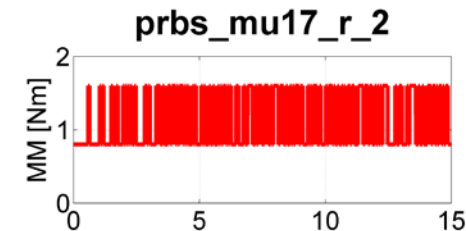
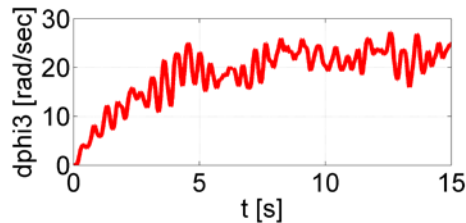
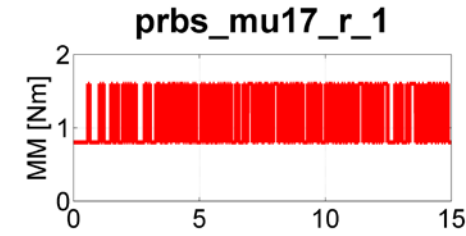
# PRBS with $\mu=17$

**Excitation:** PRBS with  $\mu=17$   
and values 0.8 Nm and 1.6 Nm

**Sample Time:** 0.003 s

## Files:

- prbs\_mu17\_r\_1
- prbs\_mu17\_r\_2
- prbs\_mu17\_r\_3





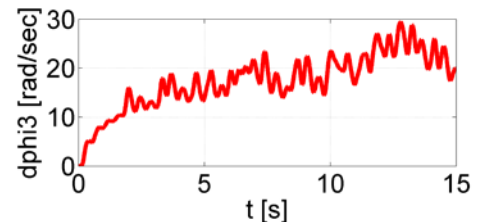
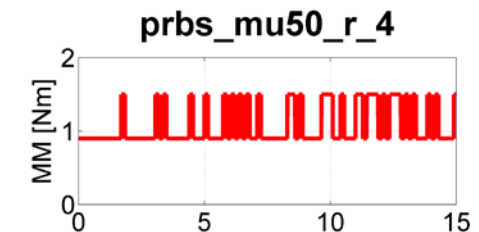
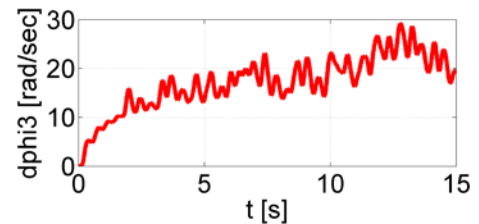
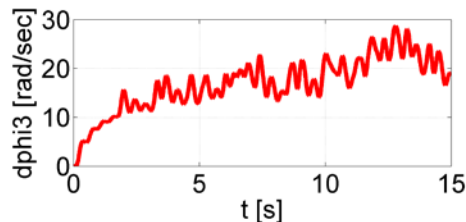
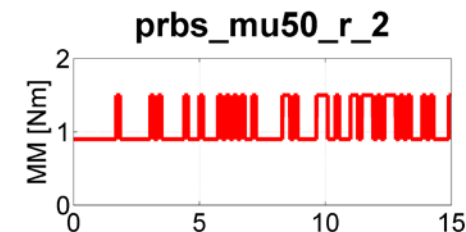
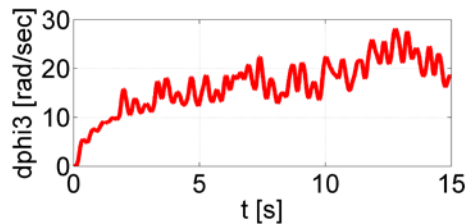
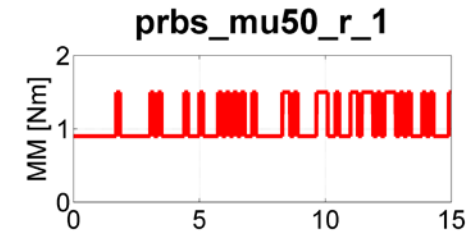
# PRBS with $\mu=50$ (1/2)

**Excitation:** PRBS with  $\mu=50$   
and values 0.8 Nm and 1.6 Nm

**Sample Time:** 0.003 s

## Files:

- prbs\_mu50\_r\_1
- prbs\_mu50\_r\_2
- prbs\_mu50\_r\_3
- prbs\_mu50\_r\_4



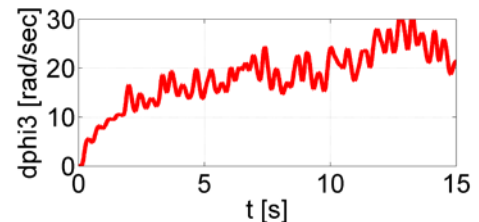
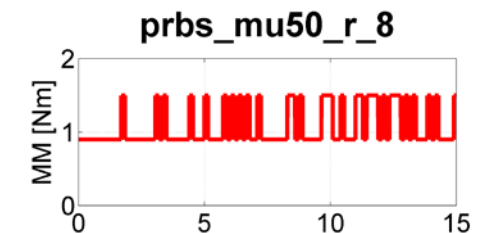
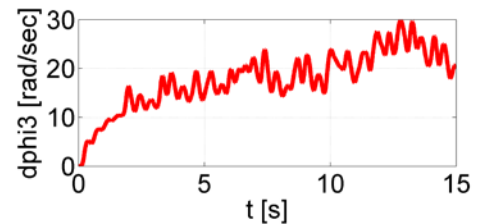
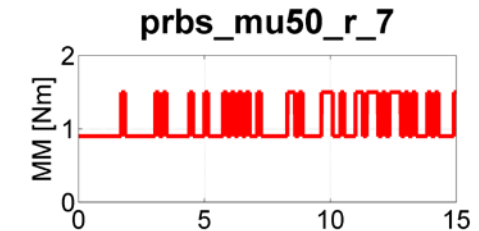
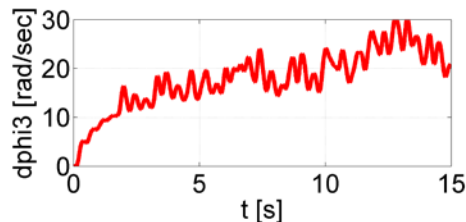
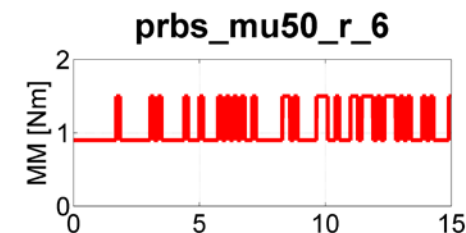
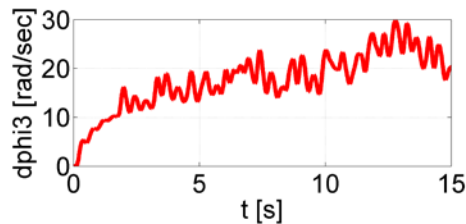
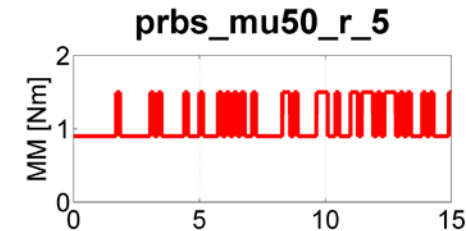
# PRBS with $\mu=50$ (2/2)

**Excitation:** PRBS with  $\mu=50$   
and values 0.8 Nm and 1.6 Nm

**Sample Time:** 0.003 s

## Files:

- prbs\_mu50\_r\_5
- prbs\_mu50\_r\_6
- prbs\_mu50\_r\_7
- prbs\_mu50\_r\_8



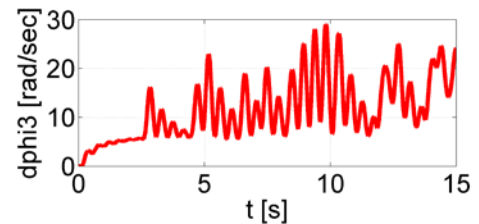
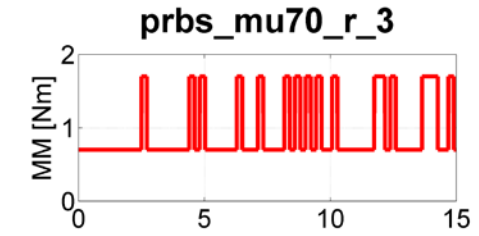
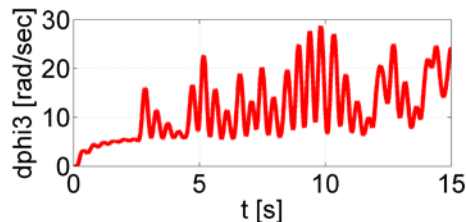
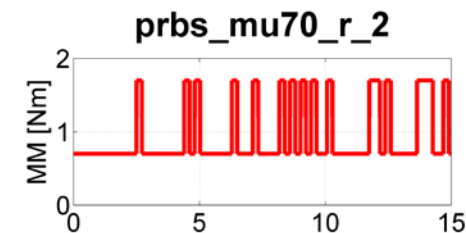
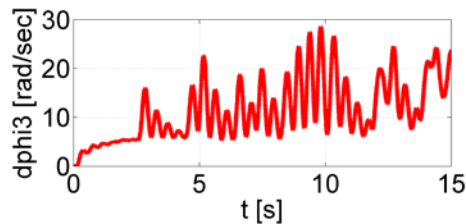
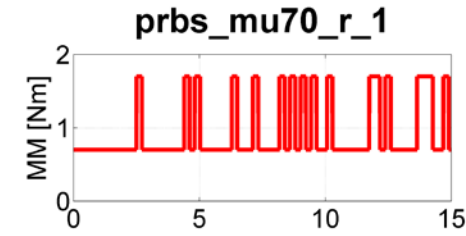
# PRBS with $\mu=70$

**Excitation:** PRBS with  $\mu=70$   
and values 0.8 Nm and 1.6 Nm

**Sample Time:** 0.003 s

**Files:**

- prbs\_mu70\_r\_1
- prbs\_mu70\_r\_2
- prbs\_mu70\_r\_3



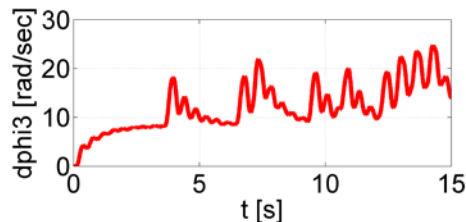
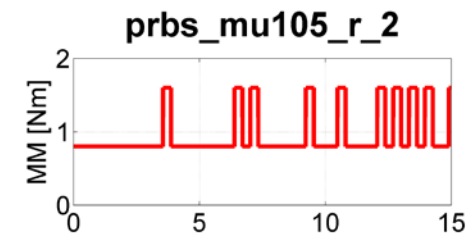
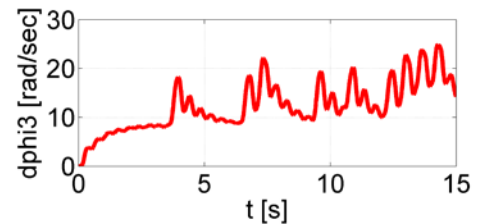
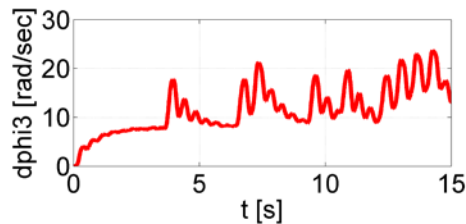
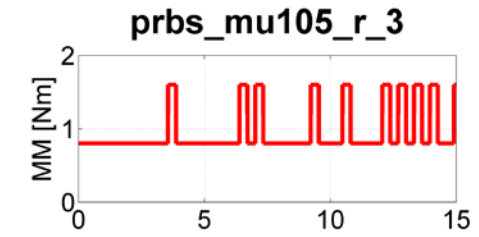
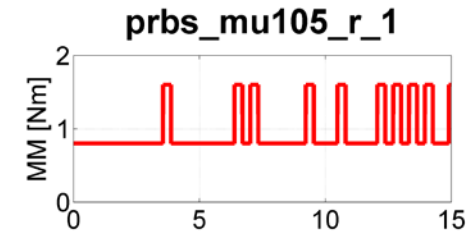
# PRBS with $\mu=105$

**Excitation:** PRBS with  $\mu=105$   
and values 0.8 Nm and 1.6 Nm

**Sample Time:** 0.003 s

## Files:

- prbs\_mu105\_r\_1
- prbs\_mu105\_r\_2
- prbs\_mu105\_r\_3



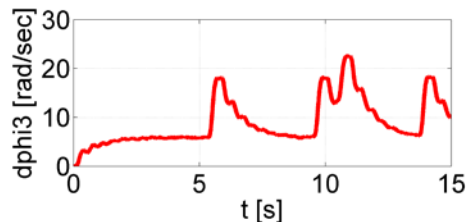
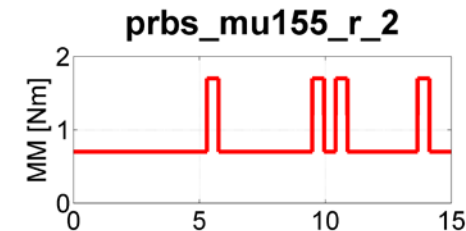
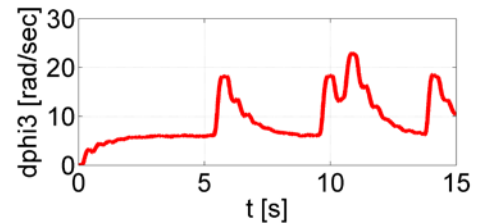
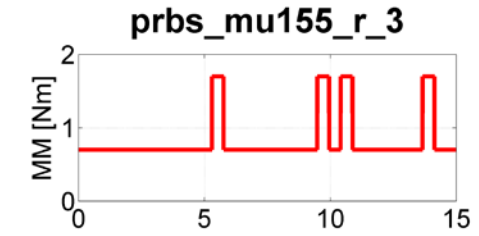
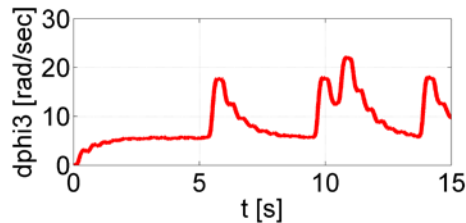
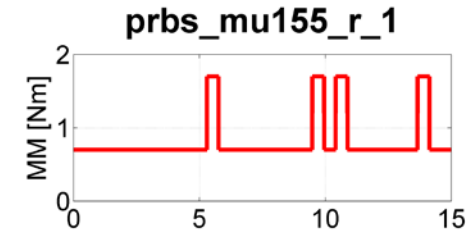
# PRBS with $\mu=155$

**Excitation:** PRBS with  $\mu=155$   
and values 0.8 Nm and 1.6 Nm

**Sample Time:** 0.003 s

## Files:

- prbs\_mu155\_r\_1
- prbs\_mu155\_r\_2
- prbs\_mu155\_r\_3



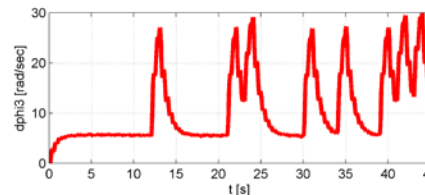
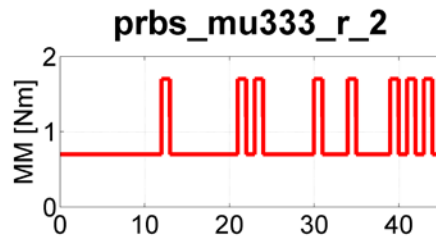
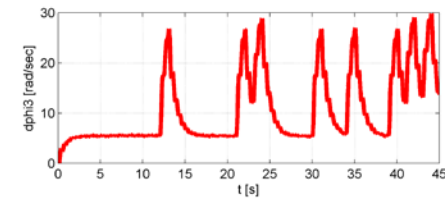
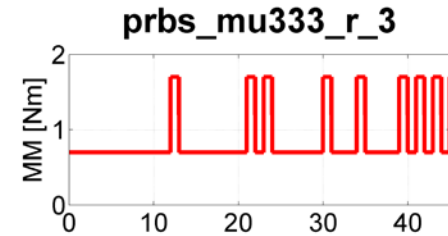
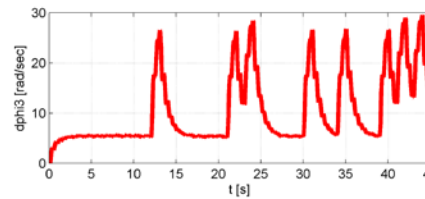
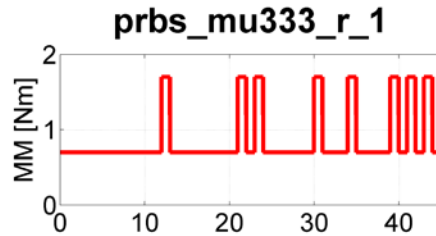
# PRBS with $\mu=333$

**Excitation:** PRBS with  $\mu=333$   
and values 0.8 Nm and 1.6  
Nm

**Sample Time:** 0.003 s

## Files:

- prbs\_mu333\_r\_1
- prbs\_mu333\_r\_2
- prbs\_mu333\_r\_3



# Evaluation with Deconvolution for Discrete-Time Model

- Use data set `prbs_mu50_r_1`
- Subtract the DC values
- Downsampling by a factor of 15
- Warning: The PRBS does only resemble the ACF of a DRBS and a white noise if evaluated over full periods!



# Evaluation with LS for Discrete-Time Model

- Use data set `prbs_mu70_r_1`
- Subtract the DC values
- Downsampling by a factor of 16





# Evaluation with COR-LS for Discrete-Time Model

- Use data set `prbs_mu17_r_2`
- Subtract the DC values
- Downsampling by a factor of 16



# Evaluation with Kiefer Wolfowitz for Discrete-Time Model

- Use data set `prbs_mu70_r_1`
- Subtract the DC values
- Downsampling by a factor of 16



# Evaluation with LS for Continuous-Time Model

- Use data set `prbs_mu70_r_1`
- Subtract the DC values
- Downsampling by a factor of 16
- Filter with a Butterworth low-pass filter of order 9 and corner frequency 6 Hz



# Evaluation with Iterative Optim. for Continuous-Time Model

- Use data set `prbs_mu50_r_1`
- Simulation must run sufficiently fast and is independent of the factor that the data are downsampled

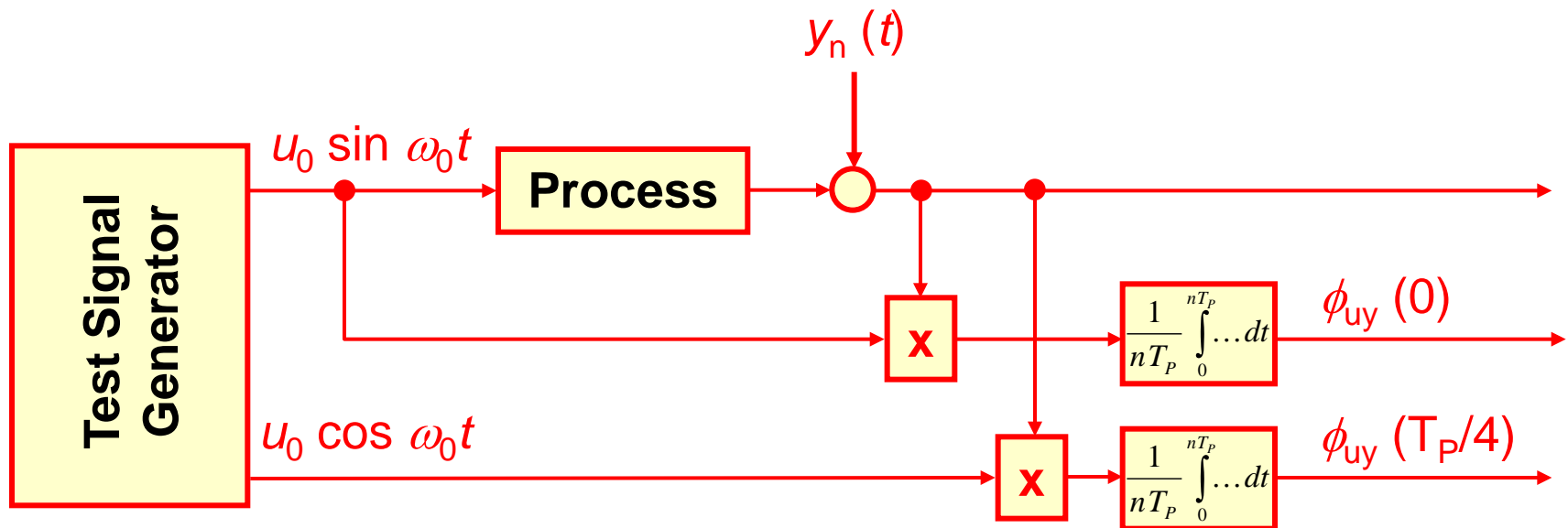


# Evaluation with LOLIMOT for Discrete-Time Model

- Use data set `prbs_mul7_r_2`
- Subtract the DC values
- Downsampling by a factor of 16



# Periodic Signals



# File Structure

Variable	Name	Unit
$\omega$	w	rad/sec
Amplitude	amplitude_osc	rad/s Nm
Phase	phase_osc	rad



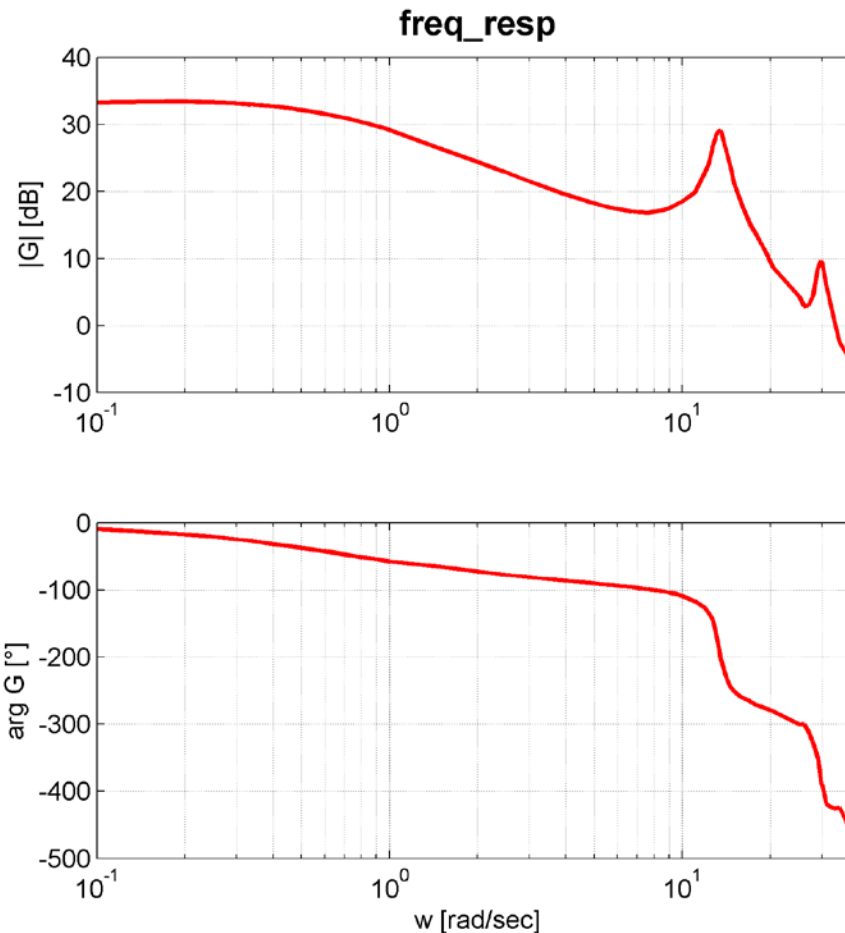
# Frequency Response Measured with Orthogonal Correlation

**Excitation:** Sinusoidal excitation and evaluation with the orthogonal correlation

**Data Points:** 68 data points between 0.1 rad/sec and 40 rad/sec.

**Files:**

- freq\_resp





# Evaluation with FR-LS for Continuous-Time Model

- Use data set `freq_resp`
- No further pre-processing necessary



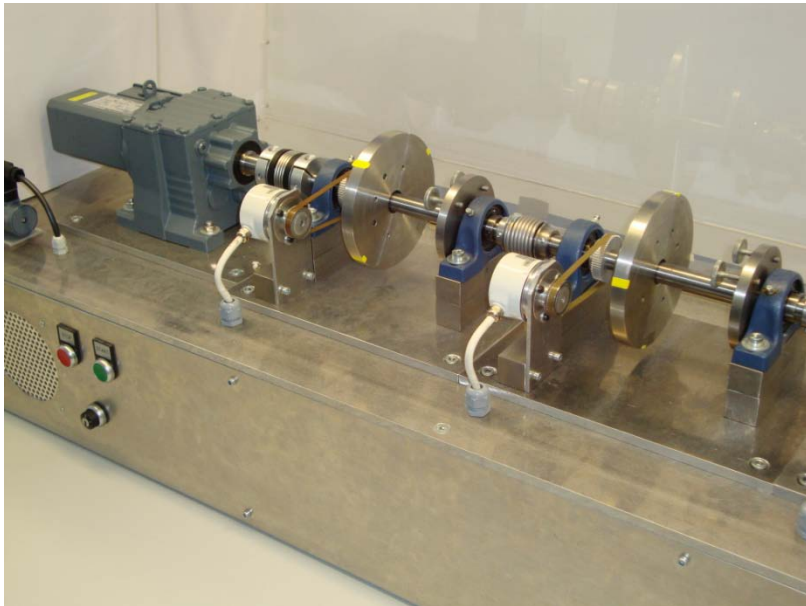
# Evaluation with Iterative Optim. for Continuous-Time Model

- Use data set `freq_resp`
- No further pre-processing necessary



# Photos of the Three-Mass Oscillator

## Detail View



File

three-mass-oscillator-photo1.jpg

## Full View



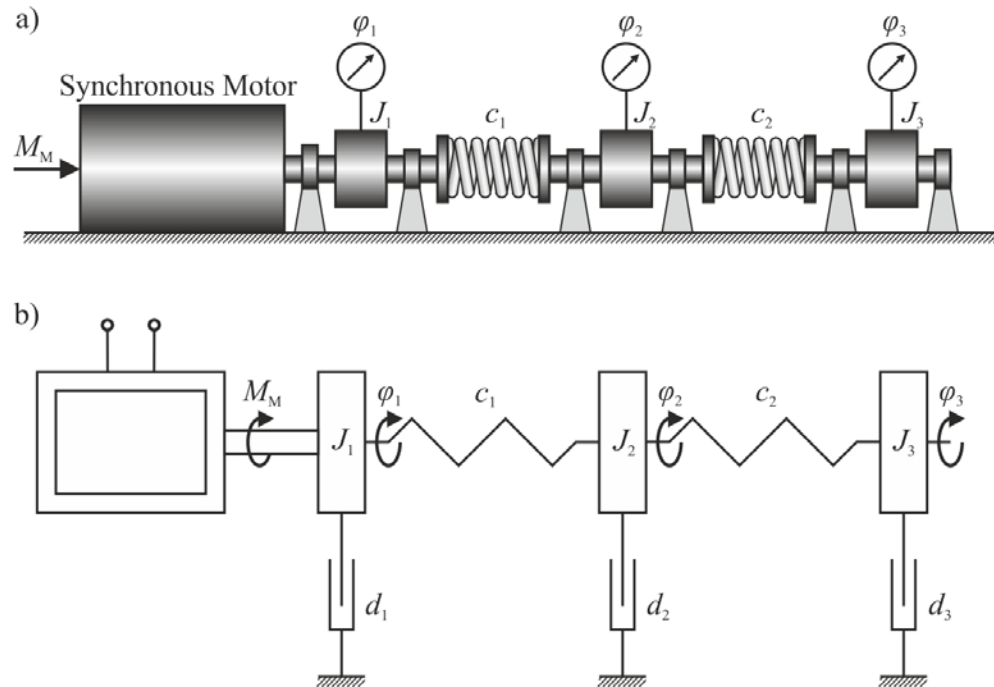
File

three-mass-oscillator-photo2.jpg



# Scheme of the Three-Mass Oscillator

## Scheme



## Files

three-mass-oscillator-scheme.png

three-mass-oscillator-scheme.eps

