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1 LAG-FM3 outg. inspec

TEST TYPE: Stand-Alone
TEST DATE (UTC): 2020/07/10 08:54:16.403
TEST PERSON: MB
TEST DEVICE: LAG-FM3
TEST PURPOSE: outg. inspec
TEST CONF NUM: xxx
TEST VERSION: xx
TEST ENVIRONMENT: amb, amb
TEST SOFTWARE:
BST Build Info: Not initialized!

1.1 Set Speed and Wait: 3000.0 rpm (Test ID: 1)

1.1.1 Method

Usually used to 'run-in' a device, e.g. create thermal equilibrium.

1. Cmd:'Set Speed' 3000.0 rpm
2. Wait 300000 msec

1.1.2 Result

Wait ...

Speed & Wait good

OK

1.2 Test Basic Communication and Confirm Correct DUT (Test ID: 2)

1.2.1 Method

Cmd: C1=0x04 C2=0x02 ('Get Info Frame')

1.2.2 Result

- No communication error

Serial Number: 0x20190006
BST Build Info:
Compile Time: Tue, 07/07/20 - 11:33:08
Software Version: untagged_v0.0.0
Debug Level: 0
Compiler: arm-none-eabi-
Compiler Version: 7.3.1 20180622 (rel
Commit IDs:
 b3caa99* : project
 9a1b7c8 : main
 1772eda : bst_src
 fecfc62 : src
 f357838 : unit_defs

Test of Basic LEOS Function [Passed]

OK

BST

1.3 Test Epoch Time Setup (Test ID: 3)

1.3.1 Method

1. Cmd: C1=0x01 C2=0x12 ('Set Epoch Time')
2. Cmd: C1=0x04 C2=0x01 ('Get LEOS System Telemetry')

1.3.2 Result

- No communication error: 1594371556568 msec
- No communication error

Serial Number: 20190006
System Time: 4232.498 sec
System Time Epoch: 1594371557.077 sec [dt_GUI: -1594371202.595]
Fri Jul 10 10:59:17 2020 (LOCAL)
Fri Jul 10 08:59:17 2020 (UTC)
Status Register: 0x80000000
0x80000000 BST_LEOS_REG_STATUS_IWDG_ACTIVE
Error Register: 0x00001900
0x00000100 BST_LEOS_REG_ERROR_COM_STATE_IDLE
0x00000800 BST_LEOS_REG_ERROR_COM_STATE_CHECK_MASTER
0x00001000 BST_LEOS_REG_ERROR_COM_STATE_REPORTED_BY_COM_MOD
Com Error Register: 0x00100000
0x00100000 BST_LEOS_COM_ERROR_TOUT_ACK
uC Temperature: 33.6 degC
Master Cmd Counter: 4368
Ext. Time Sync Counter: -1
Init Time: 0.050 sec

Test Epoch Time Setup [Passed]

OK

BST

1.4 Test Timer Function and Command Counter (Test ID: 4)

1.4.1 Method

Cmd: C1=0x04 C2=0x01 ('Get LEOS System Telemetry')

1.4.2 Result

Serial Number: 20190006
System Time: 4233.546 sec
System Time Epoch: 1594371558.125 sec [dt_GUI: -1594371202.596]
Fri Jul 10 10:59:18 2020 (LOCAL)
Fri Jul 10 08:59:18 2020 (UTC)
Status Register: 0x80000000
0x80000000 BST_LEOS_REG_STATUS_IWDG_ACTIVE
Error Register: 0x00001900
0x00000100 BST_LEOS_REG_ERROR_COM_STATE_IDLE
0x00000800 BST_LEOS_REG_ERROR_COM_STATE_CHECK_MASTER
0x00001000 BST_LEOS_REG_ERROR_COM_STATE_REPORTED_BY_COM_MOD
Com Error Register: 0x00100000
0x00100000 BST_LEOS_COM_ERROR_TOUT_ACK
uC Temperature: 33.6 degC
Master Cmd Counter: 4369
Ext. Time Sync Counter: -1
Init Time: 0.050 sec

- Time difference: 1048 msecCmd counter difference : 1

Test Timer Function and Command Counter [Passed]

OK

1.5 Internal RAM Self Test: MAX byte (Test ID: 5)

1.5.1 Method

Run the following procedure twice:

1. write 0xFF
2. read -> check: err_w0xFF (can be write or read error)
3. read -> check: err_r0xFF (indicates if read or write error)
4. write 0x00
5. read -> check: err_w0x00 (can be write or read error)
6. read -> check: err_r0x00 (indicates if read or write error)

1.5.2 Result

2020_07_10_08_59_18_755: Self Test Internal RAM Self Test: MAX byte ready

Num. of Tested Bits:	68736
Num. of Error Write 0xFF:	0
Num. of Error Read 0xFF:	0
Num. of Error Write 0x00:	0
Num. of Error Read 0x00:	0

Memory Self Test

OK

1.6 Current Control Test with 900 mA SPD=0.0 (Test ID: 6)

1.6.1 Method

Speed Tolerance used is 5.0 rpm. Speed read interval used is 500 msec.

1. Cmd:'Set Speed' 0.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd:'Set Current' 900.0 mA
5. Observe/measure current input
6. Wait until speed of 5000.0 rpm is reached (max. 300000 msec)

1.6.2 Result

RW05 Parameter read ready [com. error = 0]

```

MoI      : 0.00097855 [kgm^2]
km       :      20.2 [mNm/A]
Min Current :      1.0 [mA]
Max Current :     900.0 [mA]
Max Speed  :    5050.0 [rpm]
Max Trq.   :      20.0 [mNm]

kM_val0   :      20.1      20.1      20.1 [mNm/A]
kM_val1   :      20.1      20.1      20.1 [mNm/A]
kM_spd0   :      500.0      500.0      500.0 [rpm]
kM_spd1   :    5000.0      5000.0      5000.0 [rpm]
cur_kM    :      300.0      600.0      900.0 [mA]
Back-EMF ke :      2.115 [mV/rpm]
V_diode   :      100.0      100.0      100.0 [mV]
Mot. R.   :      10.0      10.0      10.0 [Ohm]
Temp.     :      -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.     :      27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.     :      44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a   :      81.8 [-]
T_pcb: b   :      200.0 [degC]      T_pcb,cal = a * T_pcb + b
T_mot: a   :      1.0 [-]

```

BST

T_mot: b : -0.0 [degC] T_mot = a * T_meas + b
kp Current : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]

Cmd:'Set Speed' 0.0 rpm OK [duration 17011 msec]

Cmd:'Set Current' 900.0 mA OK [com error = 0]

Data capture ready [duration 29524 msec, com_err=0]

BST

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat06_cur.txt

dt_spd [msec]	Speed [rpm]	Torque [mNm]	Speed Raw [rpm]	Torque Raw [mNm]
0	31.1	-0.42	83.3	7.99
1188	281.9	13.78	342.2	19.08
2565	563.0	18.07	592.0	18.39
3756	783.6	18.22	804.0	18.22
4818	975.6	18.11	991.9	18.16
6065	1198.2	18.02	1211.4	18.24
7290	1399.9	17.88	1422.4	18.01
8538	1621.2	17.90	1640.6	17.99
9508	1792.2	17.85	1809.7	17.94
10815	2021.0	17.76	2036.4	17.76
12045	2234.9	17.70	2248.8	17.81
13315	2454.7	17.64	2467.4	17.90
14301	2616.8	17.48	2634.4	17.39
15546	2831.0	17.51	2847.3	17.53
16823	3049.5	17.40	3064.5	17.24
18070	3261.9	17.32	3275.8	16.96
19034	3425.3	17.34	3438.7	17.57
20302	3639.1	17.12	3651.4	17.05
21547	3842.9	17.03	3858.5	16.92
22817	4055.1	17.02	4069.9	16.99
23799	4218.6	16.97	4232.7	16.96
25071	4429.1	16.82	4442.4	16.19
26285	4629.2	16.82	4642.0	17.05
27549	4836.2	16.72	4848.4	16.80
28570	5002.9	16.61	5014.5	16.13

Table 1: Current Control Test [6]

1.6.2.1 Speed and Torque Time-Response

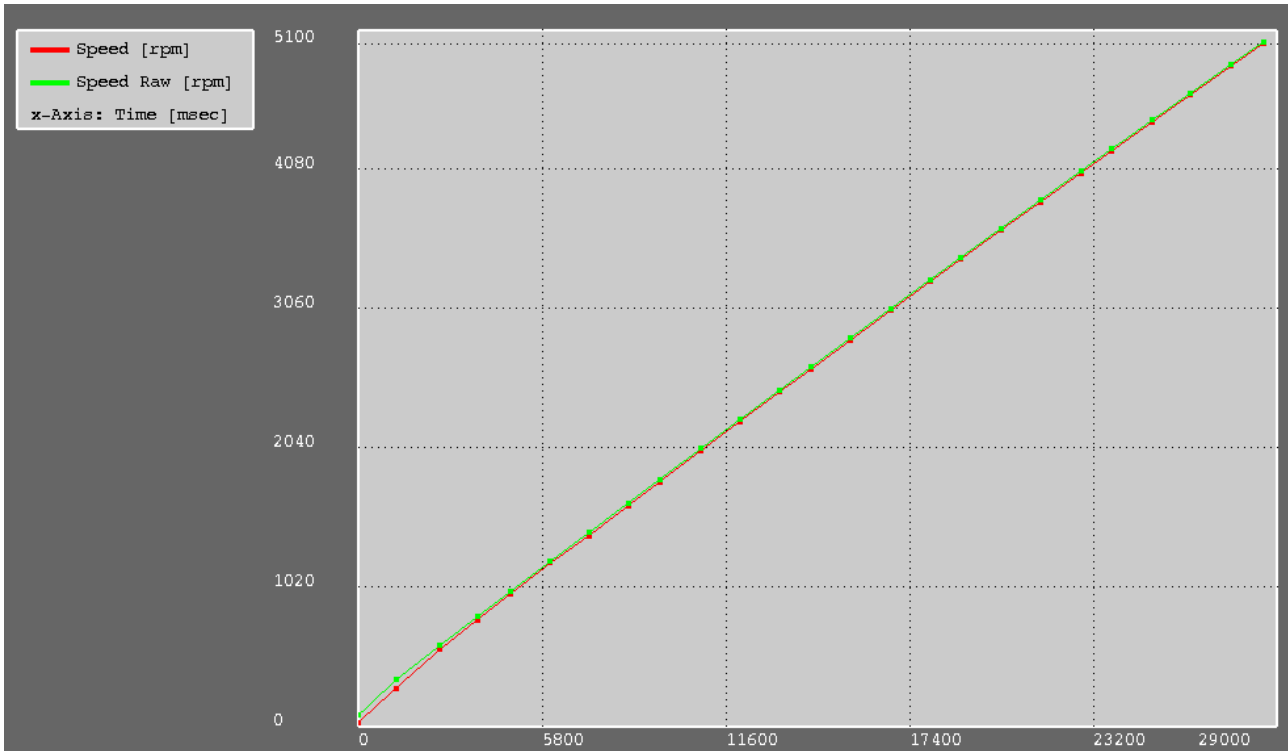


Figure 1: Current Control Test – Speed over Time [6]

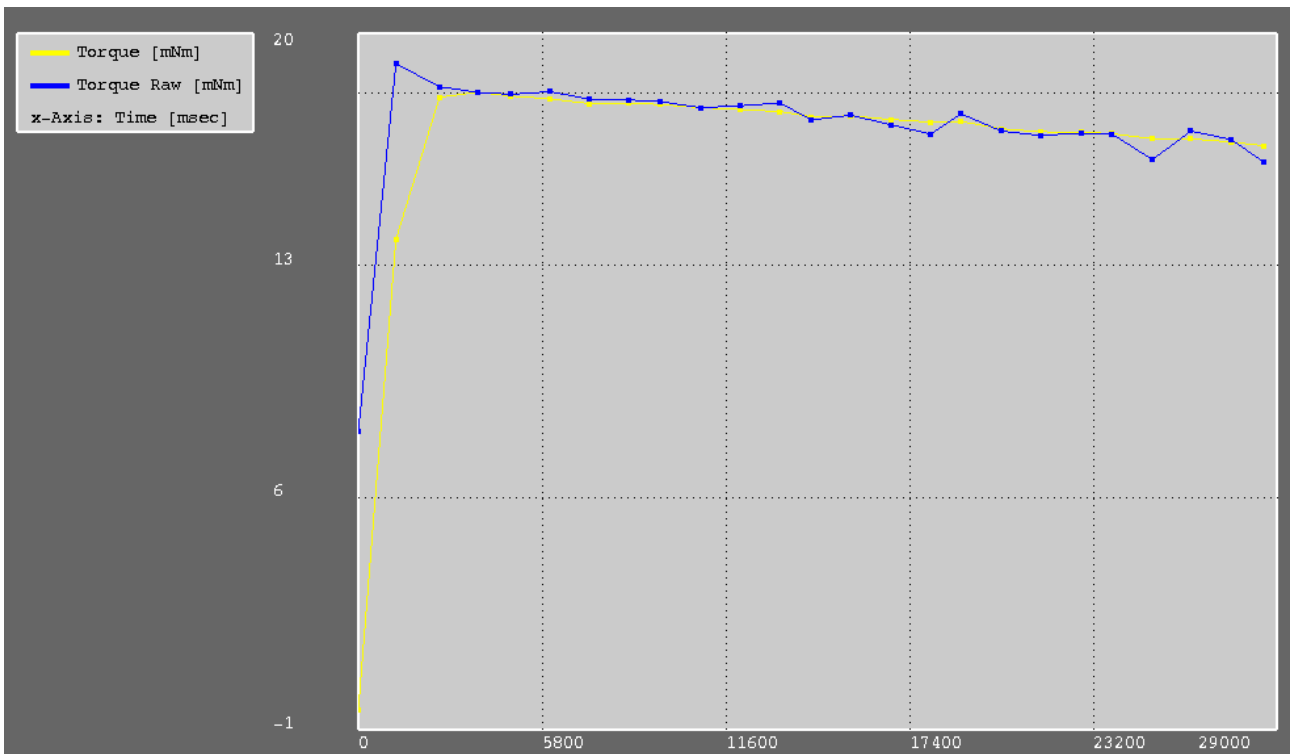


Figure 2: Current Control Test – Torque over Time [6]

1.6.2.2 Torque Speed-Response

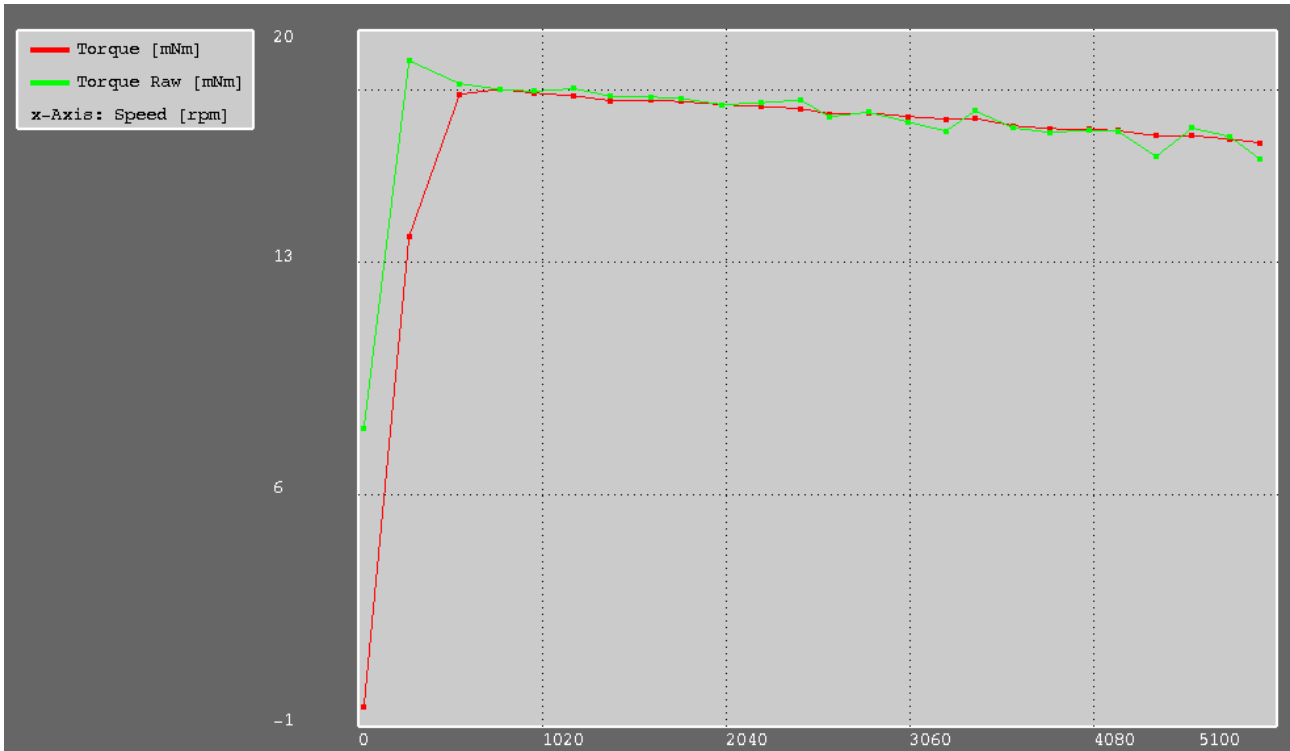


Figure 3: Current Control Test – Torque over Speed [6]

1.6.2.3 Total/Gross Torque Response and Motor Constant

Total/gross torque is calculated by adding the friction (from friction model) to the internal torque measurement.

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat06_cur_gross_km.txt

Time [msec]	Speed [rpm]	Torque (Gross) [mNm]	kM [mNm/A]	kM-exp [mNm/A]
1188	281.9	14.0	15.6	20.1
2565	563.0	18.5	20.6	20.1
3756	783.6	18.7	20.8	20.1
4818	975.6	18.7	20.7	20.1
6065	1198.2	18.6	20.7	20.1
7034	1354.6	18.4	20.5	20.1
8317	1582.1	18.6	20.7	20.1
9308	1757.0	18.6	20.7	20.1
10518	1969.0	18.6	20.7	20.1
11556	2150.0	18.6	20.7	20.1
12821	2369.4	18.6	20.7	20.1
13816	2534.8	18.2	20.2	20.1
15034	2742.9	18.6	20.7	20.1
16287	2958.0	18.7	20.7	20.1
17286	3128.5	18.6	20.7	20.1
18558	3344.6	18.7	20.7	20.1
19551	3512.4	18.6	20.6	20.1
20789	3721.1	18.6	20.6	20.1
21795	3884.3	18.7	20.7	20.1
23052	4094.3	18.6	20.7	20.1
24025	4256.0	18.6	20.7	20.1
25286	4464.7	18.7	20.7	20.1
26285	4629.2	18.6	20.7	20.1
27549	4836.2	18.6	20.7	20.1
28570	5002.9	18.6	20.7	20.1

Table 2: Current Control Test - Gross Torque & km [6]

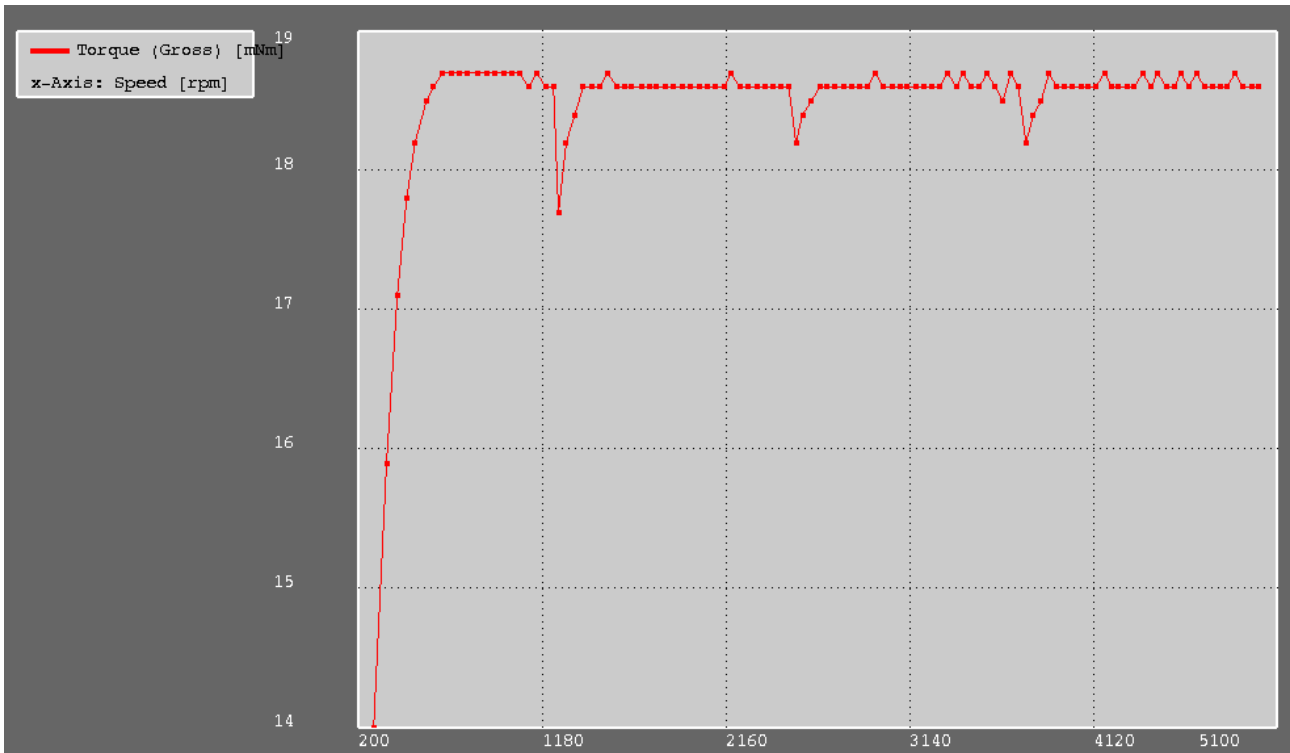


Figure 4: Current Control Test – Gross Torque over Speed [6]

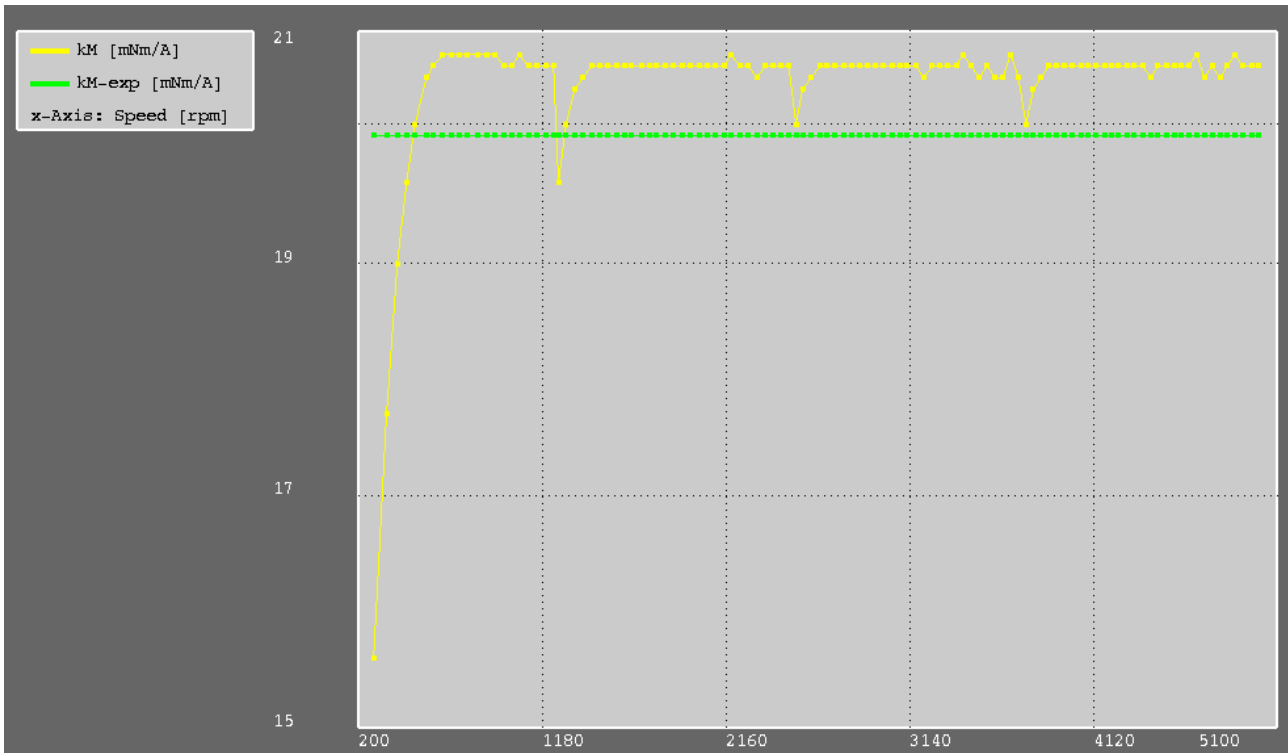


Figure 5: Current Control Test – kM over Speed [6]

Current Control good: duration 29524 < 300000 msec

OK

1.7 Speed Control Test: 0.0 to 5000.0 rpm (Test ID: 7)

1.7.1 Method

Speed Tolerance used is 2.0 rpm. Speed read interval used is 500 msec.

1. Cmd:'Set Speed' 0.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd:'Set Speed' 5000.0 rpm
5. Wait until speed of 5000.0 rpm is reached (max. 60000 msec; data capture with 500 msec)

1.7.2 Result

RW Parameter read ready [com. error = 0]

```
MoI          : 0.00097855 [kgm^2]
km           :          20.2 [mNm/A]
Min Current  :           1.0 [mA]
Max Current  :          900.0 [mA]
Max Speed    :          5050.0 [rpm]
Max Trq.     :           20.0 [mNm]
```

Cmd:'Set Speed' 0.0 rpm OK [duration 20508 msec, com_err=0]

Data capture ready [duration 31008 msec, com_err=0]

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat07_cur.txt

Time [msec]	Speed [rpm]
0	-0.0
1554	125.1
3135	473.5
4125	660.9
5650	937.8
6678	1121.4
8145	1365.6
9639	1629.9
10671	1811.1
12140	2067.5
13134	2240.0
14642	2500.3
15679	2670.6
17148	2922.4
18671	3182.0
19658	3349.2
21153	3601.1
22142	3764.9
23677	4018.1
25177	4267.2
26166	4430.7
27637	4672.4
28643	4837.0
30148	4990.2
31157	4999.3

Table 3: Speed Control Test [7]

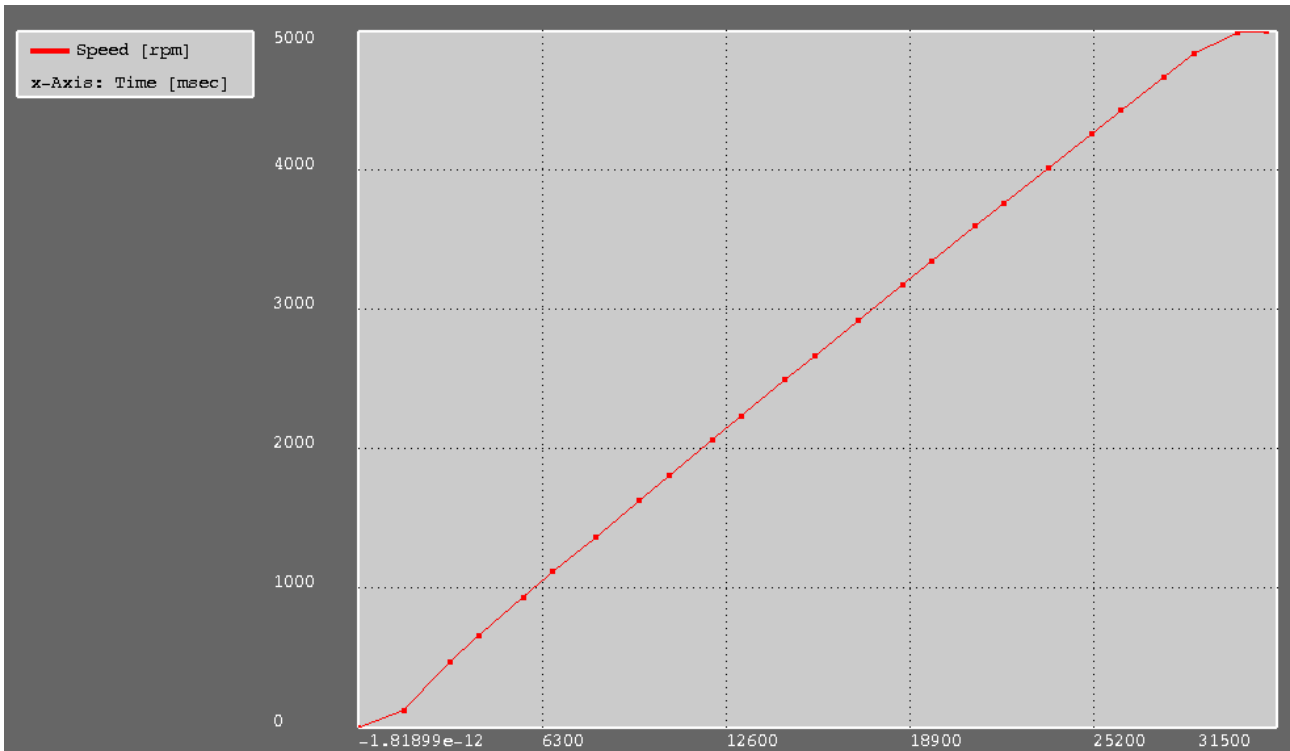


Figure 6: Speed Control Test [7]

Speed Control good [duration 31008 < 60000 msec]

OK

1.8 Speed Control Test: 5000.0 to 6000.0 rpm (Test ID: 8)

1.8.1 Method

Speed Tolerance used is 2.0 rpm. Speed read interval used is 500 msec.

1. Cmd:'Set Speed' 5000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd:'Set Speed' 6000.0 rpm
5. Wait until speed of 6000.0 rpm is reached (max. 10000 msec; data capture with 500 msec)

1.8.2 Result

RW Parameter read ready [com. error = 0]

```
MoI          : 0.00097855 [kgm^2]
km           :          20.2 [mNm/A]
Min Current  :           1.0 [mA]
Max Current  :          900.0 [mA]
Max Speed   :          5050.0 [rpm]
Max Trq.    :           20.0 [mNm]
```

Cmd:'Set Speed' 5000.0 rpm OK [duration 8 msec, com_err=0]

Data capture ready. Max. speed exceeded: Speed limit working [com_err=0]

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat08_cur.txt

Time [msec]	Speed [rpm]
0	4993.8
526	5041.6
998	5086.9
1518	5077.6
2039	5067.1
2513	5057.8
3036	5047.3
3513	5038.2
4037	5027.8
4515	5018.4
4994	5009.1
5522	4998.8
6003	4989.4
6533	4979.1
7016	4969.7
7500	4960.3
8033	4950.0
8519	4940.6
9005	4931.1
9493	4921.8
10030	4911.4

Table 4: Speed Control Test [8]

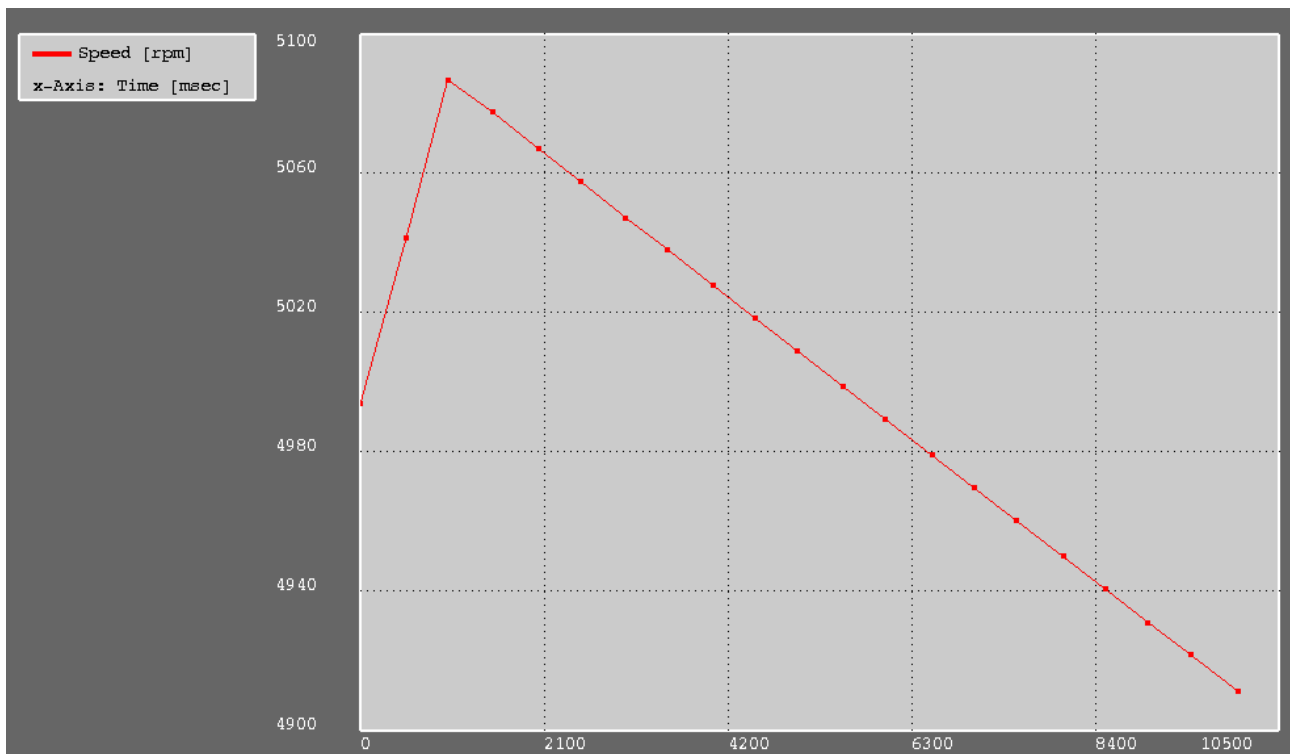


Figure 7: Speed Control Test [8]

Speed Control good [duration 0 < 10000 msec]

OK

1.9 Speed Control Test: 5000.0 to 3000.0 rpm (Test ID: 9)

1.9.1 Method

Speed Tolerance used is 2.0 rpm. Speed read interval used is 500 msec.

1. Cmd:'Set Speed' 5000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd:'Set Speed' 3000.0 rpm
5. Wait until speed of 3000.0 rpm is reached (max. 60000 msec; data capture with 500 msec)

1.9.2 Result

RW Parameter read ready [com. error = 0]

```
MoI          : 0.00097855 [kgm^2]
km           : 20.2 [mNm/A]
Min Current  : 1.0 [mA]
Max Current  : 900.0 [mA]
Max Speed    : 5050.0 [rpm]
Max Trq.     : 20.0 [mNm]
```

Cmd:'Set Speed' 5000.0 rpm OK [duration 11008 msec, com_err=0]

Data capture ready [duration 28008 msec, com_err=0]

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat09_cur.txt

Time [msec]	Speed [rpm]
0	4998.9
1493	4659.9
2505	4411.2
3519	4166.0
4983	3764.3
6003	3475.1
6981	3215.1
8465	2962.7
9493	2982.6
10518	2986.8
11964	2988.6
12988	2989.8
14011	2990.9
15516	2992.2
16478	2993.0
17501	2993.7
19004	2994.7
19966	2995.1
20987	2995.7
22490	2996.3
23511	2996.7
24472	2997.0
25974	2997.5
26995	2997.7
28015	2998.0

Table 5: Speed Control Test [9]

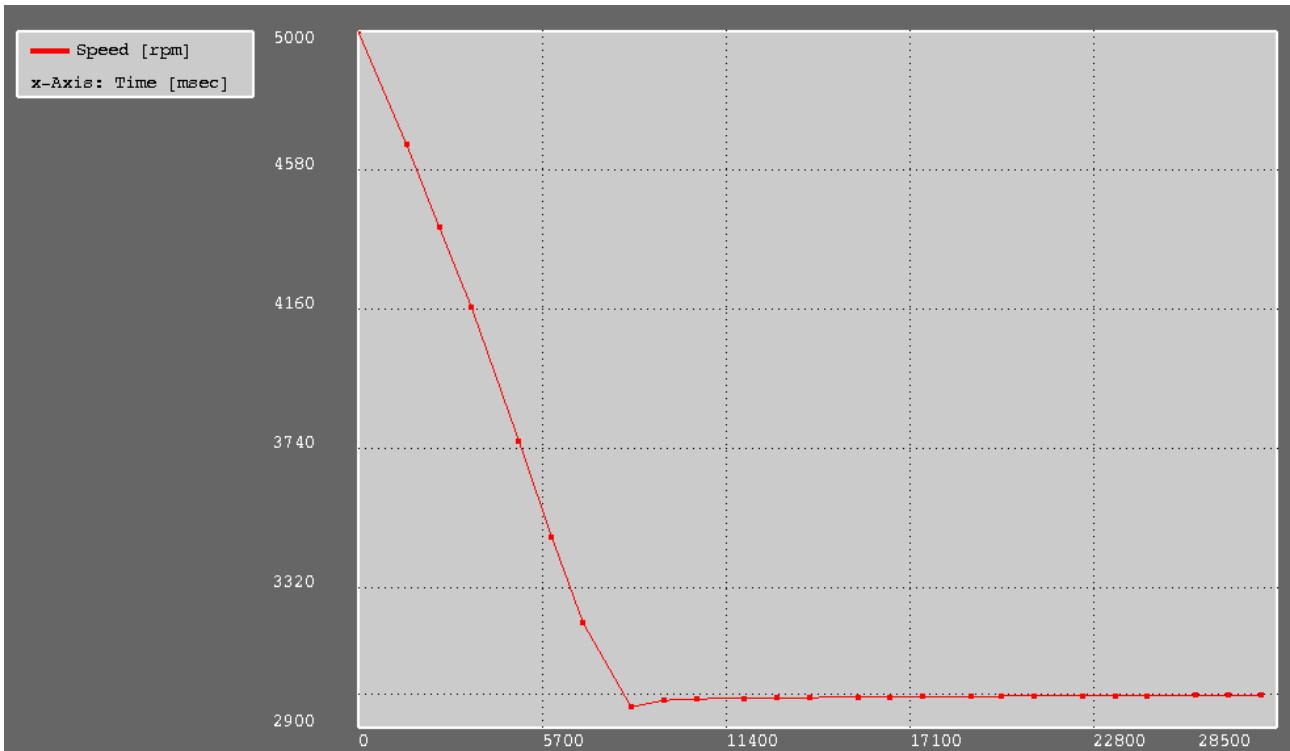


Figure 8: Speed Control Test [9]

Speed Control good [duration 28008 < 60000 msec]

OK

1.10 Speed Control Test: 3000.0 to 0.0 rpm (Test ID: 10)

1.10.1 Method

Speed Tolerance used is 2.0 rpm. Speed read interval used is 500 msec.

1. Cmd:'Set Speed' 3000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd:'Set Speed' 0.0 rpm
5. Wait until speed of 0.0 rpm is reached (max. 30000 msec; data capture with 500 msec)

1.10.2 Result

RW Parameter read ready [com. error = 0]

MoI : 0.00097855 [kgm²]
km : 20.2 [mNm/A]
Min Current : 1.0 [mA]
Max Current : 900.0 [mA]
Max Speed : 5050.0 [rpm]
Max Trq. : 20.0 [mNm]

Cmd:'Set Speed' 3000.0 rpm OK [duration 8 msec, com_err=0]

Data capture ready [duration 23508 msec, com_err=0]

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat10_cur.txt

Time [msec]	Speed [rpm]
0	2995.5
992	2810.6
1941	2571.4
2962	2310.1
3960	2075.9
4949	1862.2
5990	1653.6
6931	1468.4
7918	1275.9
8977	1051.1
9941	866.5
11000	668.5
11874	510.8
12840	348.0
13783	219.1
14960	131.5
15807	16.5
15807	16.5
17518	-4.1
18953	-19.2
18953	-19.2
20651	-25.6
21560	-15.4
22960	-5.5
23360	-2.0

Table 6: Speed Control Test [10]

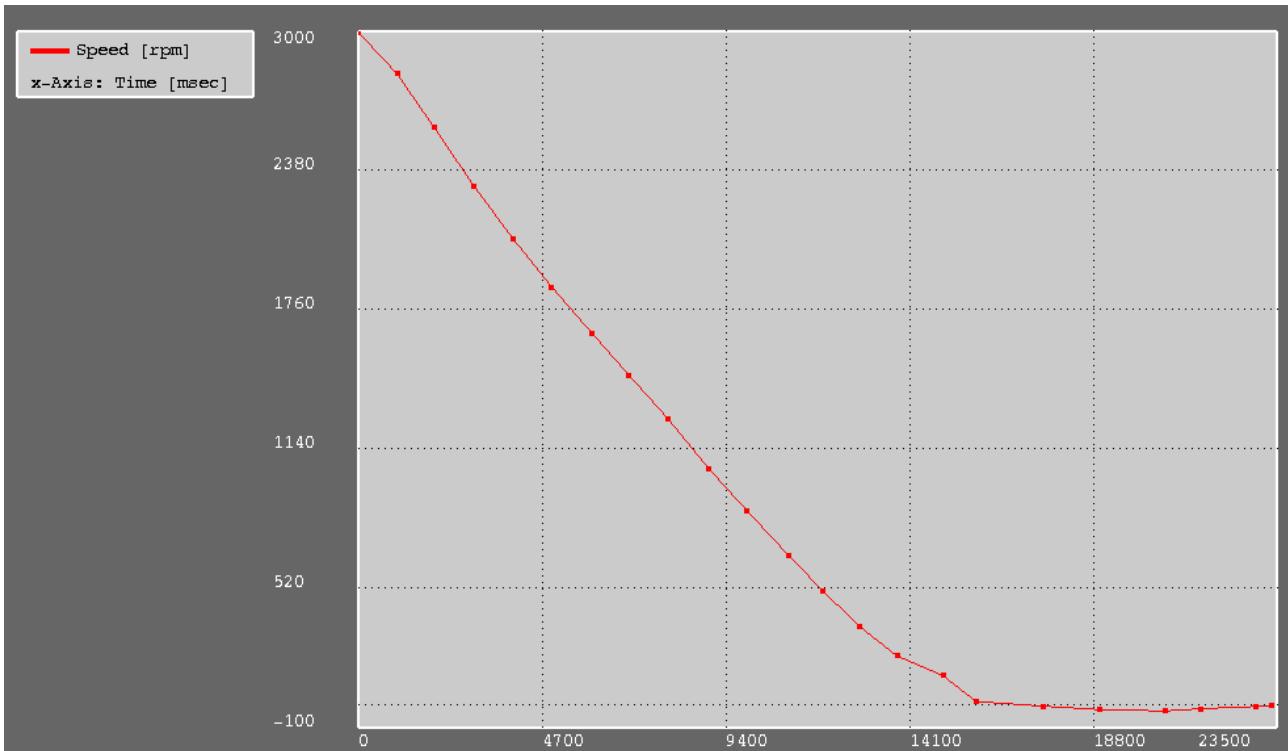


Figure 9: Speed Control Test [10]

Speed Control good [duration 23508 < 30000 msec]

OK

1.11 Open Loop Trq Ctrl: Trq=-2.0 mNm Spd=-3000 rpm @dt=0 [cmd-upd] (Test ID: 11)

1.11.1 Method

RWA05 Test Step: Speed Tolerance used is 5.0 rpm. Speed read interval used is 250 msec.

1. Cmd: 'Set Speed' -3000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd: 'Set Torque' -2.0 mNm (dt=0)
5. Loop: Read std. data and wait 50msec
6. Update trq all 250 msec with $trq = 0.00e+00 * dt*dt*dt + 0.00e+00 * dt*dt + 0.00e+00 * dt + -2.00e-03 Nm$
7. Wait for 5000 msec

1.11.2 Result

1st coeffs: -2.000e-03 0.000e+00 0.000e+00 0.000e+00

2020_07_10_09_02_56_363: 'Set Speed' -3000.0 rpm

2020_07_10_09_03_14_408: 'Set Speed' -3000.0 rpm OK [duration 18008 msec, com_err=0]

2020_07_10_09_03_19_440: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_19_691: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_19_950: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_20_190: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_20_455: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_20_700: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_20_946: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_21_200: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_21_441: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_21_691: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_21_950: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_22_200: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_22_441: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_22_700: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_22_950: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_23_200: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_23_450: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_23_690: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_23_941: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

2020_07_10_09_03_24_190: 'Set Torque (Open Loop)' -2.0 mNm OK [com. error = 0]

BST

2020_07_10_09_03_24_430: Data capture ready [duration 5013 msec, com. error = 0]

2020_07_10_09_03_24_464: 'Set Speed' OK [end speed = -3000.0; com. errors = 0]

BST

RW Parameter read ready [com. error = 0]

```

MoI      : 0.00097855 [kgm^2]
km       : 20.2 [mNm/A]
Min Current : 1.0 [mA]
Max Current : 900.0 [mA]
Max Speed  : 5050.0 [rpm]
Max Trq.   : 20.0 [mNm]

kM_val0   : 20.1 20.1 20.1 [mNm/A]
kM_val1   : 20.1 20.1 20.1 [mNm/A]
kM_spd0   : 500.0 500.0 500.0 [rpm]
kM_spd1   : 5000.0 5000.0 5000.0 [rpm]
cur_kM    : 300.0 600.0 900.0 [mA]
Back-EMF ke : 2.115 [mV/rpm]
V_diode   : 100.0 100.0 100.0 [mV]
Mot. R.   : 10.0 10.0 10.0 [Ohm]
Temp.     : -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.     : 27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.     : 44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a   : 81.8 [-]
T_pcb: b   : 200.0 [degC]      T_pcb,cal = a * T_pcb + b
T_mot: a   : 1.0 [-]
T_mot: b   : -0.0 [degC]     T_mot = a * T_meas + b
kp Current : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]

```

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat11_trq.tx

The torque value 'Trq from Cur' is calculated from the target current and motor constant plus the friction and yields a good indication of the actual torque (the measured speed/torque response is delayed due to necessary filtering, the raw values are usually too noisy)

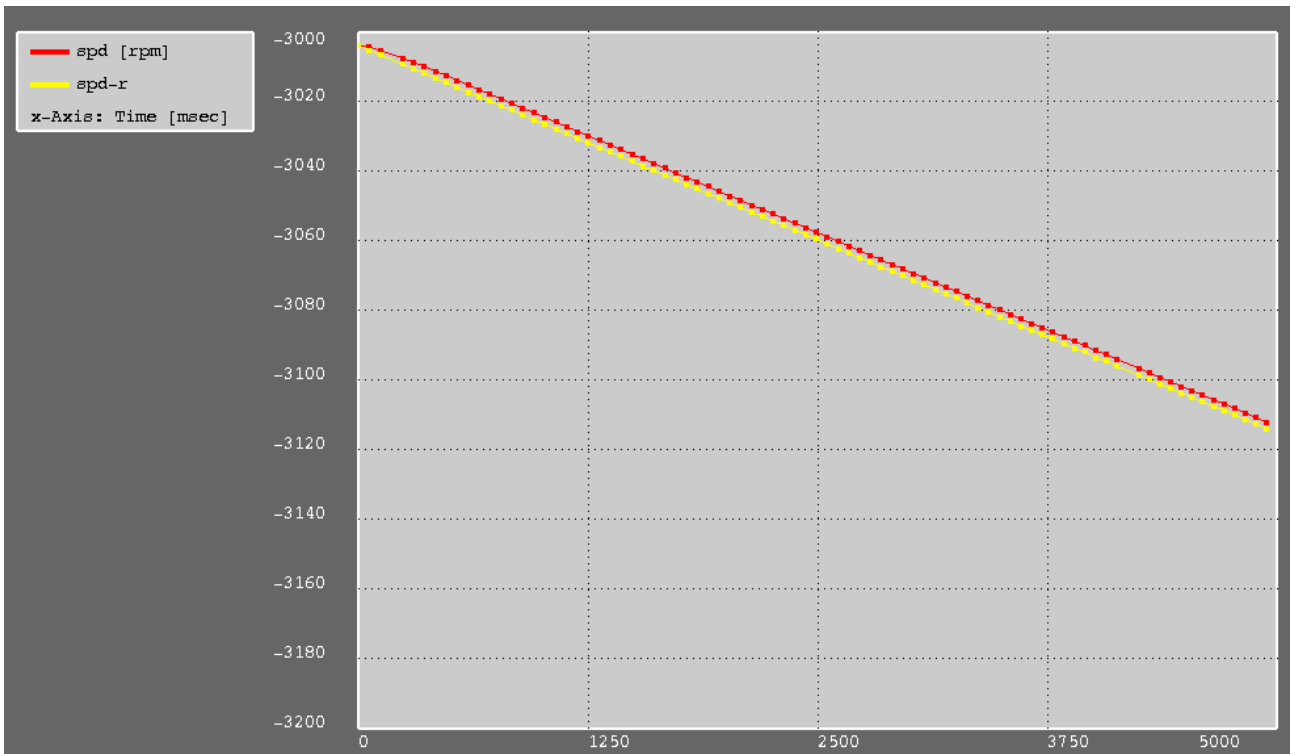


Figure 10: Torque Control Test – -2.0 mNm – Speed over Time [11]

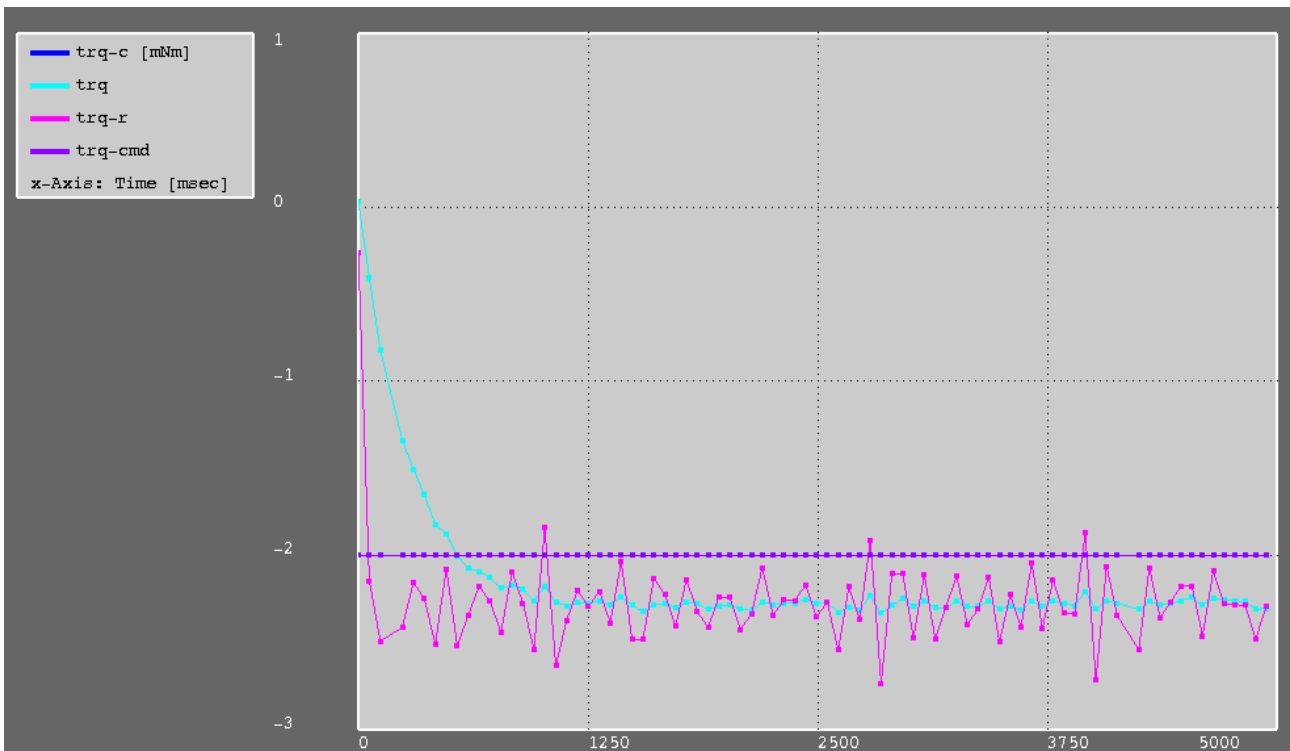


Figure 11: Torque Control Test – -2.0 mNm – Torque over Time [11]

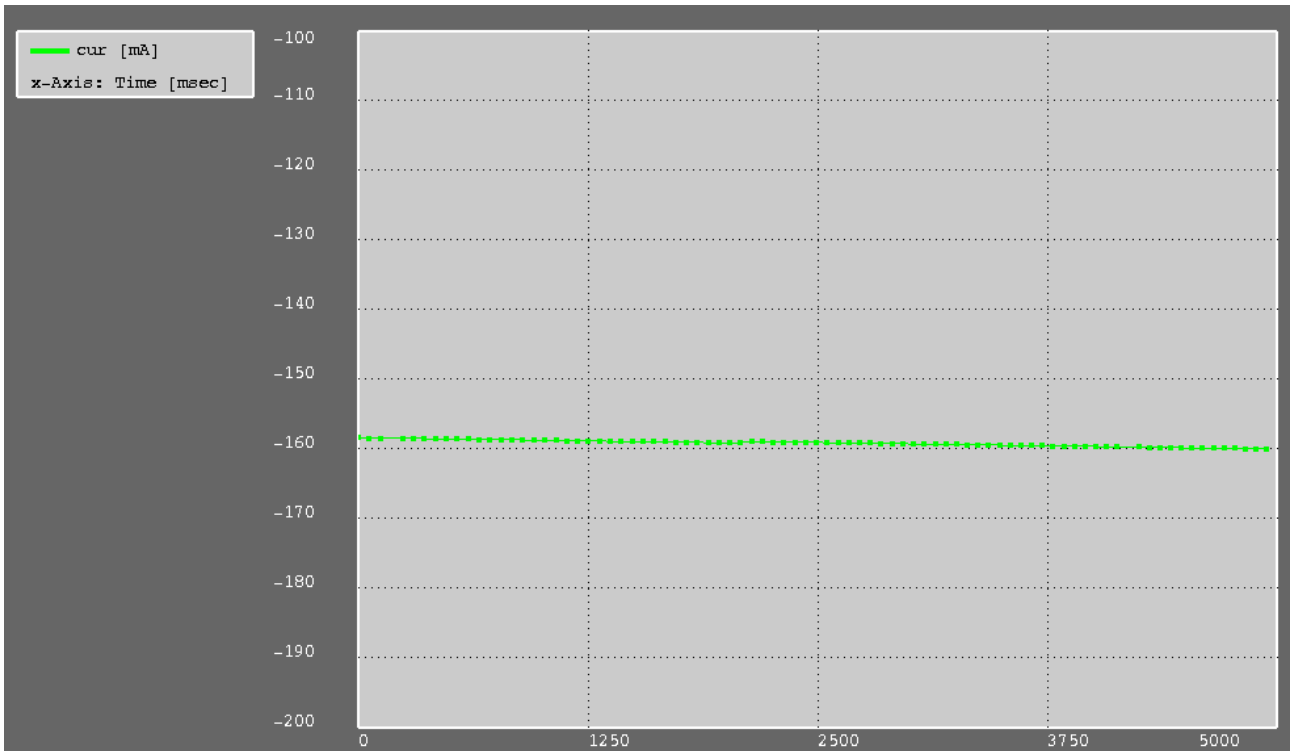


Figure 12: Torque Control Test – -2.0 mNm – Current Zoom [11]

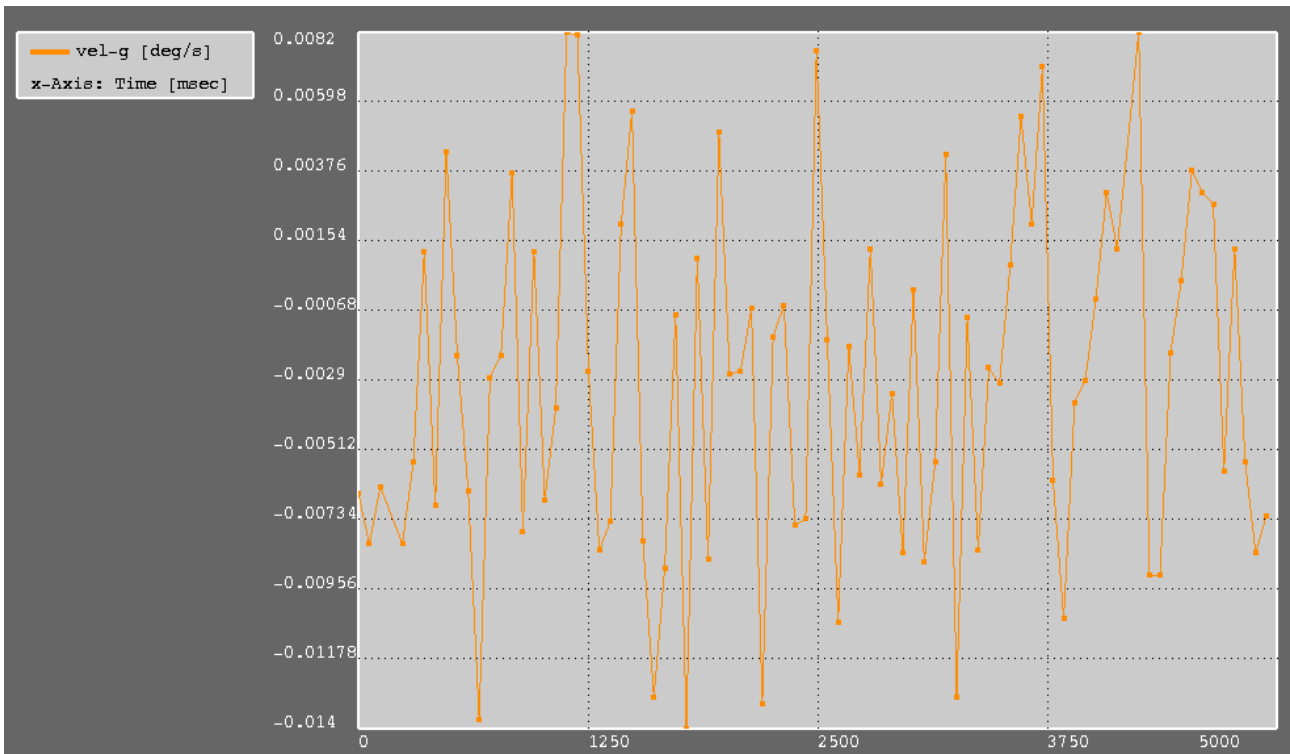


Figure 13: Torque Control Test – -2.0 mNm – Gyro Velocity [11]

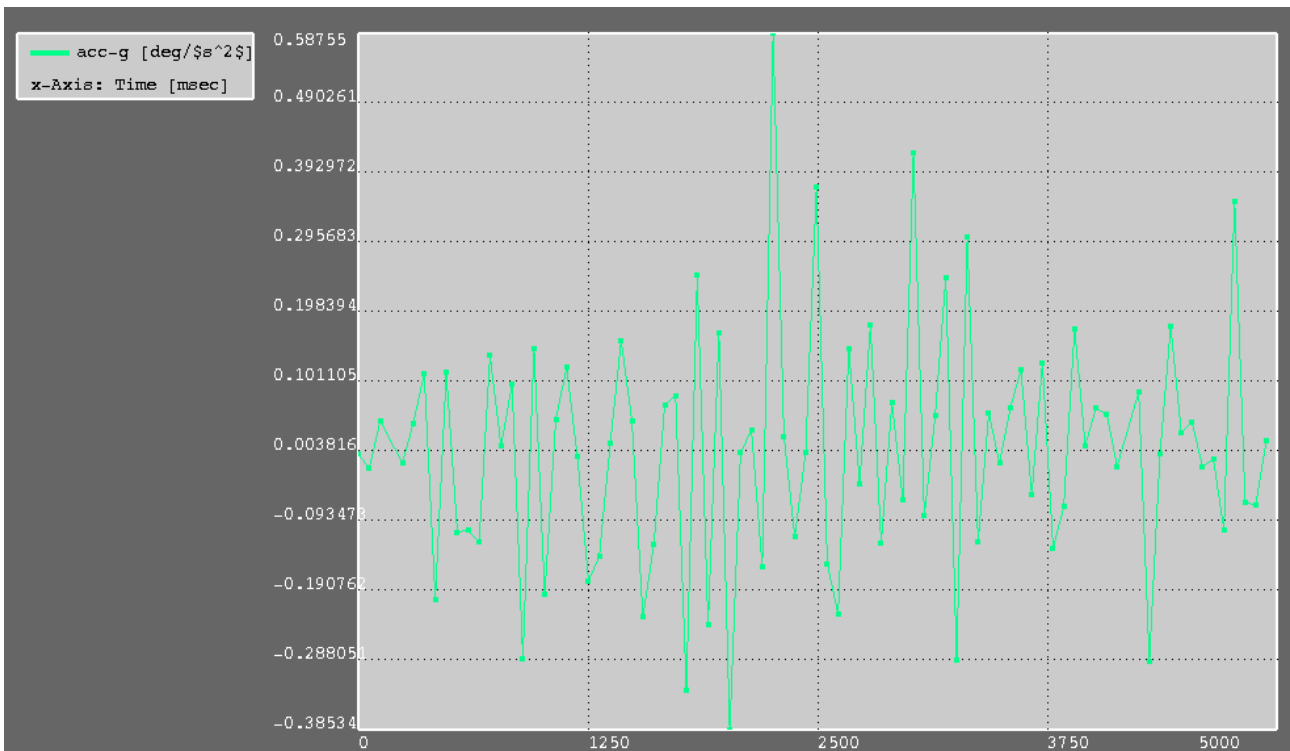


Figure 14: Torque Control Test – -2.0 mNm – Gyro Acceleration [11]

t [msec]	spd [rpm]	spd-r	cur [mA]	trq-c [mNm]	trq	trq-r	vel-g [deg/s]	acc-g [deg/\$s^2\$]	trq-cmd
0	-3003.8	-3003.8	-158.3	-2.000	0.032	-0.257	-0.0065	0.00000	-2.000
300	-3008.6	-3010.4	-158.4	-2.000	-1.502	-2.156	-0.0055	0.04316	-2.000
479	-3012.4	-3014.4	-158.5	-2.000	-1.873	-2.078	0.0044	0.11346	-2.000
717	-3017.8	-3019.8	-158.6	-2.000	-2.125	-2.263	-0.0028	0.13724	-2.000
896	-3021.8	-3023.7	-158.7	-2.000	-2.190	-2.272	-0.0077	-0.28580	-2.000
1134	-3027.1	-3029.2	-158.8	-2.000	-2.288	-2.373	0.0082	0.12055	-2.000
1312	-3031.1	-3033.1	-158.8	-2.000	-2.261	-2.205	-0.0083	-0.14283	-2.000
1490	-3035.0	-3037.1	-158.9	-2.000	-2.284	-2.480	0.0057	0.04523	-2.000
1727	-3040.4	-3042.4	-159.0	-2.000	-2.299	-2.404	-0.0008	0.08175	-2.000
1904	-3044.3	-3046.4	-159.1	-2.000	-2.305	-2.413	-0.0086	-0.23924	-2.000
2140	-3049.7	-3051.7	-158.9	-2.000	-2.315	-2.336	-0.0006	0.03388	-2.000
2317	-3053.6	-3055.5	-159.0	-2.000	-2.276	-2.255	-0.0005	0.02466	-2.000
2494	-3057.4	-3059.4	-159.0	-2.000	-2.272	-2.354	0.0076	0.37298	-2.000
2729	-3062.8	-3064.8	-159.1	-2.000	-2.310	-2.366	-0.0059	-0.04131	-2.000
2905	-3066.7	-3068.6	-159.2	-2.000	-2.286	-2.101	-0.0033	0.07123	-2.000
3140	-3071.9	-3073.9	-159.3	-2.000	-2.301	-2.479	-0.0055	0.05280	-2.000
3315	-3075.8	-3077.8	-159.4	-2.000	-2.291	-2.396	-0.0009	0.30339	-2.000
3549	-3081.0	-3083.0	-159.5	-2.000	-2.291	-2.223	0.0008	0.06388	-2.000
3724	-3084.9	-3086.9	-159.5	-2.000	-2.292	-2.418	0.0071	0.12733	-2.000
3899	-3088.8	-3090.8	-159.6	-2.000	-2.287	-2.334	-0.0036	0.17449	-2.000
4131	-3093.9	-3095.9	-159.7	-2.000	-2.274	-2.345	0.0013	-0.01734	-2.000
4364	-3099.1	-3101.0	-159.8	-2.000	-2.281	-2.357	-0.0091	0.00035	-2.000
4596	-3104.2	-3106.2	-159.9	-2.000	-2.285	-2.463	0.0031	-0.01825	-2.000
4770	-3108.0	-3109.9	-159.9	-2.000	-2.258	-2.282	0.0013	0.35316	-2.000
4943	-3111.9	-3113.9	-160.0	-2.000	-2.304	-2.291	-0.0072	0.01887	-2.000

Table 7: Torque Control Test [11]

Average error without first part (1/5) of data set: 0.28 mNm

Torque Control good: duration 5013 msec

OK

1.12 Open Loop Trq Ctrl: Trq=-15.0 mNm Spd=-3000 rpm @dt=0 [cmd-upd] (Test ID: 12)

1.12.1 Method

RWA05 Test Step: Speed Tolerance used is 5.0 rpm. Speed read interval used is 250 msec.

1. Cmd: 'Set Speed' -3000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd: 'Set Torque' -15.0 mNm (dt=0)
5. Loop: Read std. data and wait 50msec
6. Update trq all 250 msec with $\text{trq} = 0.00\text{e}+00 * \text{dt} * \text{dt} * \text{dt} + 0.00\text{e}+00 * \text{dt} * \text{dt} + 0.00\text{e}+00 * \text{dt} + -1.50\text{e}-02 \text{ Nm}$
7. Wait for 5000 msec

1.12.2 Result

1st coeffs: -1.500e-02 0.000e+00 0.000e+00 0.000e+00

2020_07_10_09_03_36_309: 'Set Speed' -3000.0 rpm

2020_07_10_09_03_36_348: 'Set Speed' -3000.0 rpm OK [duration 8 msec, com_err=0]

2020_07_10_09_03_41_378: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_41_638: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_41_879: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_42_130: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_42_389: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_42_638: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_42_879: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_43_129: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_43_388: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_43_629: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_43_878: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_44_138: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_44_388: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_44_629: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_44_878: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_45_128: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_45_388: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_45_639: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_45_888: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_46_138: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

2020_07_10_09_03_46_379: 'Set Torque (Open Loop)' -15.0 mNm OK [com. error = 0]

BST

2020_07_10_09_03_46_398: Data capture ready [duration 5043 msec, com. error = 0]

2020_07_10_09_03_46_431: 'Set Speed' OK [end speed = -3000.0; com. errors = 0]

BST

RW Parameter read ready [com. error = 0]

```

MoI      : 0.00097855 [kgm^2]
km       : 20.2 [mNm/A]
Min Current : 1.0 [mA]
Max Current : 900.0 [mA]
Max Speed  : 5050.0 [rpm]
Max Trq.   : 20.0 [mNm]

kM_val0   : 20.1 20.1 20.1 [mNm/A]
kM_val1   : 20.1 20.1 20.1 [mNm/A]
kM_spd0   : 500.0 500.0 500.0 [rpm]
kM_spd1   : 5000.0 5000.0 5000.0 [rpm]
cur_kM    : 300.0 600.0 900.0 [mA]
Back-EMF ke : 2.115 [mV/rpm]
V_diode   : 100.0 100.0 100.0 [mV]
Mot. R.   : 10.0 10.0 10.0 [Ohm]
Temp.     : -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.      : 27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.      : 44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a    : 81.8 [-]
T_pcb: b    : 200.0 [degC]      T_pcb,cal = a * T_pcb + b
T_mot: a    : 1.0 [-]
T_mot: b    : -0.0 [degC]     T_mot = a * T_meas + b
kp Current  : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]

```

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat12_trq.tx

The torque value 'Trq from Cur' is calculated from the target current and motor constant plus the friction and yields a good indication of the actual torque (the measured speed/torque response is delayed due to necessary filtering, the raw values are usually too noisy)

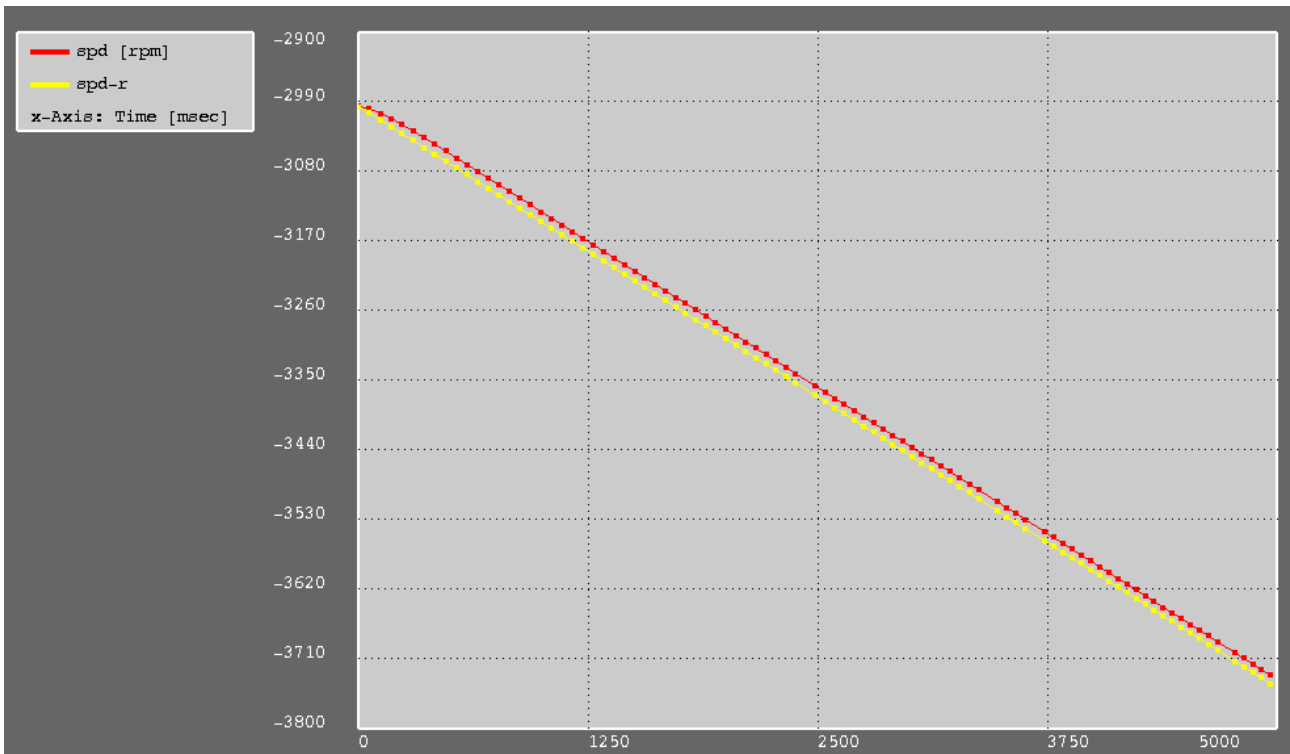


Figure 15: Torque Control Test - -15.0 mNm - Speed over Time [12]

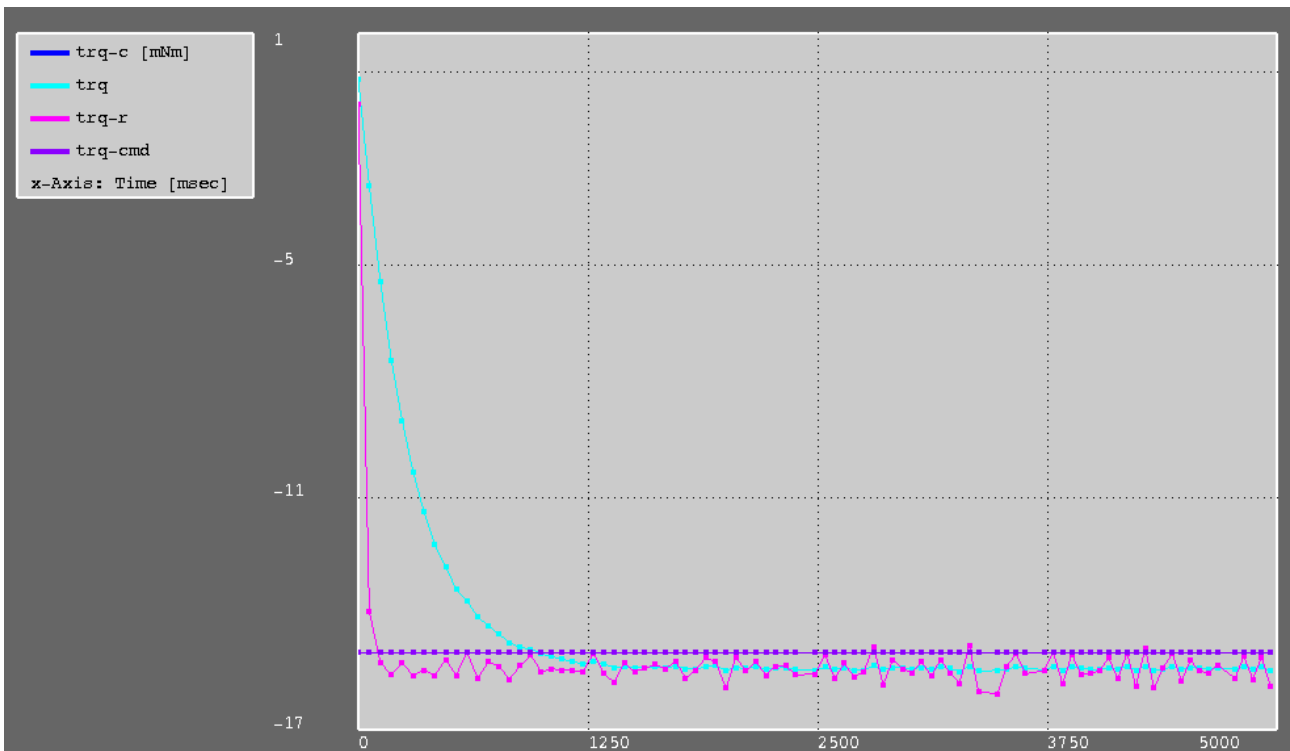


Figure 16: Torque Control Test - -15.0 mNm - Torque over Time [12]

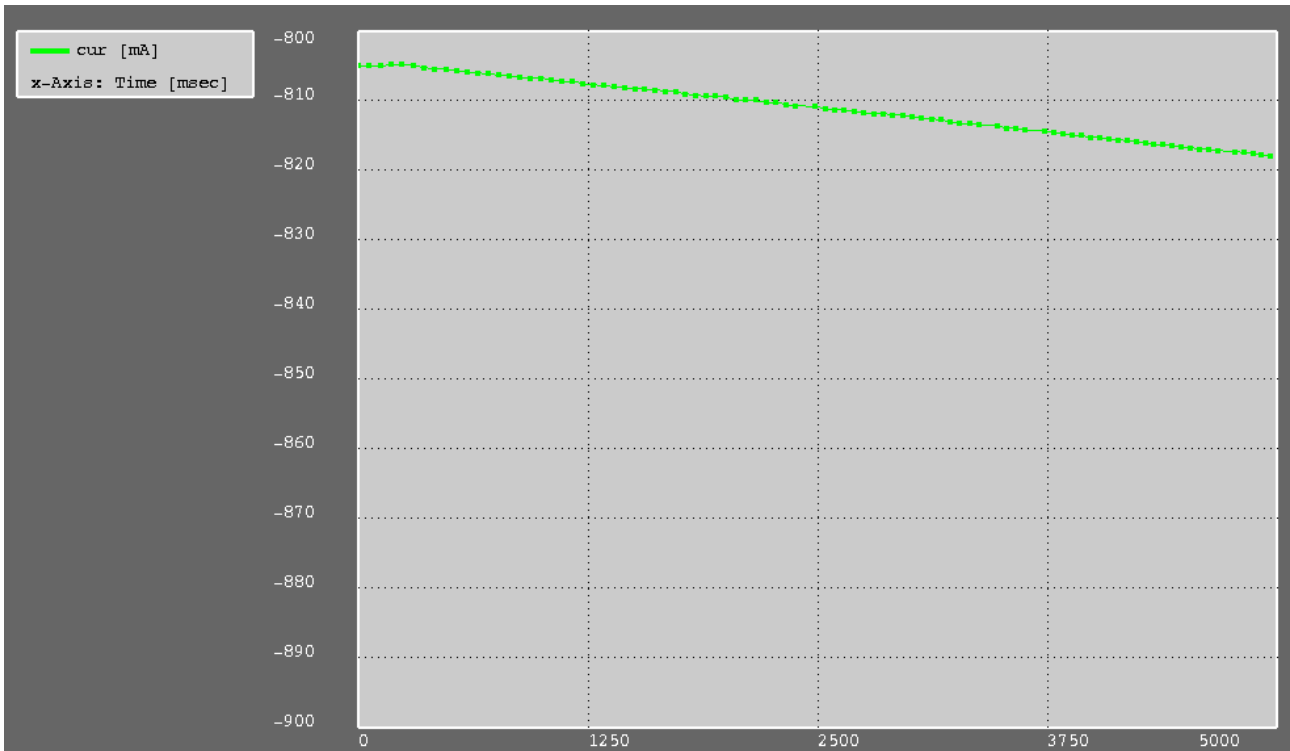


Figure 17: Torque Control Test – -15.0 mNm – Current Zoom [12]

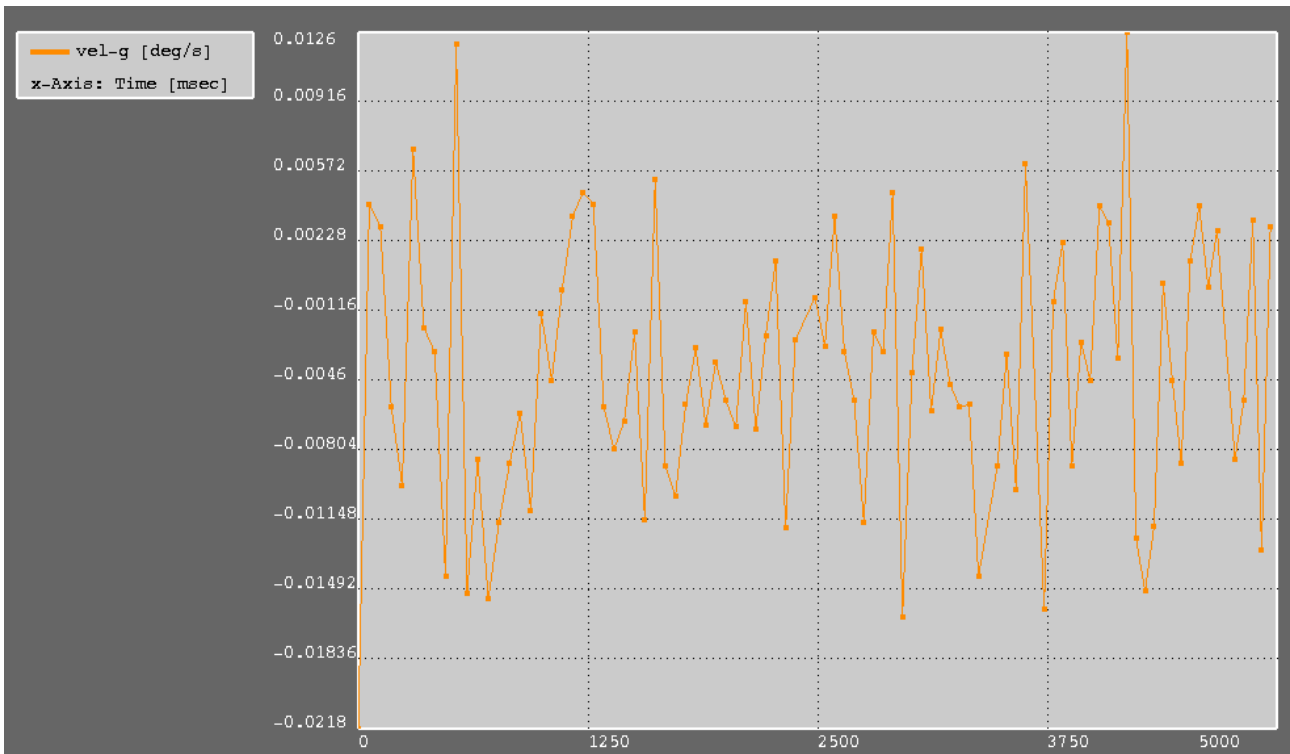


Figure 18: Torque Control Test – -15.0 mNm – Gyro Velocity [12]

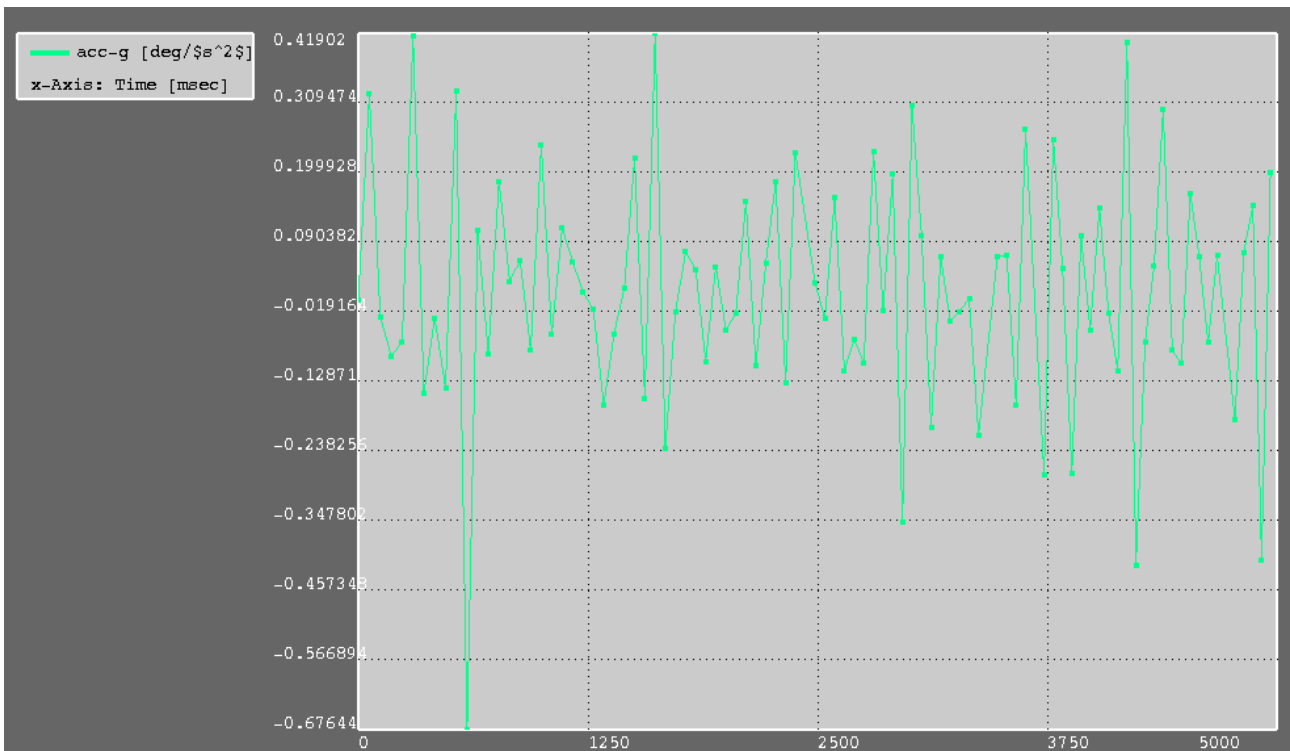


Figure 19: Torque Control Test – -15.0 mNm – Gyro Acceleration [12]

t [msec]	spd [rpm]	spd-r	cur [mA]	trq-c [mNm]	trq	trq-r	vel-g [deg/s]	acc-g [deg/\$s^2\$]	trq-cm
0	-2995.7	-2996.0	-805.0	-15.000	-0.202	-0.850	-0.0218	0.00000	-15.000
239	-3019.4	-3031.0	-804.8	-14.997	-9.013	-15.279	-0.0098	-0.06571	-15.000
475	-3053.5	-3066.5	-805.4	-14.997	-12.801	-15.188	-0.0143	-0.13884	-15.000
708	-3088.5	-3101.5	-806.1	-15.000	-14.315	-15.244	-0.0154	-0.08564	-15.000
881	-3114.6	-3127.7	-806.6	-15.000	-14.877	-15.343	-0.0062	0.06147	-15.000
1110	-3149.0	-3161.9	-807.2	-15.000	-15.181	-15.455	-0.0001	0.11235	-15.000
1336	-3183.2	-3195.9	-807.8	-15.000	-15.300	-15.548	-0.0059	-0.16590	-15.000
1504	-3208.7	-3221.4	-808.3	-15.000	-15.397	-15.501	-0.0022	0.22262	-15.000
1726	-3242.2	-3254.6	-808.7	-14.997	-15.360	-15.226	-0.0103	-0.01926	-15.000
1946	-3275.3	-3287.6	-809.3	-14.997	-15.346	-15.246	-0.0037	0.05210	-15.000
2164	-3308.2	-3320.4	-809.9	-14.997	-15.380	-15.246	-0.0070	-0.10381	-15.000
2326	-3332.6	-3344.8	-810.5	-15.000	-15.397	-15.349	-0.0119	-0.13146	-15.000
2593	-3373.0	-3385.1	-811.3	-15.000	-15.440	-15.666	0.0035	0.16004	-15.000
2804	-3404.9	-3416.7	-811.8	-15.000	-15.342	-14.853	-0.0022	0.23387	-15.000
2962	-3428.7	-3440.5	-812.1	-14.997	-15.398	-15.421	-0.0163	-0.35072	-15.000
3170	-3460.1	-3471.8	-812.7	-14.997	-15.383	-15.186	-0.0021	0.06750	-15.000
3376	-3491.3	-3503.0	-813.4	-15.000	-15.488	-16.006	-0.0143	-0.21301	-15.000
3632	-3529.7	-3541.2	-814.2	-15.000	-15.401	-15.556	0.0061	0.26827	-15.000
3834	-3560.3	-3571.8	-814.7	-15.000	-15.457	-15.819	0.0022	0.04813	-15.000
4034	-3590.6	-3601.9	-815.3	-15.000	-15.450	-15.487	0.0040	0.14449	-15.000
4233	-3620.6	-3631.9	-815.9	-15.000	-15.465	-15.876	-0.0124	-0.41708	-15.000
4381	-3643.0	-3654.2	-816.3	-15.000	-15.453	-15.401	0.0002	0.29966	-15.000
4577	-3672.5	-3683.5	-816.9	-15.000	-15.410	-15.460	0.0040	0.06802	-15.000
4820	-3709.1	-3720.0	-817.4	-14.997	-15.376	-15.113	-0.0056	0.07384	-15.000
4965	-3731.0	-3742.0	-818.0	-15.000	-15.477	-15.877	0.0030	0.20042	-15.000

Table 8: Torque Control Test [12]

Average error without first part (1/5) of data set: 0.40 mNm

Torque Control good: duration 5043 msec

OK

1.13 Open Loop Trq Ctrl: Trq=2.0 mNm Spd=-3000 rpm @dt=0 [cmd-upd] (Test ID: 13)

1.13.1 Method

RWA05 Test Step: Speed Tolerance used is 5.0 rpm. Speed read interval used is 250 msec.

1. Cmd: 'Set Speed' -3000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd: 'Set Torque' 2.0 mNm (dt=0)
5. Loop: Read std. data and wait 50msec
6. Update trq all 250 msec with $trq = 0.00e+00 * dt*dt*dt + 0.00e+00 * dt*dt + 0.00e+00 * dt + 2.00e-03 Nm$
7. Wait for 5000 msec

1.13.2 Result

1st coeffs: 2.000e-03 0.000e+00 0.000e+00 0.000e+00

2020_07_10_09_03_58_246: 'Set Speed' -3000.0 rpm

2020_07_10_09_04_02_790: 'Set Speed' -3000.0 rpm OK [duration 4508 msec, com_err=0]

2020_07_10_09_04_07_822: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_08_075: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_08_323: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_08_583: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_08_832: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_09_073: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_09_332: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_09_582: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_09_823: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_10_083: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_10_332: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_10_582: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_10_822: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_11_073: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_11_322: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_11_573: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_11_834: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_12_073: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_12_322: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_12_572: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]
2020_07_10_09_04_12_822: 'Set Torque (Open Loop)' 2.0 mNm OK [com. error = 0]

BST

2020_07_10_09_04_12_839: Data capture ready [duration 5040 msec, com. error = 0]

2020_07_10_09_04_12_872: 'Set Speed' OK [end speed = -3000.0; com. errors = 0]

BST

RW Parameter read ready [com. error = 0]

```

MoI      : 0.00097855 [kgm^2]
km       : 20.2 [mNm/A]
Min Current : 1.0 [mA]
Max Current : 900.0 [mA]
Max Speed  : 5050.0 [rpm]
Max Trq.   : 20.0 [mNm]

kM_val0   : 20.1 20.1 20.1 [mNm/A]
kM_val1   : 20.1 20.1 20.1 [mNm/A]
kM_spd0   : 500.0 500.0 500.0 [rpm]
kM_spd1   : 5000.0 5000.0 5000.0 [rpm]
cur_kM    : 300.0 600.0 900.0 [mA]
Back-EMF ke : 2.115 [mV/rpm]
V_diode   : 100.0 100.0 100.0 [mV]
Mot. R.   : 10.0 10.0 10.0 [Ohm]
Temp.     : -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.      : 27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.      : 44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a    : 81.8 [-]
T_pcb: b    : 200.0 [degC]      T_pcb,cal = a * T_pcb + b
T_mot: a    : 1.0 [-]
T_mot: b    : -0.0 [degC]     T_mot = a * T_meas + b
kp Current  : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]

```

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat13_trq.tx

The torque value 'Trq from Cur' is calculated from the target current and motor constant plus the friction and yields a good indication of the actual torque (the measured speed/torque response is delayed due to necessary filtering, the raw values are usually too noisy)

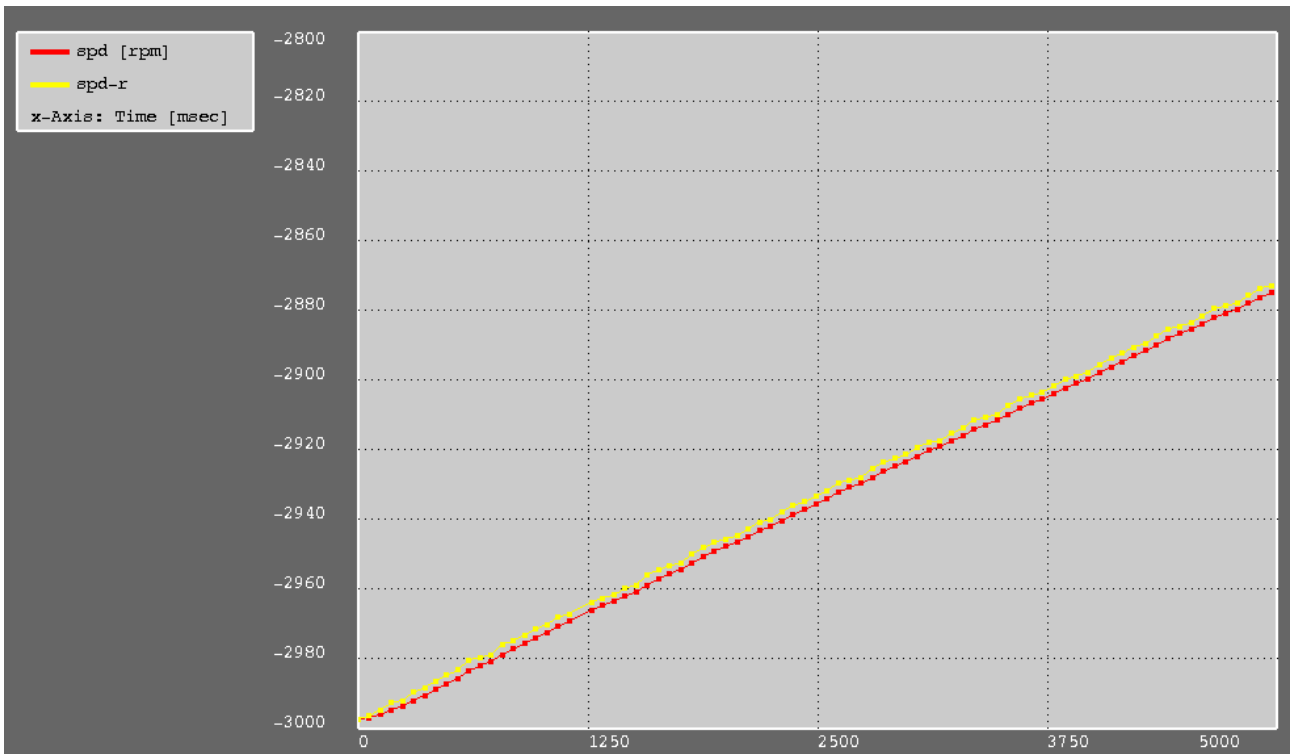


Figure 20: Torque Control Test – 2.0 mNm – Speed over Time [13]

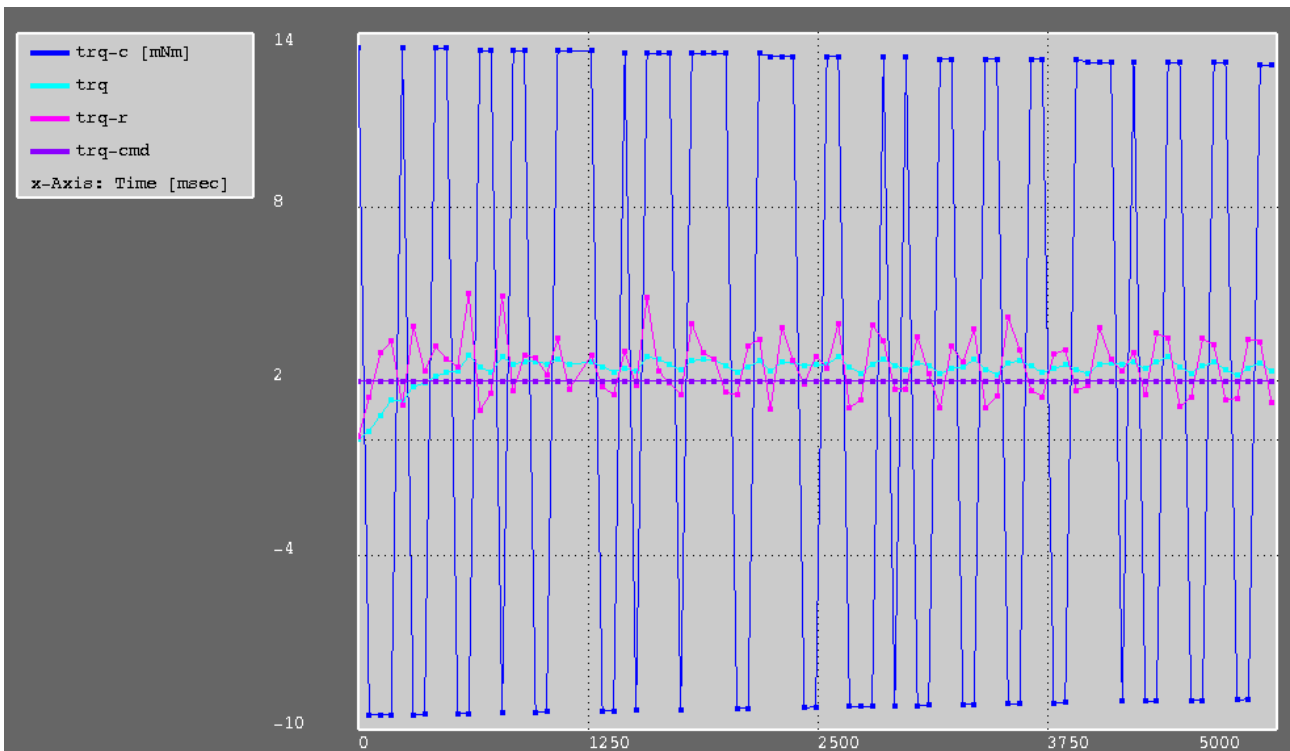


Figure 21: Torque Control Test – 2.0 mNm – Torque over Time [13]

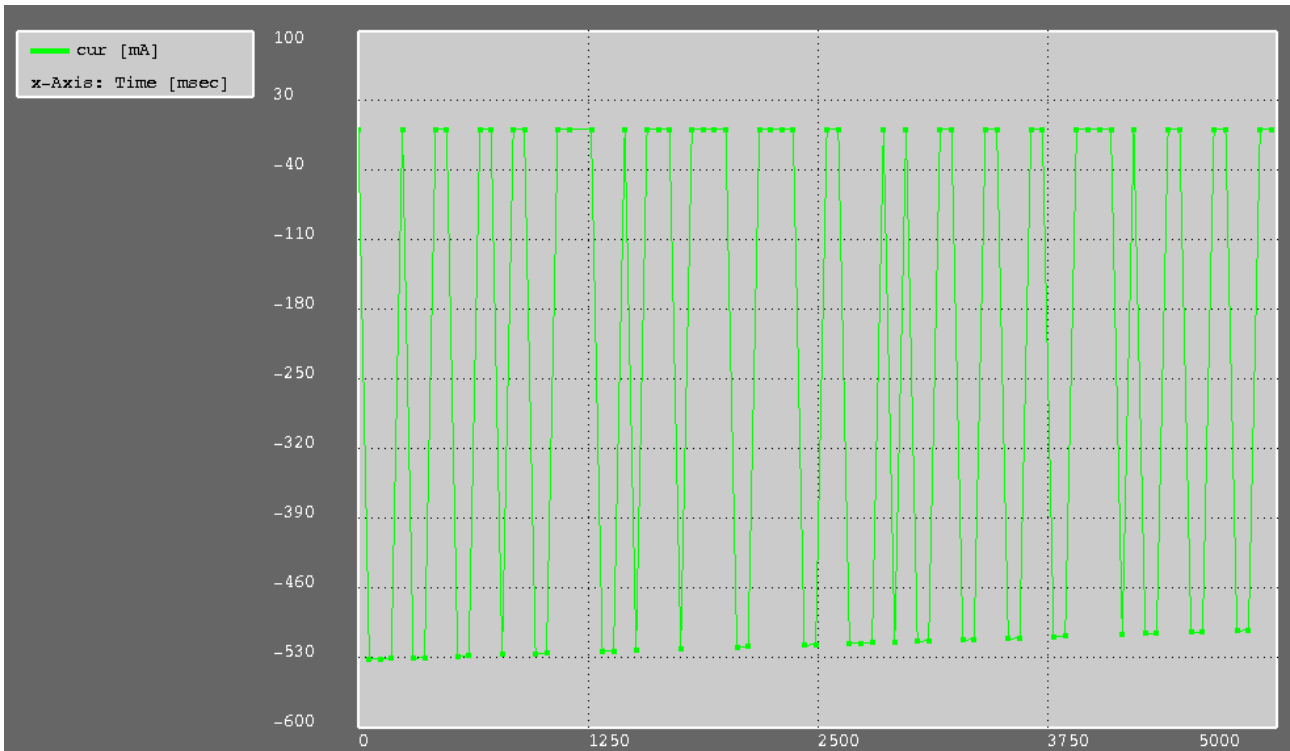


Figure 22: Torque Control Test – 2.0 mNm – Current Zoom [13]

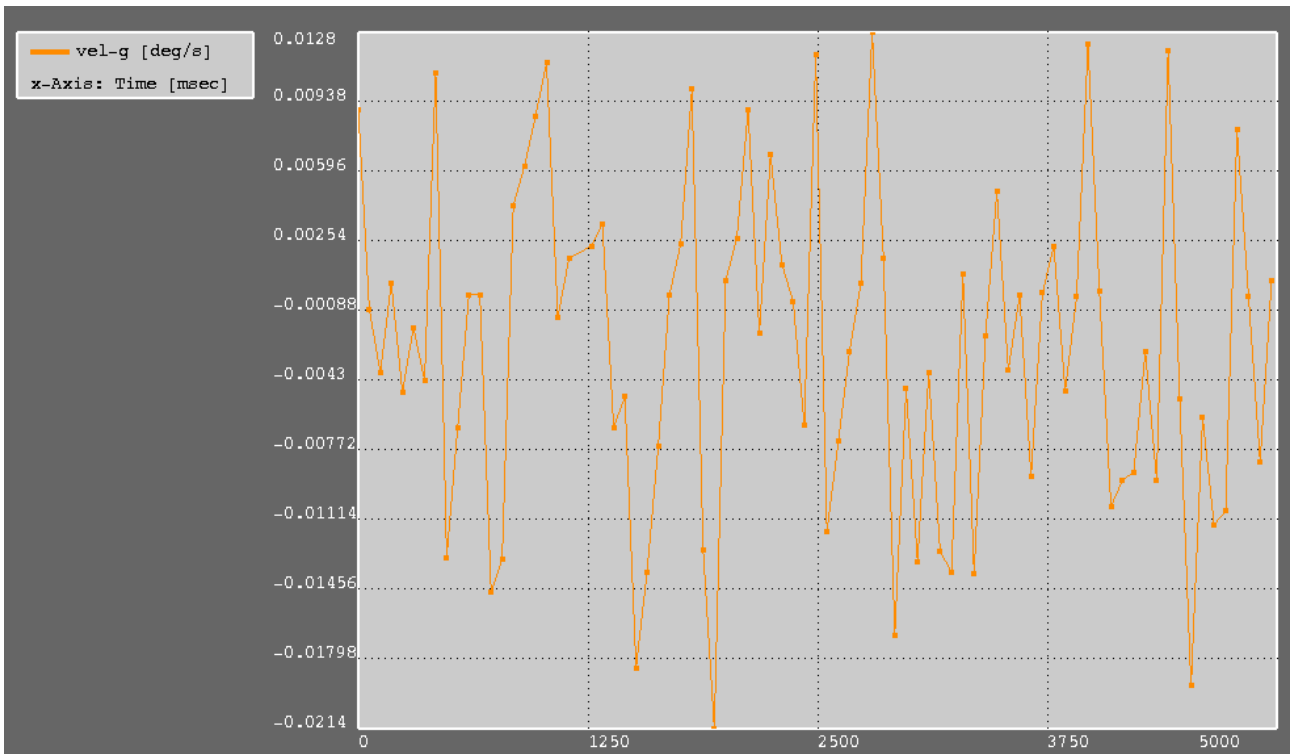


Figure 23: Torque Control Test – 2.0 mNm – Gyro Velocity [13]

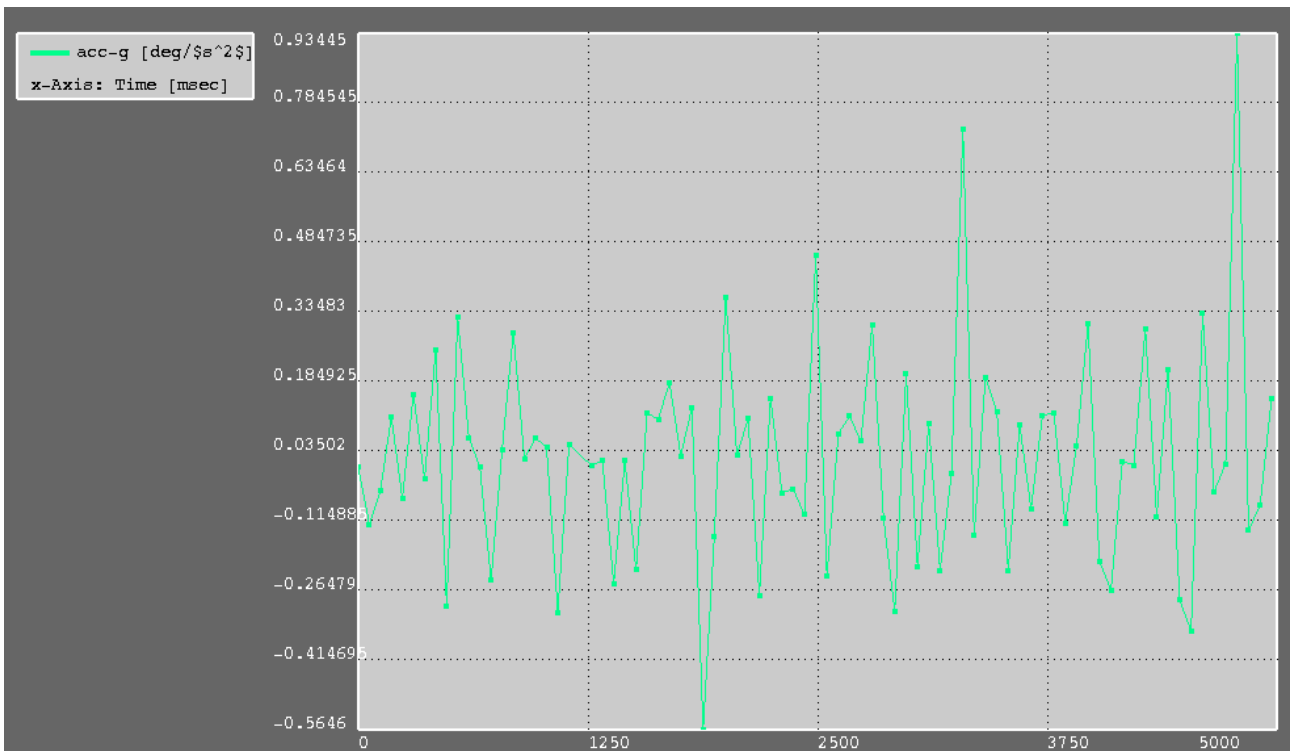


Figure 24: Torque Control Test – 2.0 mNm – Gyro Acceleration [13]

BST

t [msec]	spd [rpm]	spd-r	cur [mA]	trq-c [mNm]	trq	trq-r	vel-g [deg/s]	acc-g [deg/\$s^2\$]	trq-cmd
0	-2997.2	-2997.2	1.0	13.5	0.011	0.085	0.0090	0.00000	2.000
240	-2993.5	-2991.9	1.0	13.5	1.314	1.186	-0.0049	-0.06717	2.000
421	-2988.8	-2986.3	1.0	13.5	2.189	3.203	0.0108	0.25158	2.000
602	-2983.4	-2980.2	-527.9	-9.436	2.885	5.028	-0.0001	0.06425	2.000
844	-2977.1	-2974.8	1.0	13.4	2.609	1.666	0.0043	0.29077	2.000
1025	-2972.4	-2970.1	-525.2	-9.386	2.608	2.238	0.0113	0.04242	2.000
1268	-2966.0	-2963.6	1.0	13.4	2.685	2.883	0.0023	0.00464	2.000
1512	-2960.7	-2958.7	-522.4	-9.333	2.348	1.885	-0.0184	-0.22088	2.000
1694	-2955.5	-2953.2	1.0	13.3	2.600	1.956	-0.0001	0.18299	2.000
1877	-2950.7	-2948.1	1.0	13.3	2.766	3.000	-0.0126	-0.56460	2.000
2122	-2944.9	-2942.7	-518.5	-9.262	2.512	3.226	0.0090	0.10530	2.000
2306	-2940.2	-2937.7	1.0	13.2	2.667	3.852	0.0014	-0.05439	2.000
2490	-2935.5	-2933.2	-516.6	-9.227	2.596	2.875	0.0117	0.45650	2.000
2736	-2929.6	-2927.8	-515.1	-9.198	2.274	1.350	0.0005	0.05672	2.000
2920	-2924.6	-2922.4	-513.6	-9.170	2.563	1.737	-0.0168	-0.30865	2.000
3105	-2920.1	-2917.8	-512.5	-9.149	2.557	2.280	-0.0039	0.09331	2.000
3352	-2914.1	-2911.3	-511.1	-9.122	2.763	3.827	-0.0138	-0.14663	2.000
3538	-2909.8	-2907.2	-510.4	-9.111	2.631	4.200	-0.0038	-0.22106	2.000
3724	-2905.3	-2903.4	1.0	13.1	2.312	1.471	-0.0000	0.11157	2.000
3972	-2899.5	-2897.6	1.0	13.0	2.284	1.847	0.0122	0.30935	2.000
4159	-2894.6	-2892.2	-505.8	-9.024	2.577	2.373	-0.0092	0.01264	2.000
4346	-2889.8	-2887.2	-505.0	-9.011	2.676	3.657	-0.0092	-0.10595	2.000
4596	-2883.7	-2881.4	-503.5	-8.983	2.527	3.483	-0.0061	0.33081	2.000
4783	-2879.5	-2877.7	-502.4	-8.962	2.214	1.432	0.0080	0.93445	2.000
4971	-2874.8	-2872.7	1.0	12.9	2.372	1.275	0.0006	0.14876	2.000

Table 9: Torque Control Test [13]

Average error without first part (1/5) of data set: 0.55 mNm

Torque Control good: duration 5040 msec

OK

1.14 Open Loop Trq Ctrl: Trq=15.0 mNm Spd=-3000 rpm @dt=0 [cmd-upd] (Test ID: 14)

1.14.1 Method

RWA05 Test Step: Speed Tolerance used is 5.0 rpm. Speed read interval used is 250 msec.

1. Cmd: 'Set Speed' -3000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd: 'Set Torque' 15.0 mNm (dt=0)
5. Loop: Read std. data and wait 50msec
6. Update trq all 250 msec with $\text{trq} = 0.00\text{e}+00 * dt*dt*dt + 0.00\text{e}+00 * dt*dt + 0.00\text{e}+00 * dt + 1.50\text{e}-02 \text{ Nm}$
7. Wait for 5000 msec

1.14.2 Result

1st coeffs: 1.500e-02 0.000e+00 0.000e+00 0.000e+00

2020_07_10_09_04_24_717: 'Set Speed' -3000.0 rpm

2020_07_10_09_04_24_755: 'Set Speed' -3000.0 rpm OK [duration 8 msec, com_err=0]

2020_07_10_09_04_29_787: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_30_048: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_30_287: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_30_538: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_30_797: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_31_047: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_31_297: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_31_547: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_31_788: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_32_038: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_32_297: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_32_538: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_32_797: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_33_047: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_33_288: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_33_538: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_33_797: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_34_047: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_34_288: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_34_538: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]
2020_07_10_09_04_34_788: 'Set Torque (Open Loop)' 15.0 mNm OK [com. error = 0]

BST

2020_07_10_09_04_34_806: Data capture ready [duration 5042 msec, com. error = 0]

2020_07_10_09_04_34_840: 'Set Speed' OK [end speed = 0.0; com. errors = 0]

BST

RW Parameter read ready [com. error = 0]

```

MoI      : 0.00097855 [kgm^2]
km       : 20.2 [mNm/A]
Min Current : 1.0 [mA]
Max Current : 900.0 [mA]
Max Speed  : 5050.0 [rpm]
Max Trq.   : 20.0 [mNm]

kM_val0   : 20.1 20.1 20.1 [mNm/A]
kM_val1   : 20.1 20.1 20.1 [mNm/A]
kM_spd0   : 500.0 500.0 500.0 [rpm]
kM_spd1   : 5000.0 5000.0 5000.0 [rpm]
cur_kM    : 300.0 600.0 900.0 [mA]
Back-EMF ke : 2.115 [mV/rpm]
V_diode   : 100.0 100.0 100.0 [mV]
Mot. R.   : 10.0 10.0 10.0 [Ohm]
Temp.     : -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.      : 27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.      : 44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a    : 81.8 [-]
T_pcb: b    : 200.0 [degC]      T_pcb,cal = a * T_pcb + b
T_mot: a    : 1.0 [-]
T_mot: b    : -0.0 [degC]     T_mot = a * T_meas + b
kp Current  : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]

```

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat14_trq.tx

The torque value 'Trq from Cur' is calculated from the target current and motor constant plus the friction and yields a good indication of the actual torque (the measured speed/torque response is delayed due to necessary filtering, the raw values are usually too noisy)

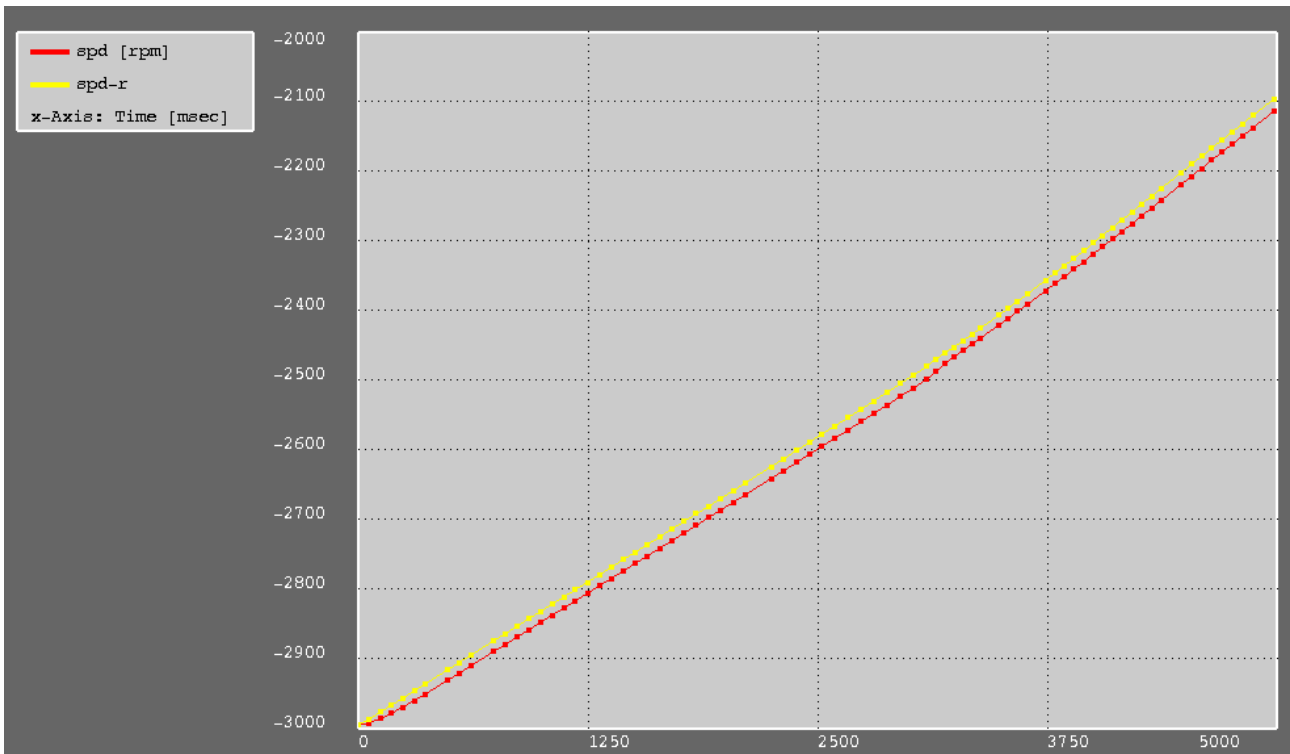


Figure 25: Torque Control Test – 15.0 mNm – Speed over Time [14]

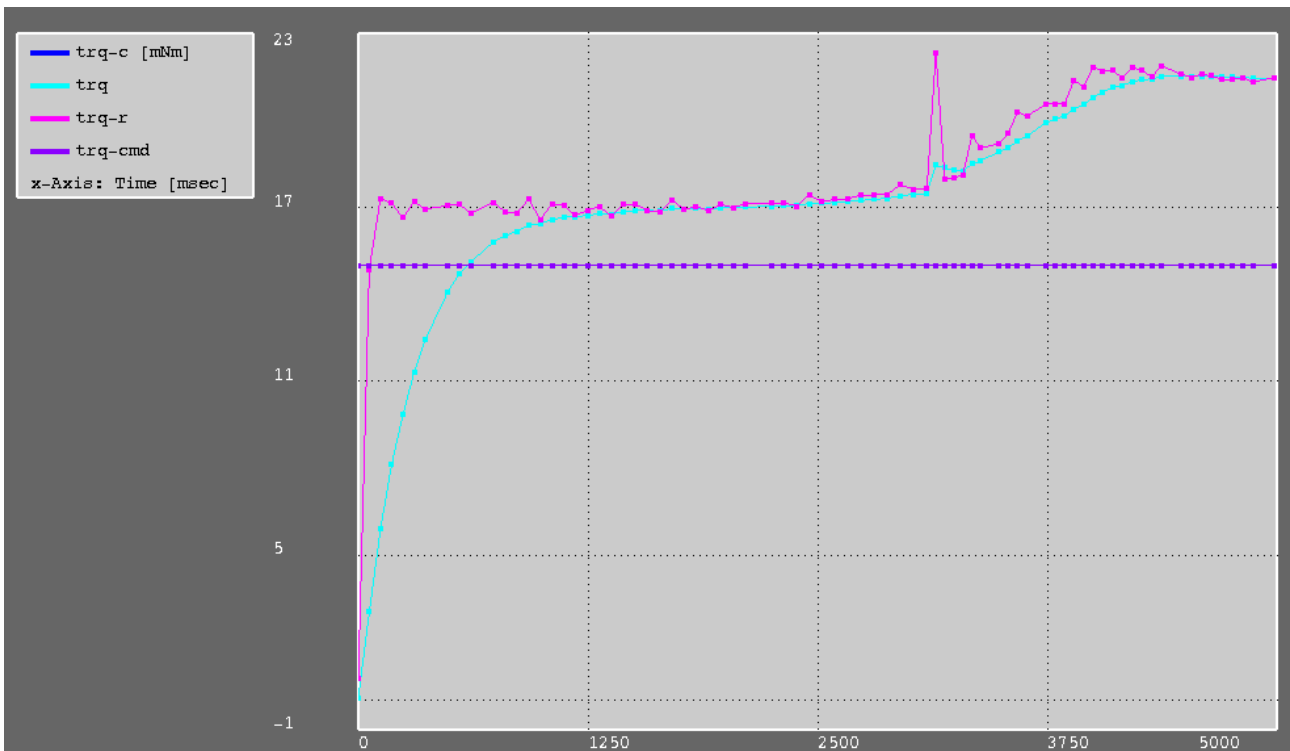


Figure 26: Torque Control Test – 15.0 mNm – Torque over Time [14]

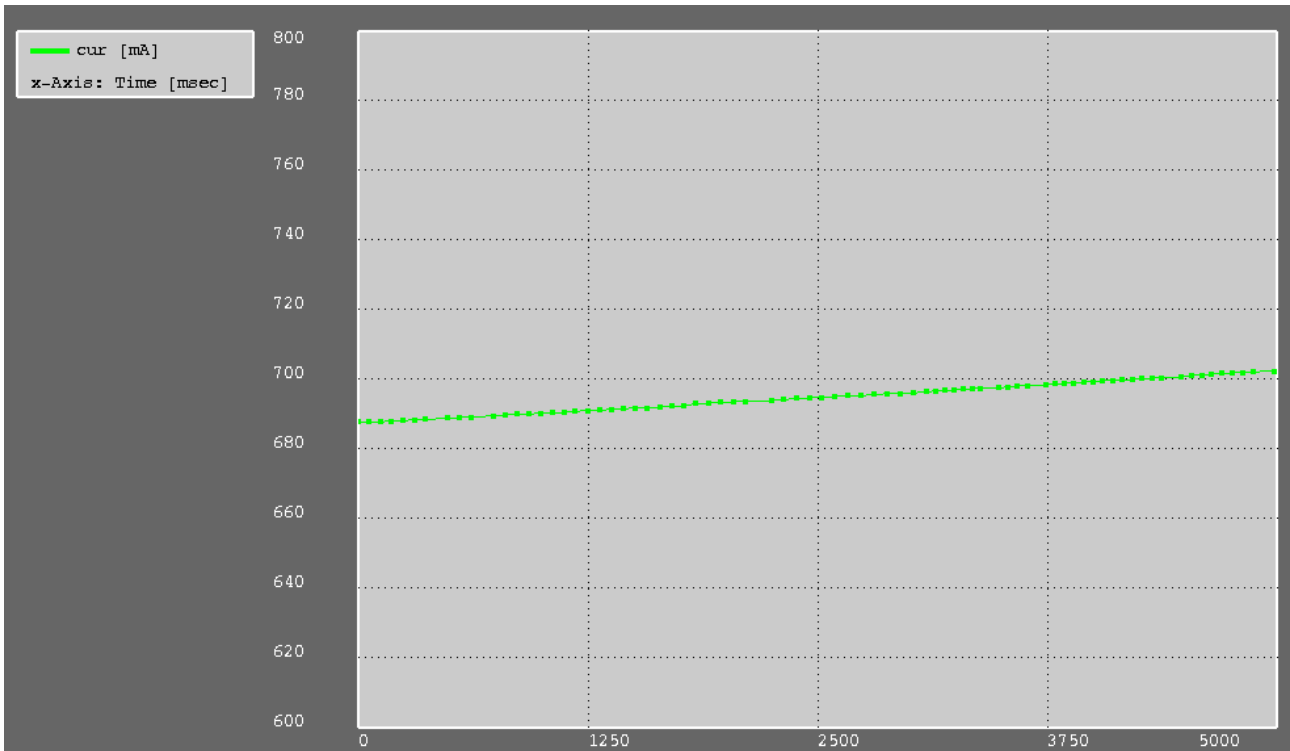


Figure 27: Torque Control Test – 15.0 mNm – Current Zoom [14]

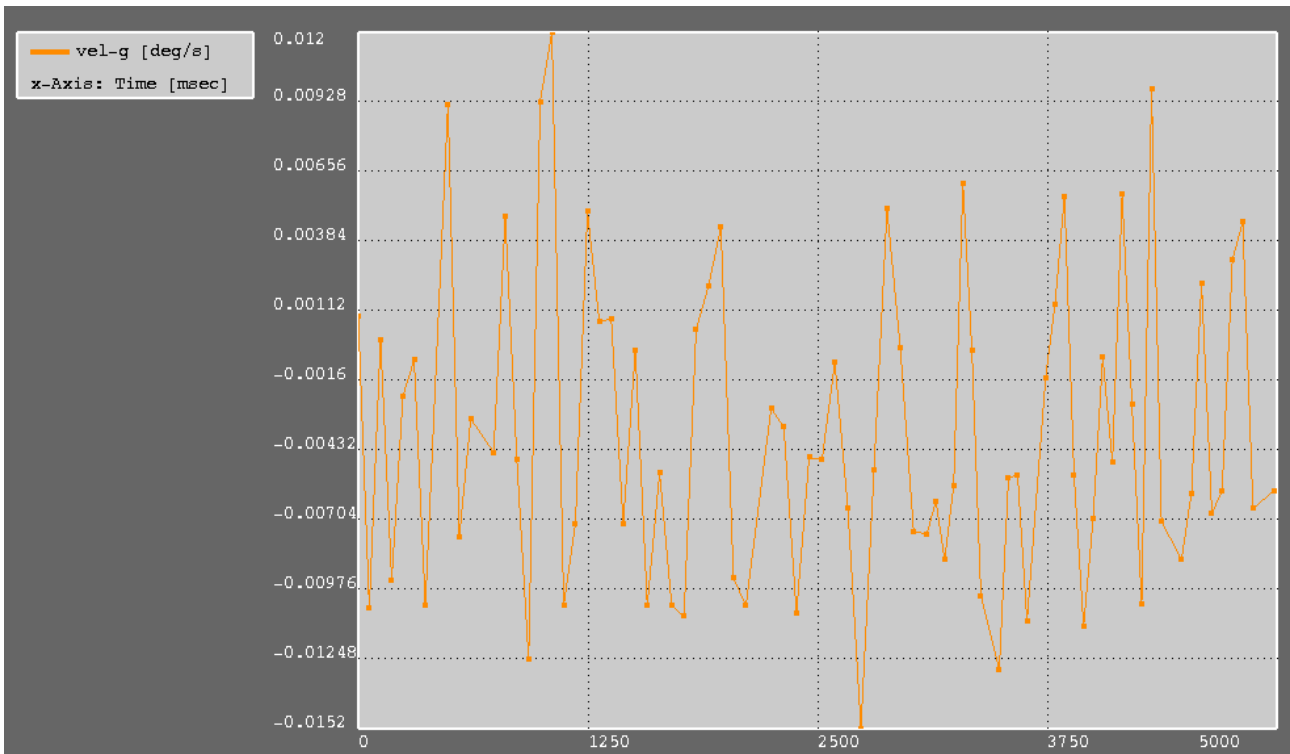


Figure 28: Torque Control Test – 15.0 mNm – Gyro Velocity [14]

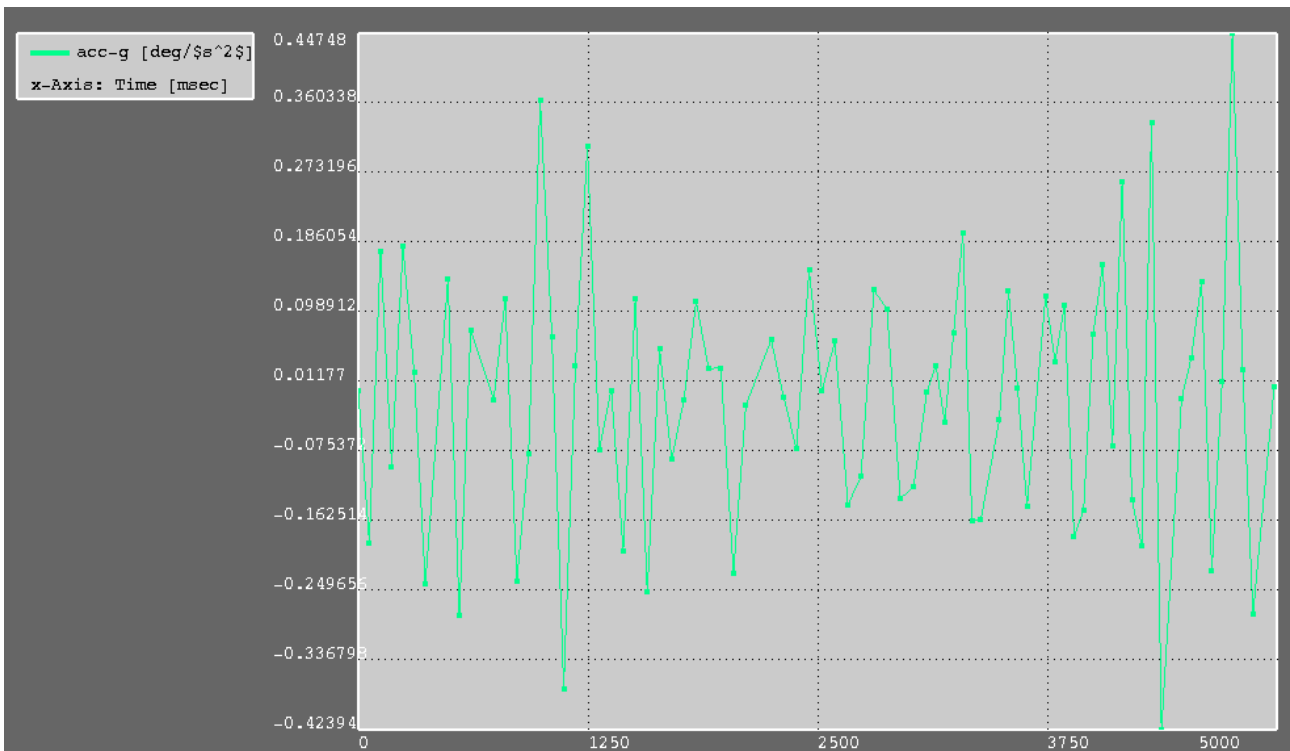


Figure 29: Torque Control Test – 15.0 mNm – Gyro Acceleration [14]

t [msec]	spd [rpm]	spd-r	cur [mA]	trq-c [mNm]	trq	trq-r	vel-g [deg/s]	acc-g [deg/\$s^2\$]	trq-cmd
0	-2995.2	-2995.0	687.8	15.0	0.104	0.765	0.0009	0.00000	15.000
243	-2969.0	-2956.0	688.2	15.0	9.851	16.639	-0.0022	0.18194	15.000
488	-2930.2	-2915.1	688.9	15.0	14.098	17.062	0.0092	0.14054	15.000
737	-2889.3	-2873.8	689.6	15.0	15.816	17.177	-0.0044	-0.01088	15.000
927	-2858.1	-2842.4	690.1	15.0	16.399	17.279	-0.0125	-0.07814	15.000
1118	-2826.7	-2810.8	690.5	15.0	16.670	17.062	-0.0104	-0.37248	15.000
1312	-2794.9	-2778.9	691.2	15.0	16.785	17.034	0.0007	-0.07316	15.000
1573	-2751.9	-2735.6	691.8	15.0	16.893	16.902	-0.0104	-0.25153	15.000
1773	-2719.1	-2702.6	692.3	15.0	16.950	16.926	-0.0108	-0.01065	15.000
1974	-2685.9	-2669.2	693.4	15.0	16.978	17.093	0.0044	0.02865	15.000
2247	-2640.8	-2623.8	694.0	15.0	17.035	17.156	-0.0027	0.06368	15.000
2454	-2606.3	-2588.9	694.7	15.0	17.130	17.422	-0.0046	0.15087	15.000
2665	-2571.2	-2553.5	695.3	15.0	17.194	17.299	-0.0066	-0.14238	15.000
2950	-2523.0	-2504.7	695.9	15.0	17.404	17.780	-0.0003	-0.13478	15.000
3144	-2486.7	-2469.2	696.7	15.0	18.457	22.343	-0.0063	0.03219	15.000
3291	-2457.3	-2443.3	697.2	15.0	18.257	18.126	0.0061	0.19734	15.000
3489	-2419.9	-2405.8	697.6	15.0	18.922	19.199	-0.0129	-0.03669	15.000
3640	-2391.0	-2376.4	698.3	15.0	19.467	20.138	-0.0110	-0.14454	15.000
3844	-2350.6	-2335.3	698.9	15.0	20.143	20.572	0.0056	0.10706	15.000
4052	-2307.9	-2291.6	699.6	15.0	20.977	21.685	-0.0007	0.15840	15.000
4211	-2274.8	-2258.1	699.9	15.0	21.320	21.821	-0.0025	-0.13664	15.000
4372	-2241.0	-2224.0	700.5	15.0	21.512	21.873	-0.0071	-0.42394	15.000
4590	-2195.3	-2178.0	701.3	15.0	21.525	21.584	0.0022	0.13699	15.000
4758	-2160.5	-2143.0	701.9	15.0	21.483	21.408	0.0031	0.44748	15.000
4985	-2113.4	-2095.6	702.4	15.0	21.442	21.472	-0.0059	0.00458	15.000

Table 10: Torque Control Test [14]

Average error without first part (1/5) of data set: 3.74 mNm

Torque Control good: duration 5042 msec

OK

1.15 Friction Measurement (1 times) (Test ID: 15)

1.15.1 Method

Speed Reading from 4900.0 rpm to 500.0 rpm. Speed Tolerance used is 5.0 rpm. Speed read interval used is 500 msec.

1. Cmd: 'Set Speed' 5000.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Pos+Neg Commutation Test -> Procedure is repeated for: Cmd 'Set Current +MIN', Cmd 'Set Current -MIN'
5. Wait until speed of 500.0 rpm is reached (max. 12 min)
6. Check friction: error must be smaller than 0.00 mNm (only in cases when no internal currents are triggered)
7. Check if duration is bigger than min. time = 270000 msec (only in cases when no internal currents are triggered)

1.15.2 Result

BST

==== CASE: 0 ====

RW Parameter read ready [com. error = 0]

```
MoI      : 0.00097855 [kgm^2]
km       : 20.2 [mNm/A]
Min Current : 1.0 [mA]
Max Current : 900.0 [mA]
Max Speed  : 5050.0 [rpm]
Max Trq.   : 20.0 [mNm]

kM_val0   : 20.1 20.1 20.1 [mNm/A]
kM_val1   : 20.1 20.1 20.1 [mNm/A]
kM_spd0   : 500.0 500.0 500.0 [rpm]
kM_spd1   : 5000.0 5000.0 5000.0 [rpm]
cur_kM    : 300.0 600.0 900.0 [mA]
Back-EMF ke : 2.115 [mV/rpm]
V_diode   : 100.0 100.0 100.0 [mV]
Mot. R.   : 10.0 10.0 10.0 [Ohm]
Temp.     : -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.      : 27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.      : 44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a    : 81.8 [-]
T_pcb: b    : 200.0 [degC] T_pcb,cal = a * T_pcb + b
T_mot: a    : 1.0 [-]
T_mot: b    : -0.0 [degC] T_mot = a * T_meas + b
kp Current  : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]
```

Cmd:'Set Speed' 5000.0 rpm OK [duration 30512 msec, com_err=0]

Cmd:'Set Current 0.001 A' OK [com. error = 0]

Data capture ready [duration 570060 msec, com. error = 0]

Motor Temperature: avg=30.6 min=30.1 max=31.2 degC

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat15_fric00

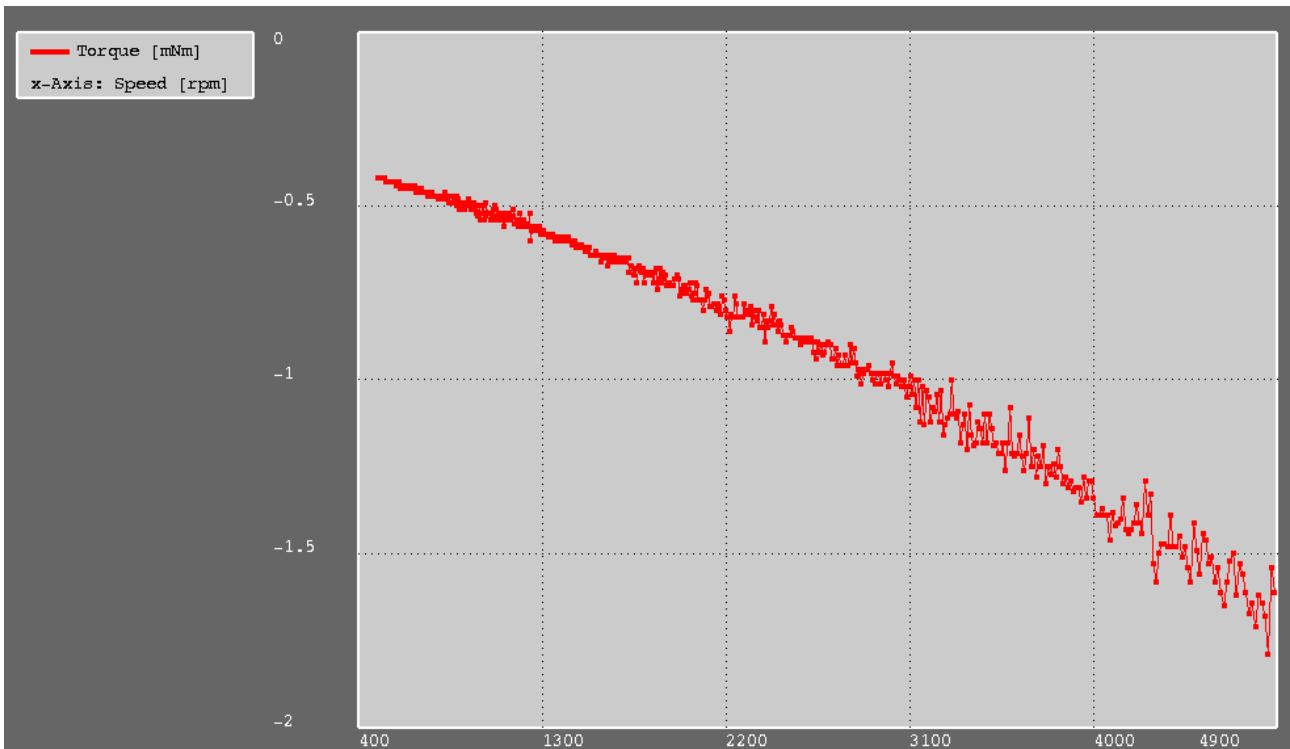


Figure 30: Friction Test - Torque Plot [15,0,0]

Speed [rpm]	Torque [mNm]
497.5	-0.42
592.4	-0.44
687.4	-0.45
791.0	-0.48
894.3	-0.51
1007.2	-0.52
1120.4	-0.53
1244.5	-0.60
1369.5	-0.60
1506.8	-0.62
1645.8	-0.66
1799.1	-0.72
1953.9	-0.71
2117.3	-0.75
2297.7	-0.81
2480.8	-0.87
2684.7	-0.92
2892.2	-0.97
3123.6	-1.00
3360.4	-1.13
3627.3	-1.21
3903.1	-1.32
4213.3	-1.36
4536.9	-1.44
4890.3	-1.61

Table 11: Friction Test Reduced Data [15,0,0]

It should be noted that the firsts measurements (at start speed) logged can still show the wheel in state transition (speed control to idle) depending on the 'speed init' and 'speed start measurement' values, so lower friction values can be seen.

Measured Values:

pos/forward commutation:

a=-2.292e-09 b=-1.413e-06 c=-3.190e-04 | 30.6 degC | -1.7 | -1.0 | -0.5 mNm @ 5|3|1 krpm

Expected Values:

pos/forward commutation:

a= 1.309e-08 b=-1.491e-05 c=-1.306e-03 | -4.0 degC | -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
a=-2.118e-09 b=-2.085e-06 c=-3.462e-04 | 27.0 degC | -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
a=-2.370e-09 b=-1.682e-06 c=-2.932e-04 | 44.0 degC | -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
| 30.6 degC | -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm

Friction good: duration 570060 > 270000 msec

BST

==== CASE: 1 ====

RW Parameter read ready [com. error = 0]

```
MoI      : 0.00097855 [kgm^2]
km       :      20.2 [mNm/A]
Min Current :      1.0 [mA]
Max Current :     900.0 [mA]
Max Speed  :    5050.0 [rpm]
Max Trq.   :      20.0 [mNm]

kM_val0   :      20.1      20.1      20.1 [mNm/A]
kM_val1   :      20.1      20.1      20.1 [mNm/A]
kM_spd0   :     500.0     500.0     500.0 [rpm]
kM_spd1   :    5000.0    5000.0    5000.0 [rpm]
cur_kM    :     300.0     600.0     900.0 [mA]
Back-EMF ke :     2.115 [mV/rpm]
V_diode   :     100.0     100.0     100.0 [mV]
Mot. R.   :      10.0      10.0      10.0 [Ohm]
Temp.     :      -4 [degC]
Friction p[] : 1.309e-08 -1.491e-05 -1.306e-03
--> -5.5 | -4.7 | -2.7 mNm @ 5|3|1 krpm
Friction n[] : 1.868e-08 -6.273e-05 -4.983e-04
--> -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
Temp.     :      27 [degC]
Friction p[] : -2.118e-09 -2.085e-06 -3.462e-04
--> -2.0 | -1.2 | -0.6 mNm @ 5|3|1 krpm
Friction n[] : 4.056e-09 -4.661e-05 -3.364e-04
--> -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
Temp.     :      44 [degC]
Friction p[] : -2.370e-09 -1.682e-06 -2.932e-04
--> -1.8 | -1.1 | -0.5 mNm @ 5|3|1 krpm
Friction n[] : 5.691e-09 -4.443e-05 -3.007e-04
--> -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
T_pcb: a   :      81.8 [-]
T_pcb: b   :     200.0 [degC]      T_pcb,cal = a * T_pcb + b
T_mot: a   :      1.0 [-]
T_mot: b   :      -0.0 [degC]      T_mot = a * T_meas + b
kp Current : 7.650e+03 []
spd_cfilter_k: 0.60 []
trq_cfilter_k: 0.80 []
settle current: 0.200 [A]
settle time: 1500 [msec]
```


Cmd:'Set Speed' 5000.0 rpm OK [duration 28010 msec, com_err=0]

Cmd:'Set Current -0.001 A' OK [com. error = 0]

Data capture ready [duration 47021 msec, com. error = 0]

Motor Temperature: avg=30.2 min=30.2 max=30.4 degC

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat15_fric00

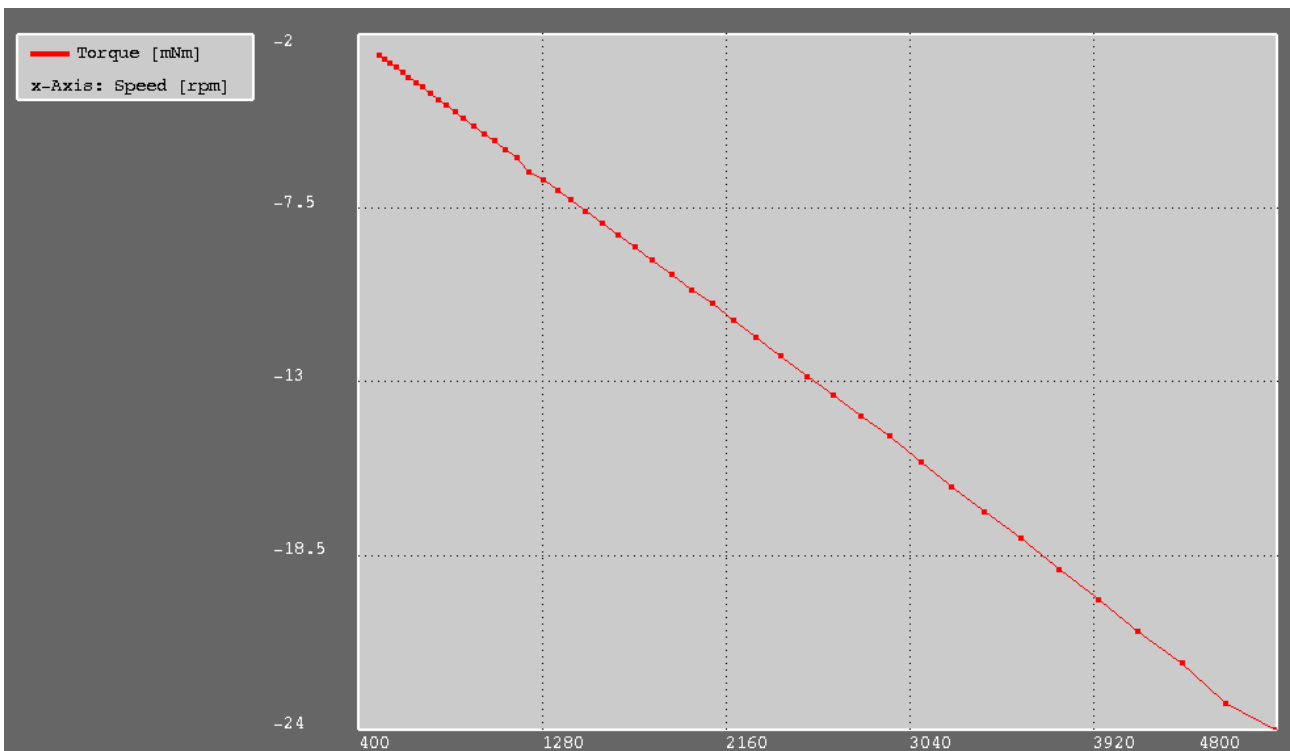


Figure 31: Friction Test - Torque Plot [15,0,1]

Speed [rpm]	Torque [mNm]
497.8	-2.65
552.9	-2.92
610.6	-3.20
674.2	-3.52
743.5	-3.86
821.6	-4.24
905.4	-4.67
1000.9	-5.15
1105.1	-5.65
1218.0	-6.37
1354.1	-6.92
1489.9	-7.59
1566.6	-7.96
1725.7	-8.74
1902.0	-9.60
2095.5	-10.50
2306.1	-11.59
2551.4	-12.82
2805.1	-14.06
3093.5	-15.52
3399.5	-17.09
3758.5	-18.92
4133.0	-20.89
4556.4	-23.17
4793.1	-24.00

Table 12: Friction Test Reduced Data [15,0,1]

It should be noted that the firsts measurements (at start speed) logged can still show the wheel in state transition (speed control to idle) depending on the 'speed init' and 'speed start measurement' values, so lower friction values can be seen.

Measured Values:

```
neg/reverse commutation:
a=-2.267e-09 b=-4.656e-05 c=-2.323e-04 | 30.2 degC | -25.2 | -15.1 | -5.1 mNm @ 5|3|1 krpm
```

Expected Values:

```
neg/reverse commutation:
a= 1.868e-08 b=-6.273e-05 c=-4.983e-04 | -4.0 degC | -28.2 | -18.4 | -6.9 mNm @ 5|3|1 krpm
a= 4.056e-09 b=-4.661e-05 c=-3.364e-04 | 27.0 degC | -23.6 | -14.6 | -5.2 mNm @ 5|3|1 krpm
a= 5.691e-09 b=-4.443e-05 c=-3.007e-04 | 44.0 degC | -22.0 | -13.7 | -4.9 mNm @ 5|3|1 krpm
| 30.2 degC | -23.3 | -14.4 | -5.1 mNm @ 5|3|1 krpm
```

BST

Friction test passed

OK

1.16 Current Control Test with 900 mA SPD=0.0 (Test ID: 16)

1.16.1 Method

Speed Tolerance used is 5.0 rpm. Speed read interval used is 500 msec.

1. Cmd:'Set Speed' 0.0 rpm
2. Wait until speed target is fulfilled (max. 2 min)
3. Wait 5 secs
4. Cmd:'Set Current' 900.0 mA
5. Observe/measure current input
6. Wait until speed of 5000.0 rpm is reached (max. 80000 msec)

1.16.2 Result

RW Parameter read ready [com. error = 0]

```
MoI          : 0.00097855 [kgm^2]
km           : 20.2 [mNm/A]
Min Current  : 1.0 [mA]
Max Current  : 900.0 [mA]
Max Speed    : 5050.0 [rpm]
Max Trq.     : 20.0 [mNm]
```

Cmd:'Set Speed' 0.0 rpm OK [duration 13514 msec]

Cmd:'Set Current' 900.0 mA OK [com error = 0]

Data capture ready [duration 29557 msec, com_err=0]

Data File:

data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat16_cur.txt

dt_spd [msec]	cur [mA]	spd [rpm]	trq [mNm]	trq-c [mNm]
0	900.0	2.6	-0.00	18.18
1354	900.0	204.1	12.28	18.18
2664	900.0	483.3	17.73	18.18
3891	900.0	713.8	18.18	18.18
5156	900.0	942.8	18.09	18.18
6437	900.0	1171.2	18.00	18.18
7381	900.0	1323.4	17.57	18.18
8689	900.0	1554.4	17.87	18.18
9899	900.0	1767.4	17.83	18.18
11162	900.0	1988.3	17.70	18.18
12464	900.0	2214.4	17.66	18.18
13695	900.0	2427.3	17.61	18.18
14692	900.0	2591.0	17.44	18.18
15949	900.0	2806.8	17.51	18.18
17176	900.0	3016.7	17.40	18.18
18436	900.0	3231.0	17.32	18.18
19723	900.0	3448.7	17.23	18.18
20934	900.0	3652.6	17.12	18.18
21957	900.0	3819.0	17.02	18.18
23175	900.0	4022.2	17.03	18.18
24449	900.0	4233.8	16.93	18.18
25716	900.0	4443.2	16.79	18.18
26927	900.0	4642.5	16.82	18.18
28187	900.0	4848.3	16.63	18.18
29206	900.0	5014.3	16.56	18.18

Table 13: Current Control Test [16]

1.16.2.1 Speed and Torque Time-Response

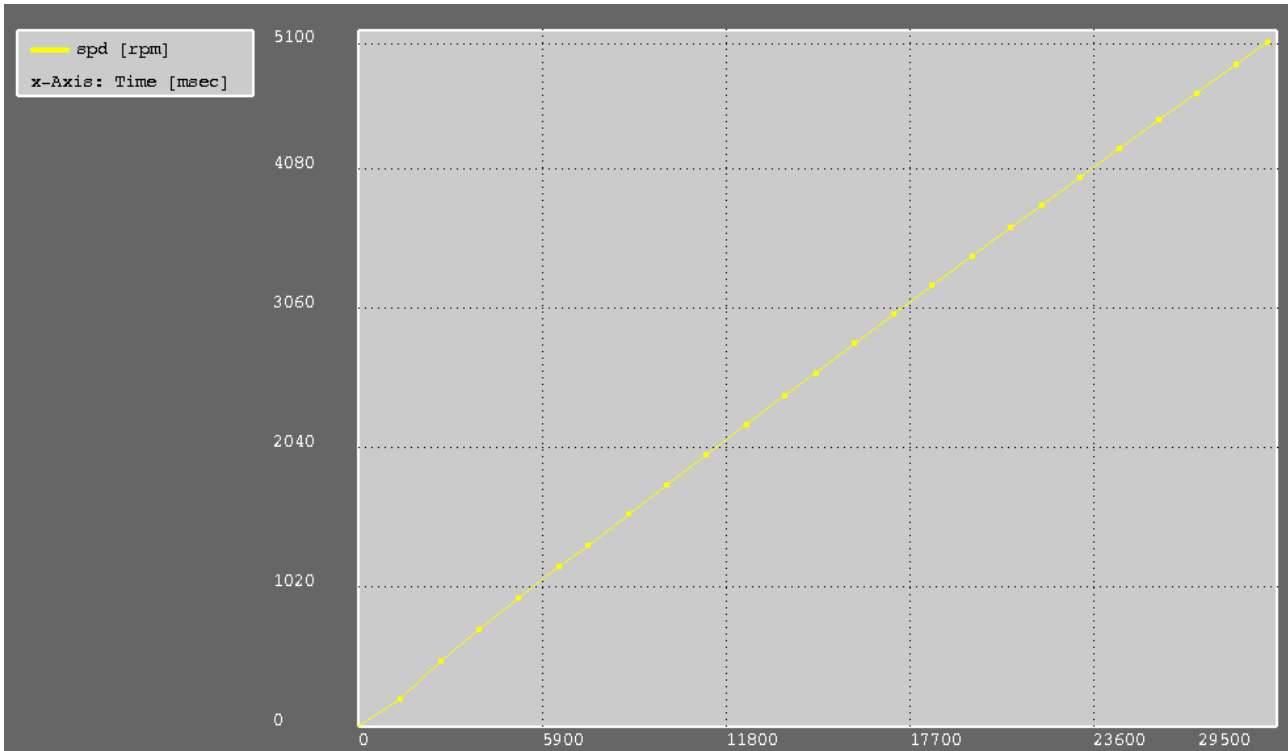


Figure 32: Current Control Test – Speed over Time [16]

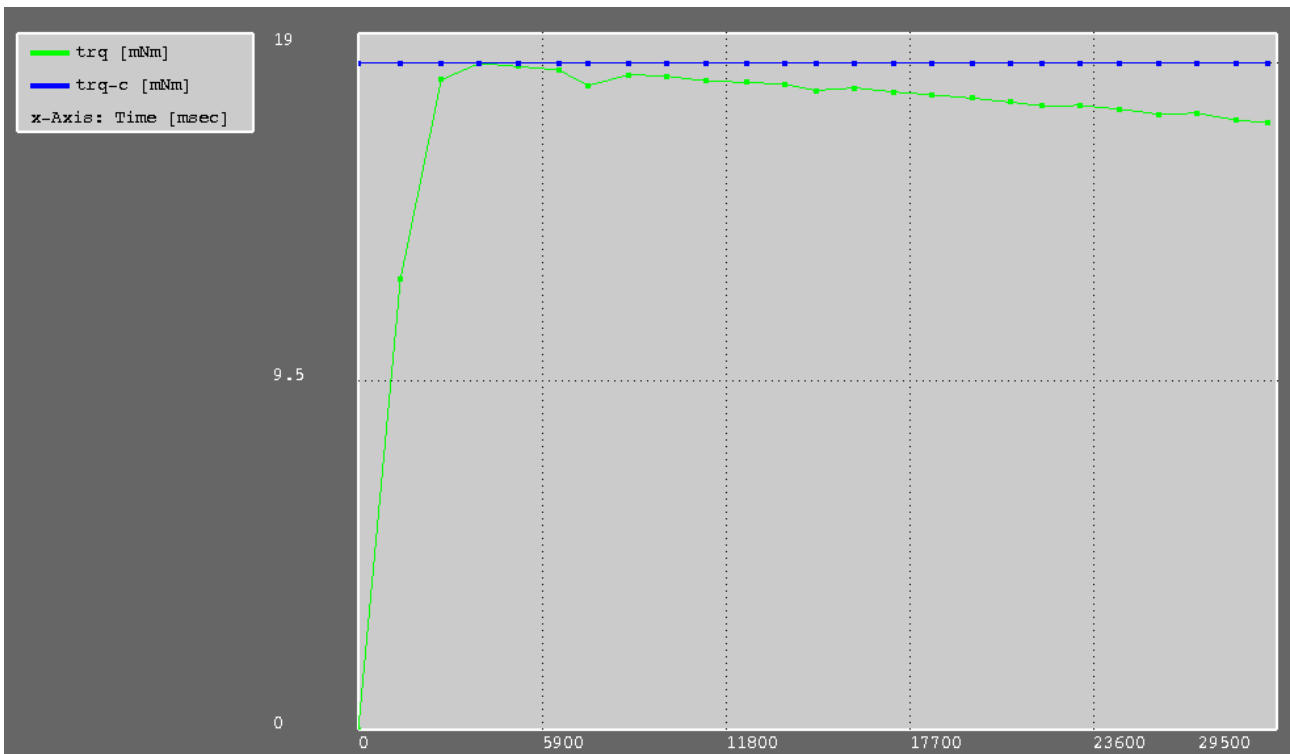


Figure 33: Current Control Test – Torque over Time [16]

1.16.2.2 Torque Speed-Response

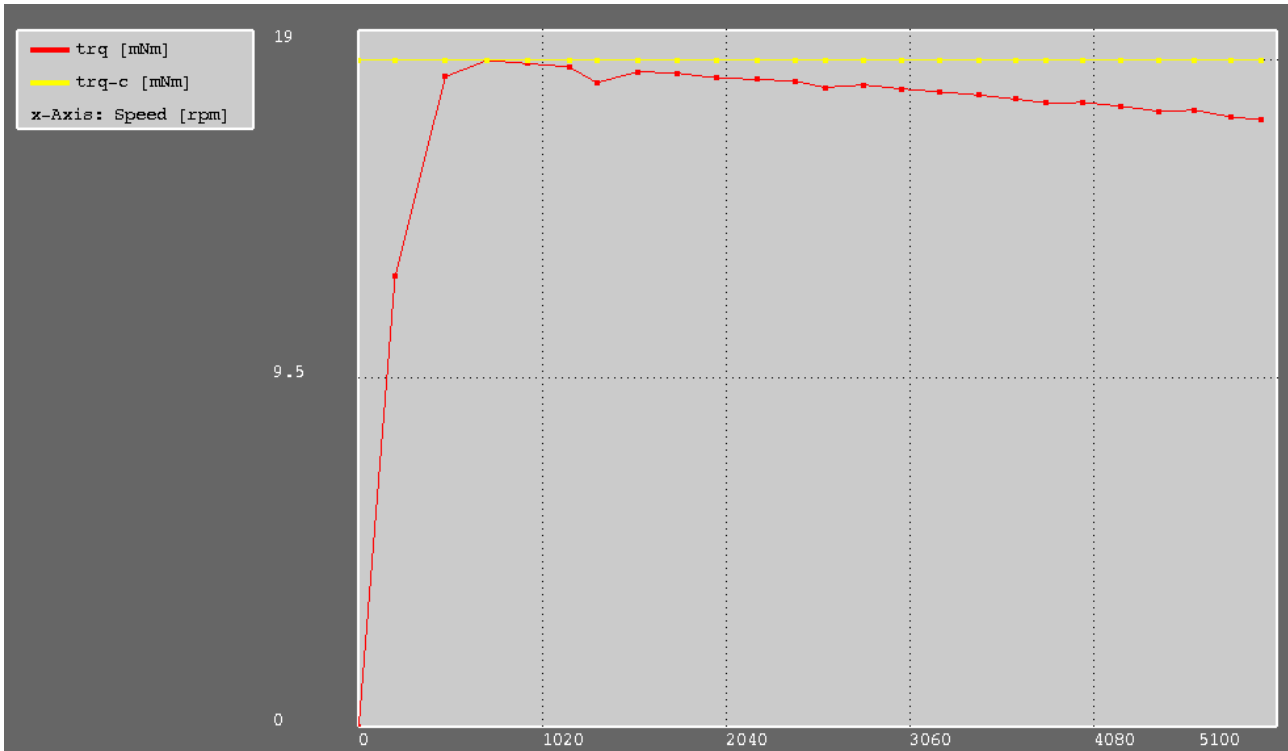


Figure 34: Current Control Test – Torque over Speed [16]

Current Control good: duration 29557 < 80000 msec

OK

1.17 FOG Test: Noise and Bias [0.0 rpm] (Test ID: 17)

1.17.1 Method

FOG is assumed to lie horizontally upside-down (so RWA not upside-down) and no Earth coordinates defined.

1. Cmd: 'Set Speed' 0.0 rpm
2. Cmd: 'Get RWA05 Std. Tele' all 25ms for 60000 ms (1x)

1.17.2 Result

2020_07_10_09_17_18_079: 'Set Speed' 0.0 rpm

2020_07_10_09_17_42_624: 'Set Speed' 0.0 rpm OK [duration 24514 msec, com_err=0]

Data File: data/2020_07_10_08_53_22/2020_07_10_08_54_16_rwa05_ft_000/rwa05_ft_000_dat17_fog_0

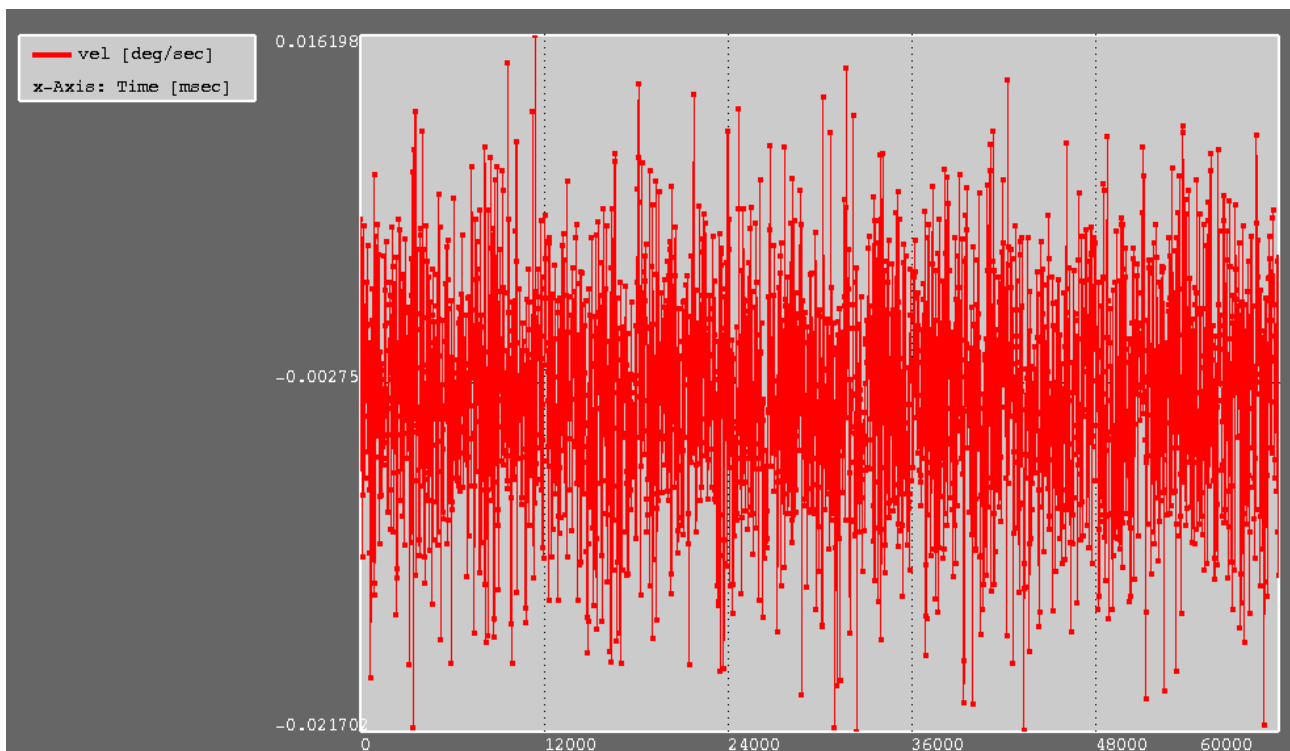


Figure 35: FOG Raw Data – 0.0 rpm [17,0]

t [msec]	vel [deg/sec]
0	0.006154
2500	0.006178
5000	0.003159
7500	0.006178
10020	-0.007826
12520	-0.003672
15040	0.000933
17540	-0.002709
20020	-0.004551
22540	0.005984
25040	0.001809
27540	-0.005344
30040	-0.002795
32540	-0.009197
35040	-0.001574
37540	0.000715
40020	-0.004703
42520	-0.003609
45020	-0.009969
47520	-0.001660
50020	-0.000888
52520	-0.019455
55020	-0.008684
57520	-0.013095
60000	-0.013226

Table 14: FOG Test [17,0]

Mean Value: -0.003510 deg/s

Std. Deviation: 0.005943 deg/sec

BST

Summary:

Mean Value: $-0.003510 \text{ deg/s} = -12.6 \text{ deg/h}$

-> bias = $-0.7 [+ 11.9 \text{ deg/h}; 24\text{h/d} * \sin(52.52\text{deg})]$

Std. Deviation: 0.005943 deg/sec

-> ARW(50Hz <> BST_GYRO_TRIG_INTVL=20ms) = 0.0504 deg/rt-hr

Sub-Set[0]: $m=-11.4 \text{ deg/h} \mid \text{ARW}[50\text{Hz}] = 0.0504 \text{ deg/rt-hr}$

(sub-sets created just by dividing the complete data set into equal portions)

Sub-Set[1]: $m=-12.2 \text{ deg/h} \mid \text{ARW}[50\text{Hz}] = 0.0500 \text{ deg/rt-hr}$

(sub-sets created just by dividing the complete data set into equal portions)

Sub-Set[2]: $m=-14.1 \text{ deg/h} \mid \text{ARW}[50\text{Hz}] = 0.0492 \text{ deg/rt-hr}$

(sub-sets created just by dividing the complete data set into equal portions)

Sub-Set[3]: $m=-13.3 \text{ deg/h} \mid \text{ARW}[50\text{Hz}] = 0.0508 \text{ deg/rt-hr}$

(sub-sets created just by dividing the complete data set into equal portions)

Sub-Set[4]: $m=-12.1 \text{ deg/h} \mid \text{ARW}[50\text{Hz}] = 0.0514 \text{ deg/rt-hr}$

(sub-sets created just by dividing the complete data set into equal portions)

Gyro Test good: duration 92519 msec

OK

1.18 Self Test Short (Test ID: 18)

1.18.1 Method

Purpose is to test if the RWA can start from each motor phase combination.

1. Cmd: 'Set Speed 0rpm'
2. Wait 5 secs
3. Cmd: 'Start Self Test Short'
4. Wait 60 secs
5. Cmd: 'Get Self Test Results'
6. repeat until all phases are tested ... max. 10x

1.18.2 Result

Cmd:'Set Speed' 0.0 rpm OK [duration 8 msec, com_err=0]

Fails: 0 (should be 0, otherwise timeout on a phase)

Tests per Phase: CB= 2 AB= 2 AC= 2 BC= 3 BA= 1 CA= 3

-- total: CB= 2 AB= 2 AC= 2 BC= 3 BA= 1 CA= 3

(should be > 0, each phase tested at least once)

Self Test Short completed.

OK

BST

2 Complete Test Result

2.1 Comment

2.2 Result Status

OK