SRON	TEST REPORT	Doc. no. : FPSS-xxx Issue : 1 Date : 8 june 2009 Category : Page : 1 of 44
HIFI - IST		

Title CoP – Diplexer Step Response

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Checked by	:		Date	:	
Agreed by	:		Date	:	
Authorised by	:		Date	:	

Distribution

Document Change Record

Issue	Date	Changed Section	Description of Change
Draft	8 june 2009	All	New document

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1 TEST SUMMARY

In the following report you will find the results of the Diplexer Step Response Test during the CoP phase performed on June 1st 2009 (nominal only). The test was designed to characterise the mechanical performance in space in order to optimise diplexer response time. The current filter setting used in the control unit was found to be very conservative. The diplexers were found to be very homogeneous in performance both between different units and between different step-positions and –sizes. By changing the filter settings it is possible to improve the settling time for large steps to < 0.17 sec and for small steps to < 0.10 sec.

Bullet wise these are the findings:

- Current filter settings (2.4 Hz – 227 raw) result in diplexer settling times of 0.45 – 0.50 sec for large steps (3 mA) and 0.35 - 0.45 seconds for small steps (0.2 mA)
- The optimised filter-setting is 9 Hz (162 raw). The settling times will then be reduced to 0.14 - 0.17 seconds for large steps and < 0.1 sec for small steps.
- Contrary to the model there is no significant increase in damping found due to cryogenic temperatures (lower resistivity in aluminium and therefore higher counter-currents)
- It is advisable to re-measure the diplexer response once nominal L2-temperatures have been reached.
- The mechanisms in band 3V and 6V hit the end-stop for a large step in the positive current direction in the unfiltered case. They appear to be less well centred than the other mechanisms.
- The mechanisms in band 3H and 6H have a lower resonance frequency of 8.0 Hz compared to the 9.5 Hz for all other mechanisms. Cause?
- A small resonance peek at 11.8 Hz has been found in the control current for diplexers 3 H and 4 V.

2 TEST SETUP

2.1 Personnel

Test Engineer: W.M. Laauwen

2.2 Equipment under Test

HIFI FM diplexer mechanism for bands 3,4 6 and 7 both H and V polarisation in He2-conditions; CoP phase.

2.3 Test Set-up

The diplexers under test are on board Herschel in a space environment (zero gravity). The thermal environment (L2) is below nominal temperature. This has some influence on the result and a verification in nominal conditions is recommended.
The stepresponse is measured in a fast mode in which voltage and current are read out alternating with a sampling time of 3 msec. Each mechanism is subjected to 4 different steps in both directions (large, small around zero and small at the two extremes). These steps are repeated for 4 different filter settings: 2.4, 4.8, 9.6 and ~100 Hz (227, 201,158 and 1 raw). Note that the filter only filters the input to the current-source that moves the diplexer. It has no influence whatsoever on the stability of the diplexer current.

2.4 Software and Reference Data

CUS 16.108
OBS 6.1.1
MIB 2147/11.11 (hifi/aspi)

Data is extracted in HCSS (User release 1.03RC1) via dedicated scripts. Further analysis is done in mathcad.

3 TEST RESULTS

The diplexer mechanisms are used in bands 3, 4, 6 and 7, one for each polarisation. A total of 8 mechanisms were thus tested. Each mechanism was subjected to 4 different steps (large, small around zero and small at the two extremes) in both directions. These steps were repeated for four different filter-settings: 2.4, 4.8, 9.6 and ~100 Hz (227, 201, 158 and 1 raw). The steps were sampled in a fast mode (3 msec sample-time) were voltage and current were alternatingly measured. The relevant ObsId's are listed in table 1. All the individual step-responses can be found in the appendix.

ObsID	Script name	Band
1342177614	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B3H	3 H
1342177615	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B3V	3 V
1342177622	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B4H	4 H
1342177623	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B4V	4 V
1342177630	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B6H	6 H
1342177631	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B6V	6 V
1342177638	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B7H	7 H
1342177639	Calibration_mo_2-HIFI-COP-2.1-DipRespTime_B7V	7 V

Table 1; Testresults in hifi_icc_ops_1@iccdb1.sron.rug.nl

Large step response

In general the behaviour of the mechanisms was very homogeneous both between the different mechanisms and the different steps. Figure 1 shows for all mechanisms the stepresponse of the diplexer voltage for a large step with the filter off (~100 Hz, 1 raw). The control source acts as a ideal current source and therefore shows only the step. In the voltage one can see the induced voltage from the movement of the diplexer, the voltage in this case is therefore the more interesting one.

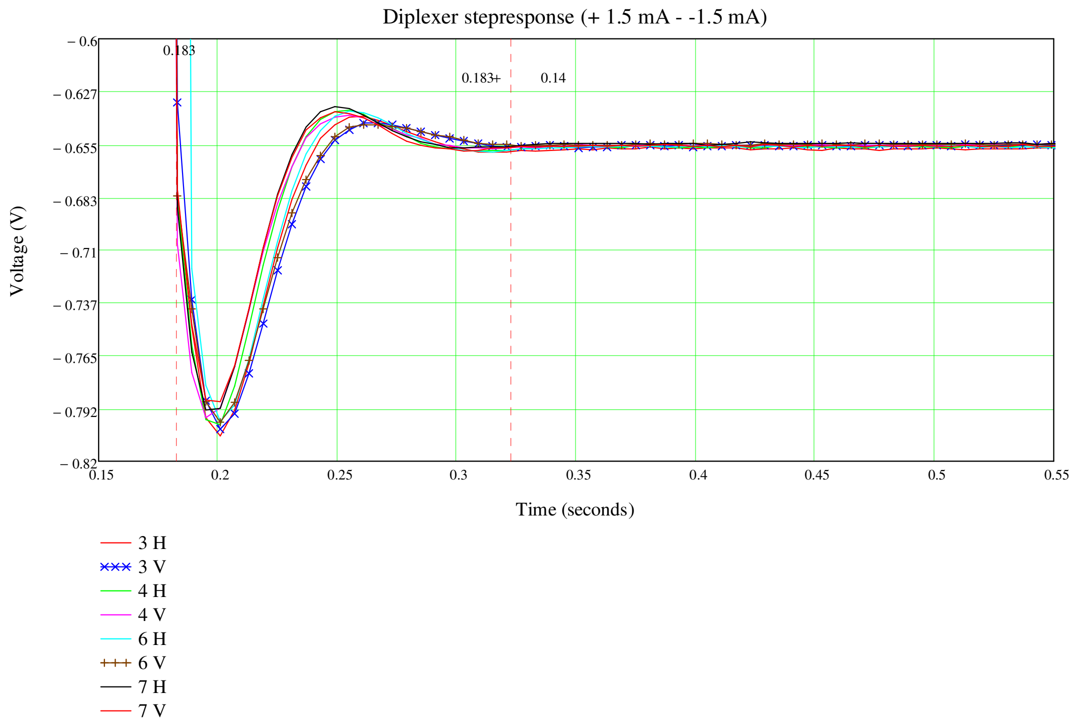


Figure 1; Stepresponse for all mechanisms (filter off).

In figure 1 bands 3V and 6V deviate slightly but all mechanisms are stable again after 0.14 seconds. The large step in the other direction yields a slightly different result, see figure 2. Two of the mechanisms (bands 3 H and 6 H) hit the endstop while overshooting.

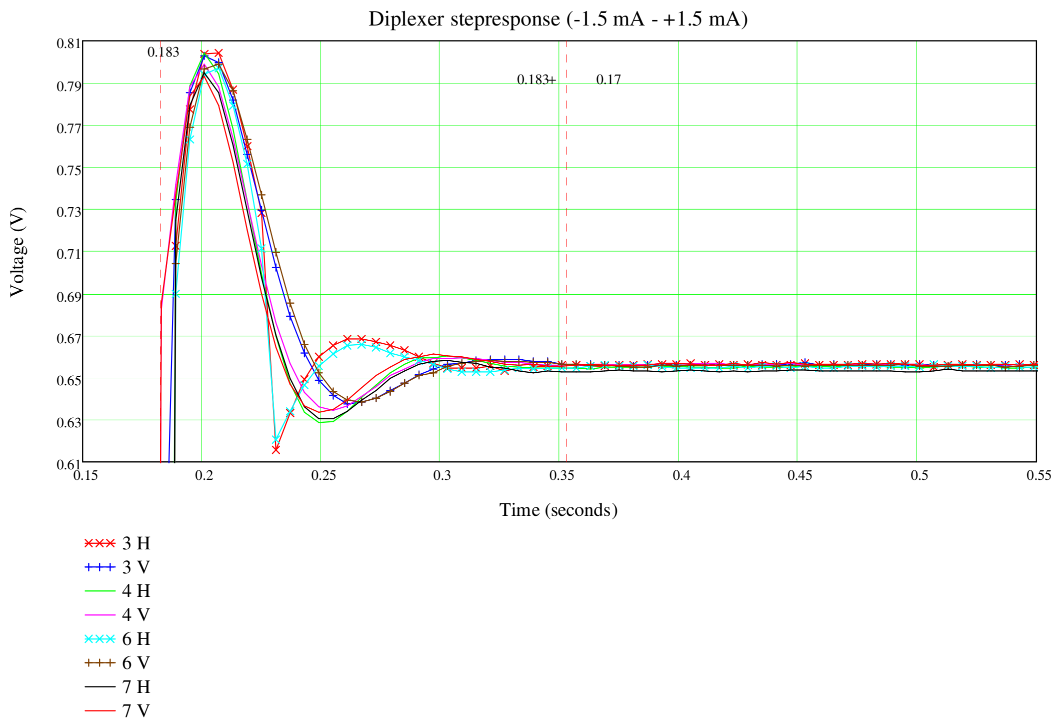


Figure 2; Stepresponse for all mechanisms (filter off, reverse direction).

Here also bands 3V and 6V behave slightly different. All mechanisms are stable after 0.16 seconds. Although these large steps are not used in normal operation some filtering is needed to prevent routinely hitting the endstops for 3H and 6H.

Small step response

For nominal steps, even far away from the restposition, the endstops will never be hit. Figure 3 shows such a step. A stable position is reached within 0.1 second for all mechanisms, 70 msec is probably already accurate enough.

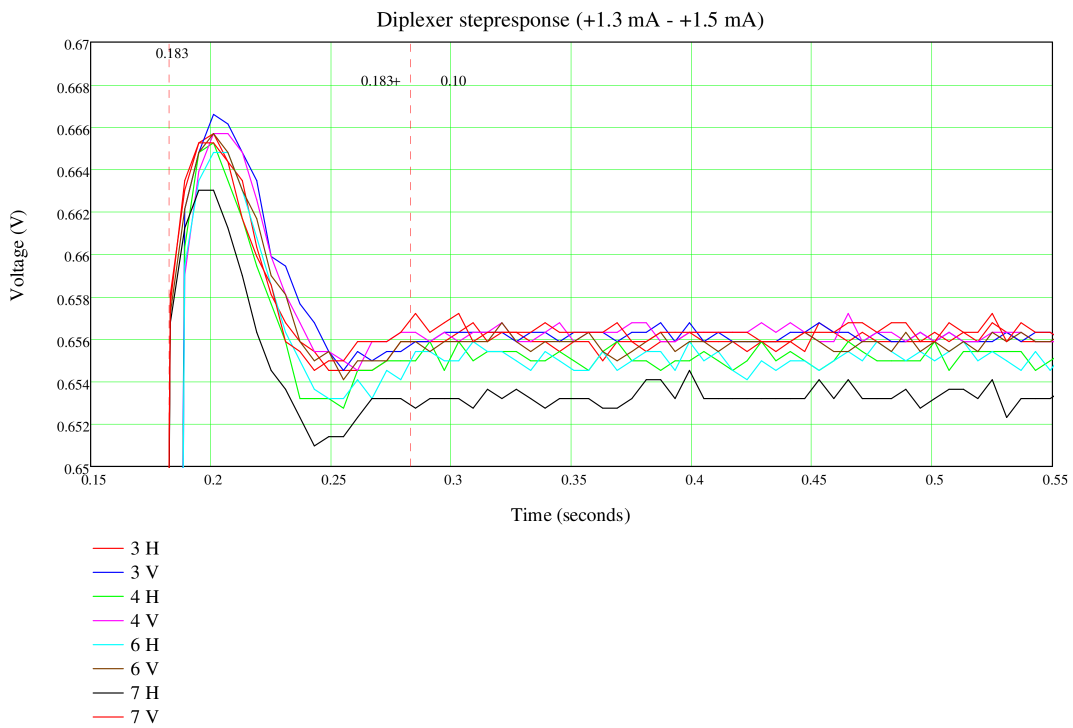


Figure 3; small step response for all mechanisms (filter off).

Fitting the response

If we take again figure 1 and try to fit it with an exponentially decaying sinusoidal we get the result in figure 4.

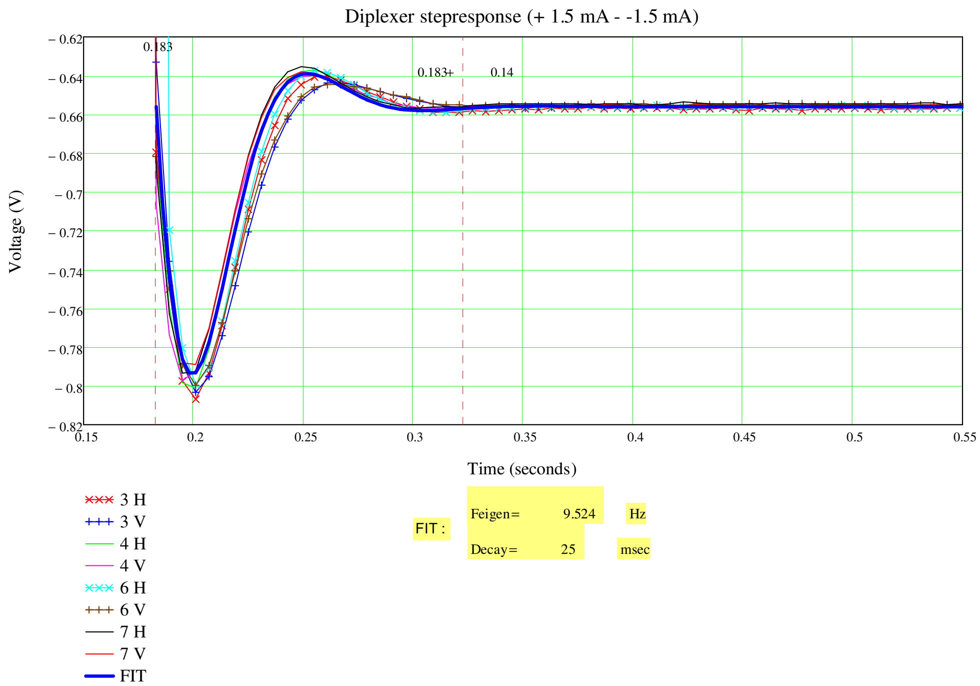


Figure 4; Fit to figure 1.

Typical frequency of the mechanisms is 9.5 Hz with a decay time of 25 msec. If we now try to fit only the two outlying bands (3H and 6H) we find figure 5. These mechanisms have a slightly lower resonance frequency of 7.8 Hz but similar damping.

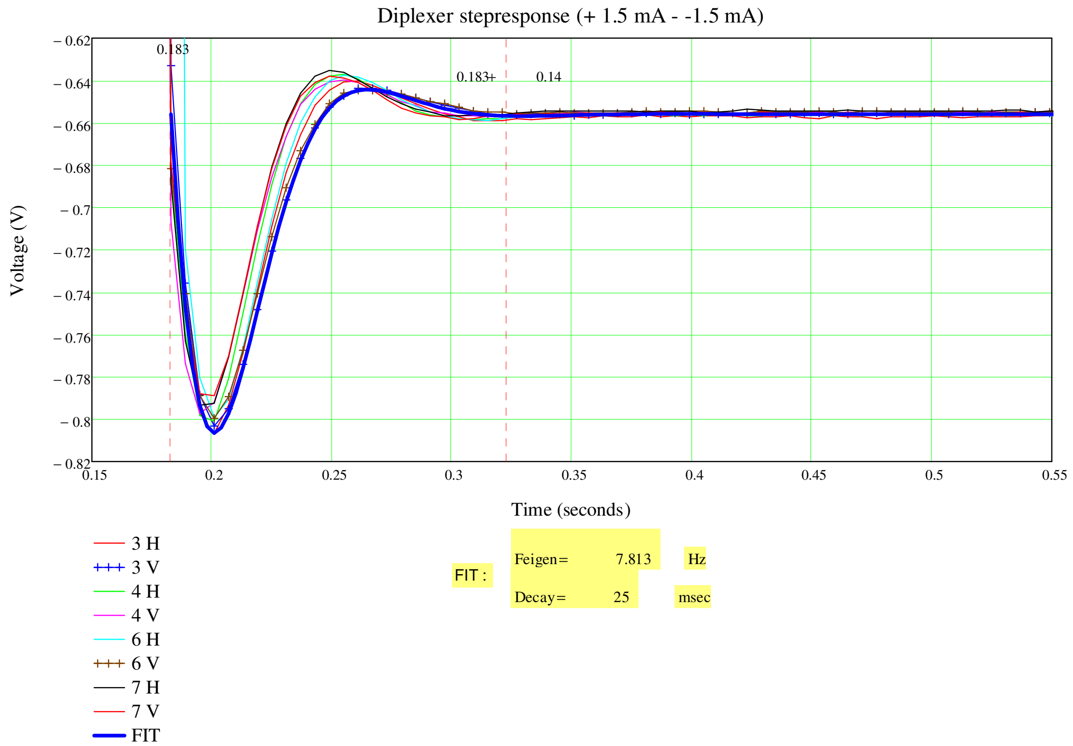


Figure 5; Fit to bands 3H and 6H.

Looking at the overshoot in the other extreme (positive currents) one would expect no change in resonance frequency but slightly less damping. Fitting to figure 2 produces figure 6 which shows indeed the same resonance frequency of 9.5 Hz, but a slightly longer decay time of 29 msec.

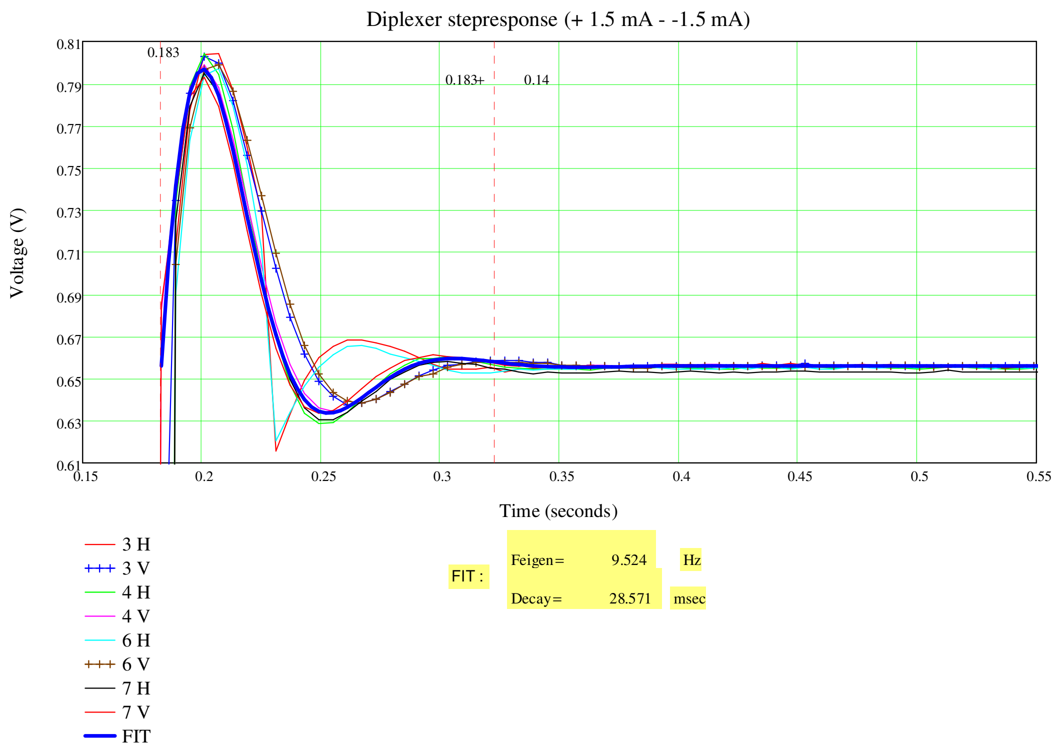


Figure 6; Fit to figure 2.

To optimise diplexer performance and to reduce overshoot the mechanisms should be made critically damped. The damping cannot be changed since it is determined by the mechanics and its temperature. What we can do is shape the input to the current source by setting the filter. Ideally this should be set to the resonance frequency of the mechanism to “ease” the diplexer to its new position. In our measurement set we have a filter-setting of 9.6 Hz (158 raw) which is close enough.

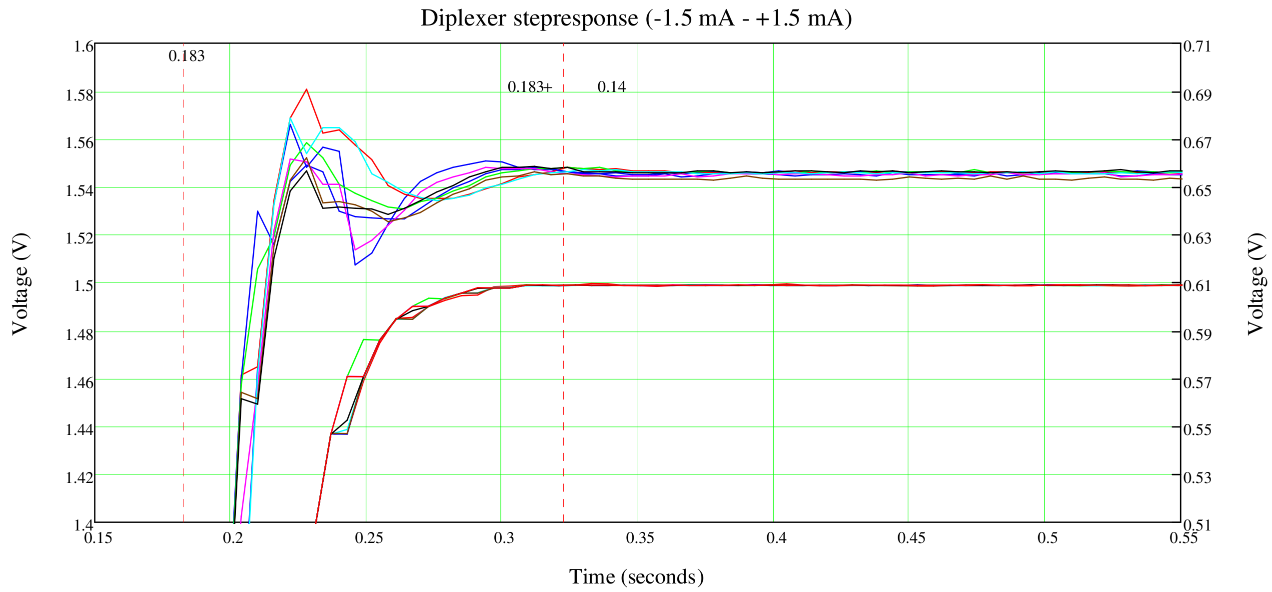


Figure 7; Stepresponse for all mechanisms (filter = 9.6 Hz, 158 raw)

Indeed, in figure 7 we see hardly any overshoot. Since we are shaping the current step we also have to plot and analyse the diplexer current. The current reaches its final value faster than the voltage. Looking at the voltages the mechanisms are faster and setlle already after 0.14 seconds (was 0.17).
There is still some indication of hitting an endstop in the curve for 3H. Also the responses for 3V and 6V show overshoot. They have a lower resonance frequency and therefore require a slower filter setting.

Stability/noise
The diplexer step-response is measured for 6 seconds. Since the final position is reached well within the first second, the rest of the time can be used to check the diplexer stability. To do this the standard deviation for the last 800 samples (4.8 seconds) of voltage and current is calculated. In figure 8 these values are plotted against scan number for band 3H.

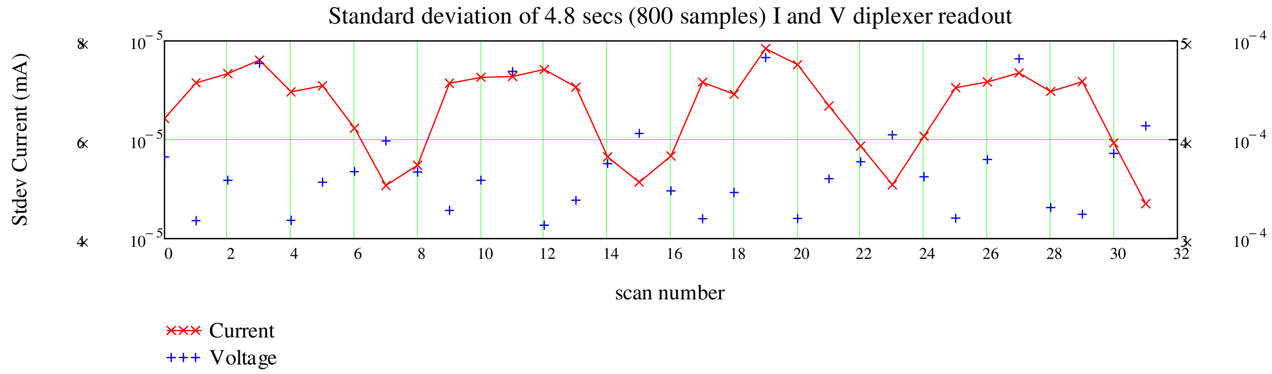


Figure 8; Diplexer stability.

The scans are repated in clusters of eight with increasing filter frequency. The filter seems to have no influence at all on the stability (as expected) but there is a repetitive pattern for the 8 scans which points to a position dependence. In figure 9 the standard deviation is plotted against diplexer postion, again for band 3H but the other bands follow the same trend.

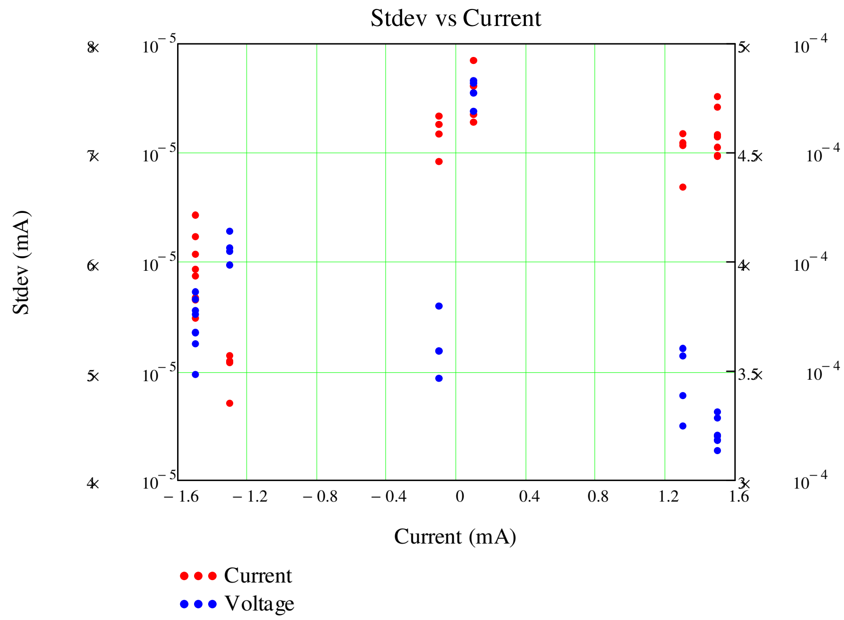


Figure 9; Band 3H Stdev vs diplexer position.

There is no clear dependence on position, if any the current-stability is best around the negative extreme. So why there is this clear pattern in figure 8 is unknown.

A further thing to do is take the fourier transform of the noise to look for frequency components. This yielded results for bands 3H and 4V (figure 10):

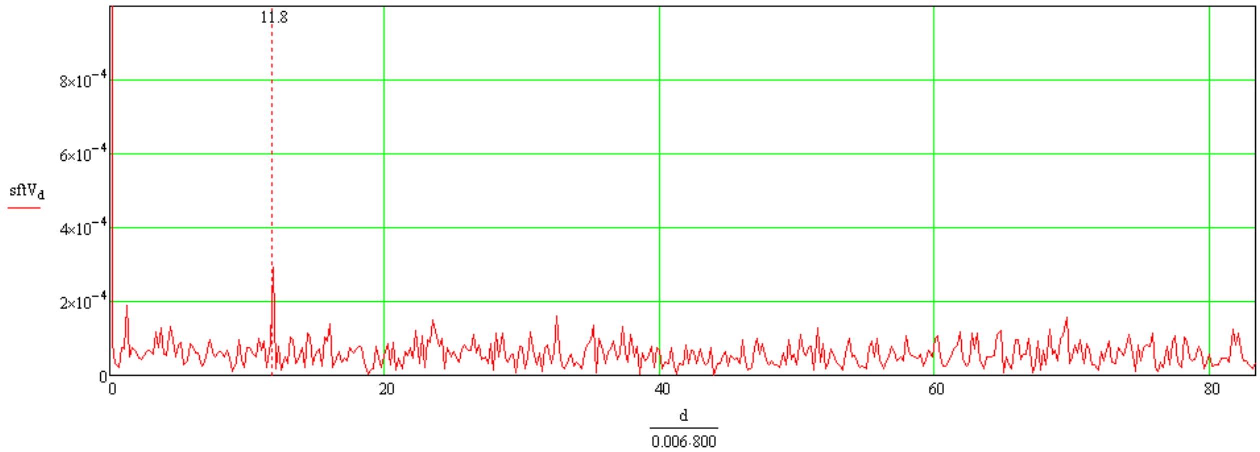


Figure 10; Resonance in FTS of diplexer-current in endposition.

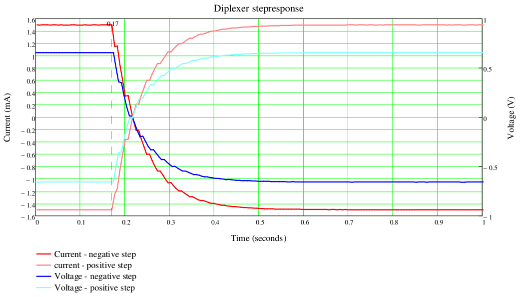
For these two bands there is a resonance-peek visible at 11.8 Hz in the FTS of the current for almost all stepresponses. The voltage shows nothing (possibly a matching dip at 11.8 hz but not convincingly).

Conclusion
For optimal performance of all mechanisms a filter setting of 9 Hz or 162 raw is recommended. With this filter-setting all mechanisms will behave similar and settle in the same time. It is important to note that the damping of the mechanisms is produced by currents flowing through the aluminium housing. The resistance of aluminium and thus the damping is critically dependent on temperature in the 2-15 K regime these mechanisms are operated in. It is therefore advisable to re-measure the responses once the nominal operating temperature is reached.

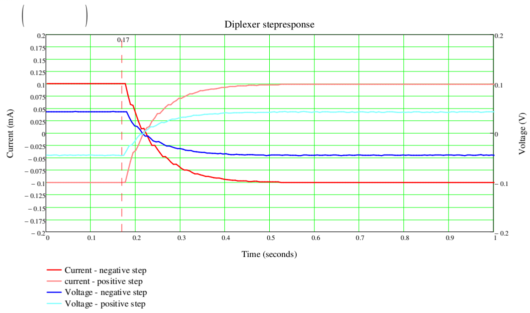
APPENDIX: ALL CURVES.

Band 3H

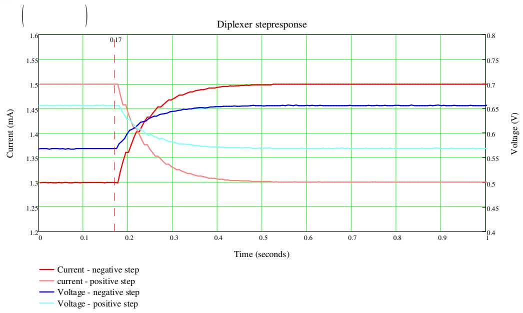
Filter = 2.4 Hz (227 raw)



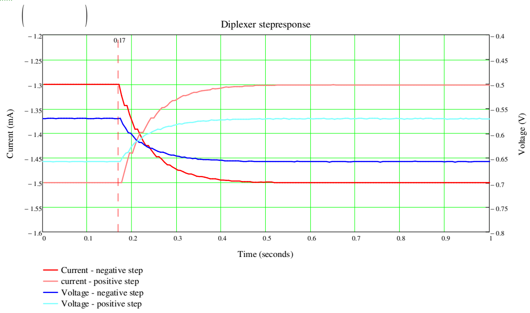
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

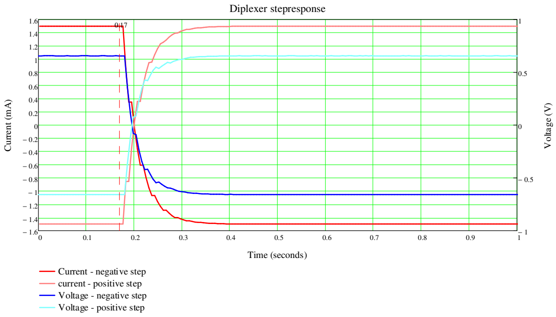


step= 3
curve= step+ 4 filter

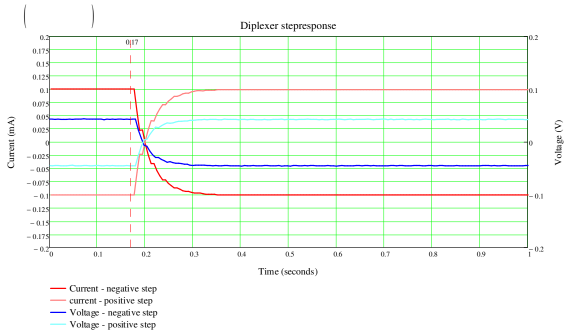


Band 3H

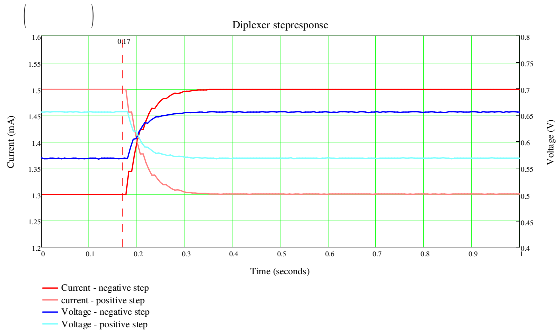
Filter = 4.8 Hz (201 raw)



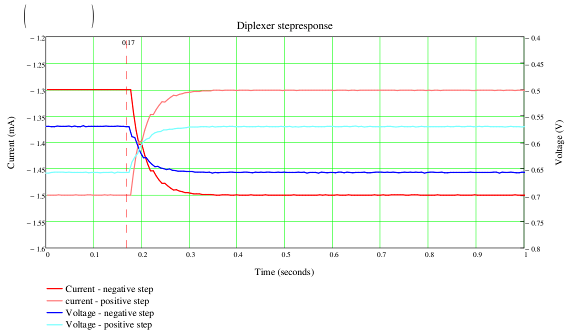
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

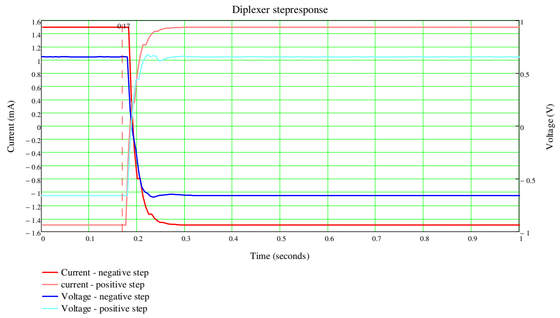


step= 3
curve= step+ 4 filter

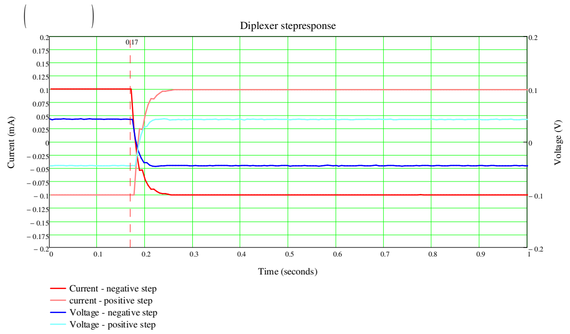


Band 3H

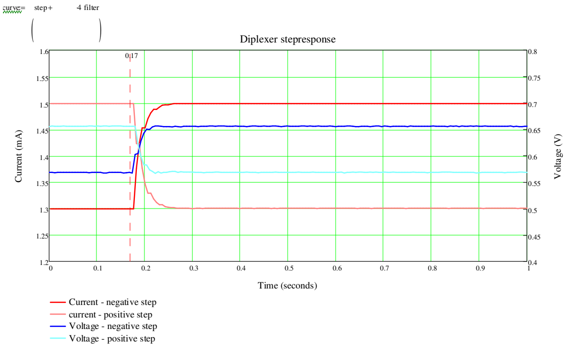
Filter = 9.6 Hz (158 raw)



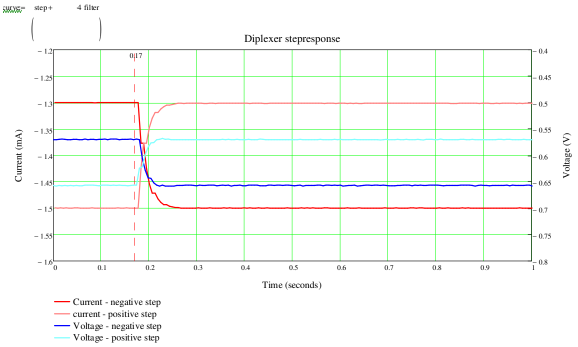
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

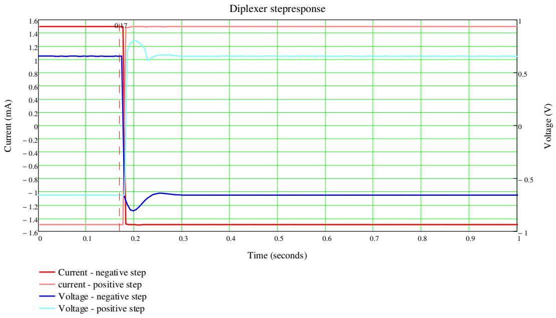


step= 3
curve= step+ 4 filter

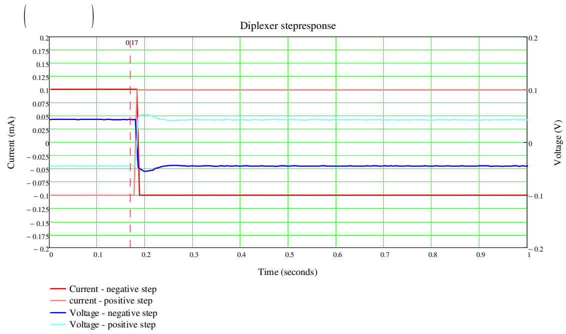


Band 3H

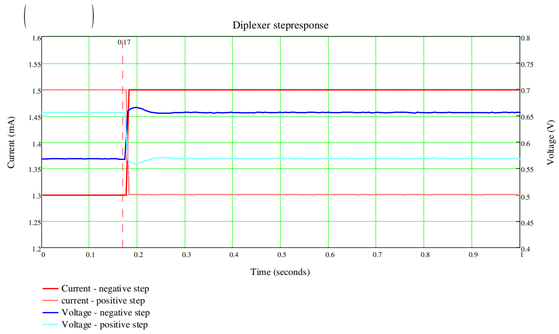
Filter = ~100 Hz (1 raw)



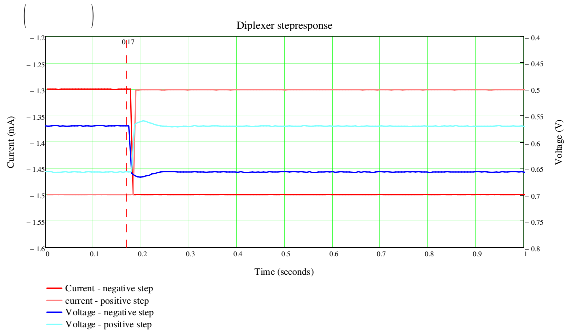
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

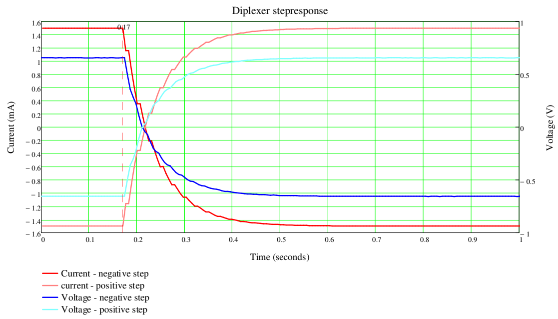


step= 3
curve= step+ 4 filter

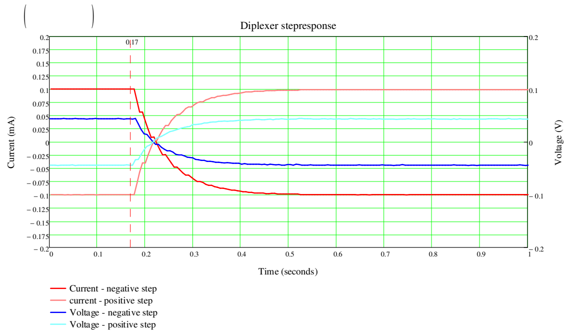


Band 3V

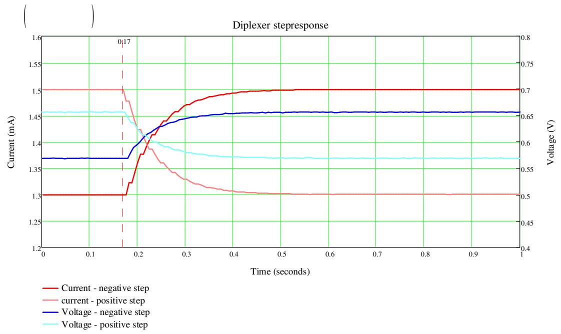
Filter = 2.4 Hz (227 raw)



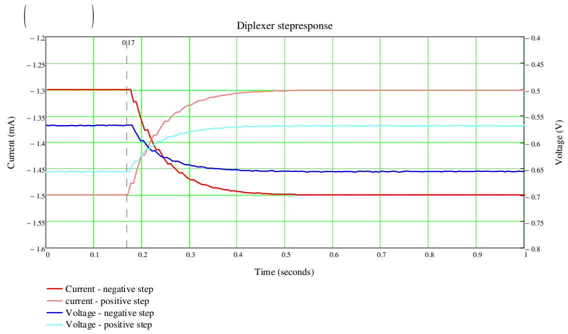
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

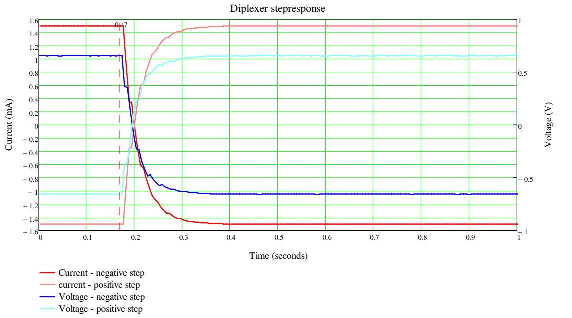


step= 3
curve= step+ 4 filter

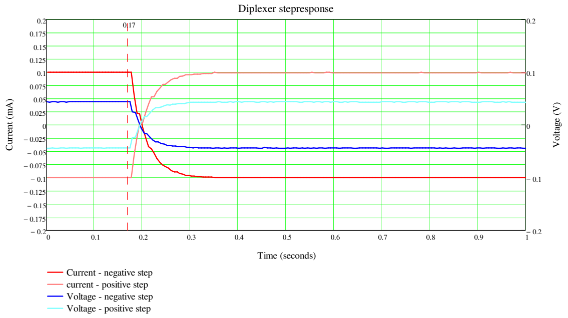


Band 3V

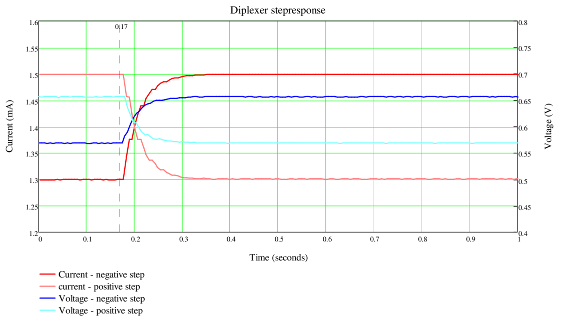
Filter = 4.8 Hz (201 raw)



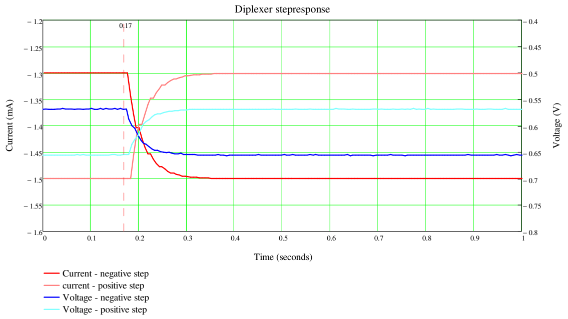
step := 1
curve := (step + 4·filter)



step := 2
curve := (step + 4·filter)

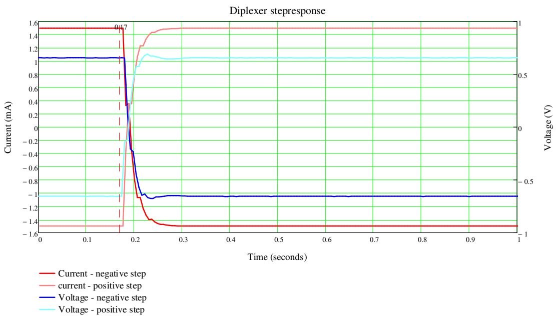


step := 3
curve := (step + 4·filter)

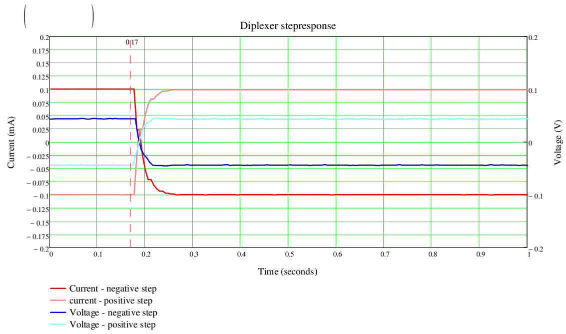


Band 3V

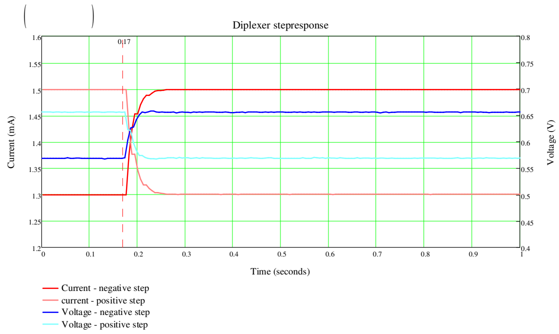
Filter = 9.6 Hz (158 raw)



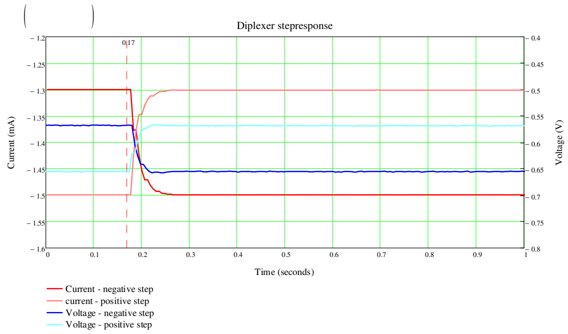
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

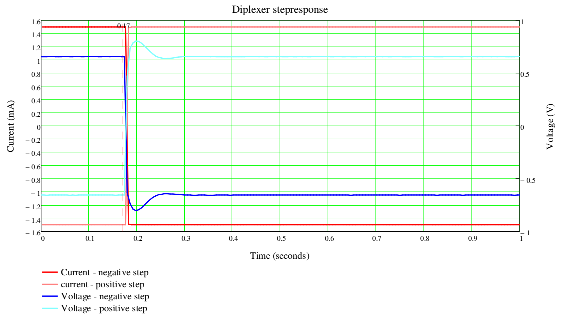


step= 3
curve= step+ 4 filter

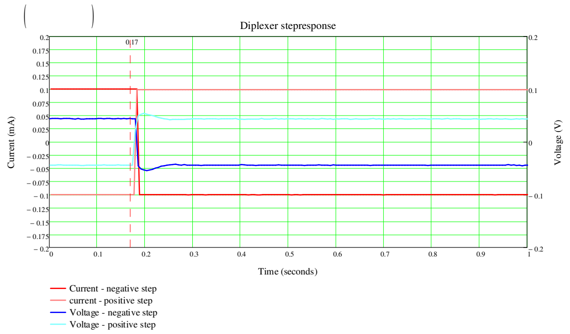


Band 3V

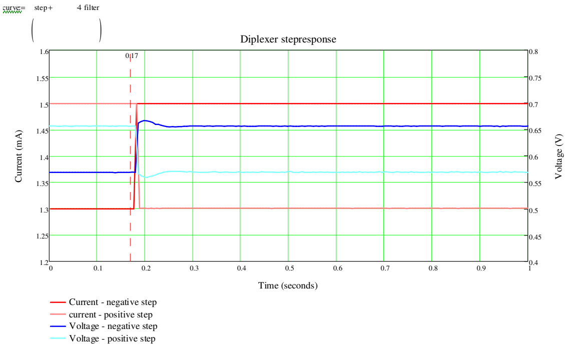
Filter = ~100 Hz (1 raw)



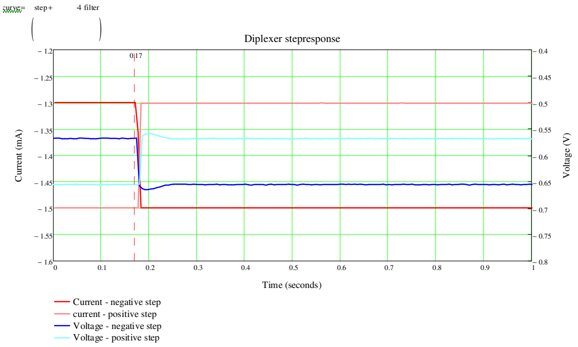
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

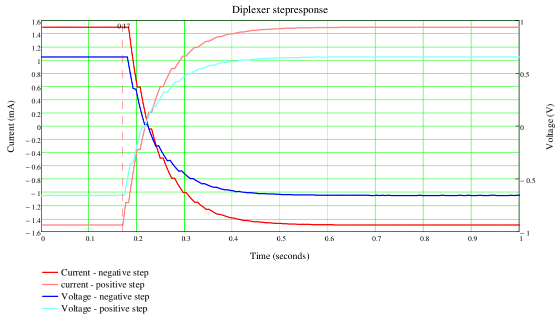


step= 3
curve= step+ 4 filter

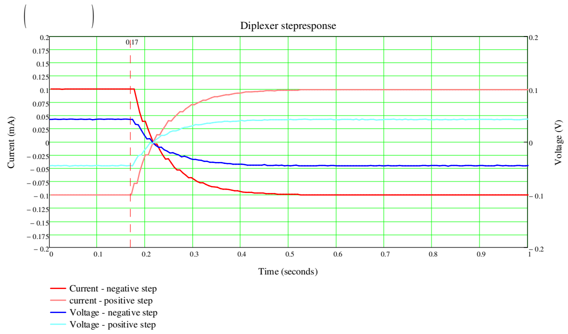


Band 4H

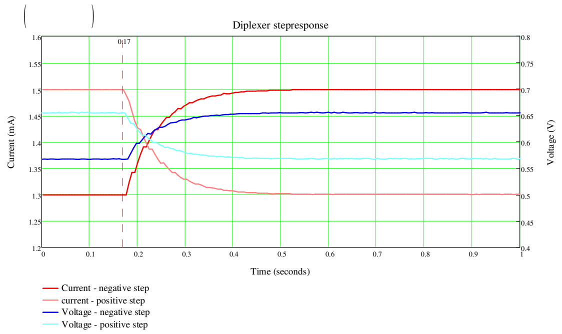
Filter = 2.4 Hz (227 raw)



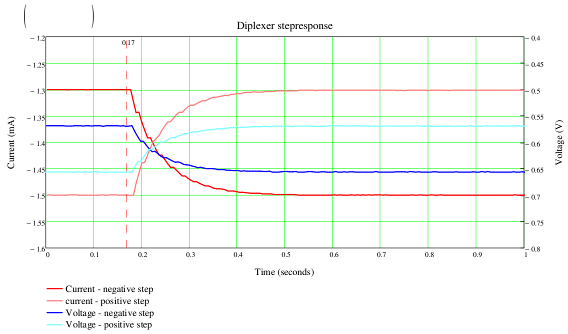
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

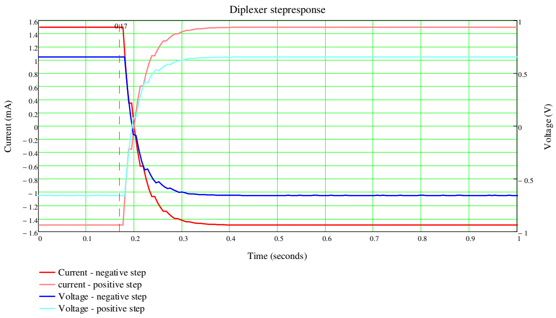


step= 3
curve= step+ 4 filter

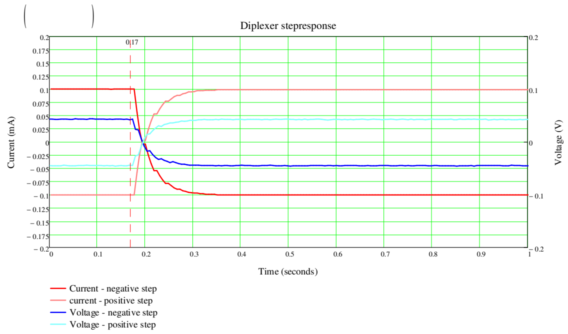


Band 4H

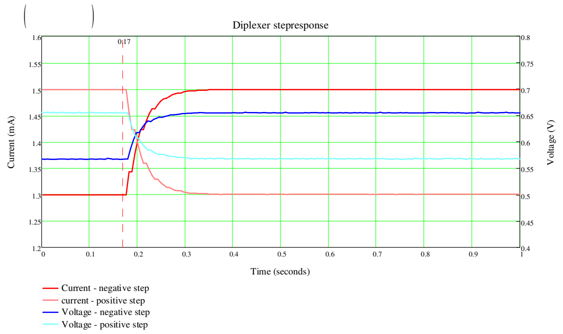
Filter = 4.8 Hz (201 raw)



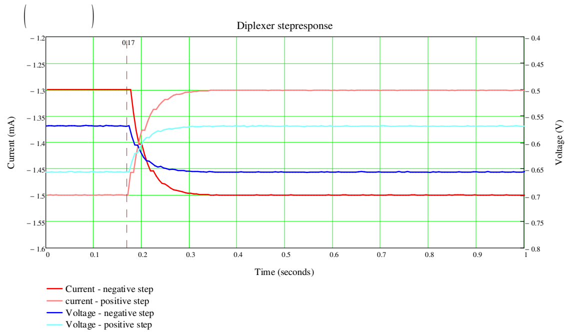
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

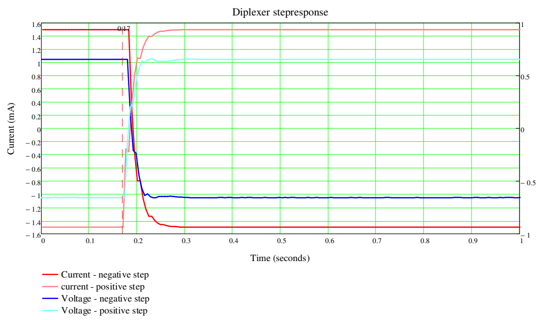


step= 3
curve= step+ 4 filter

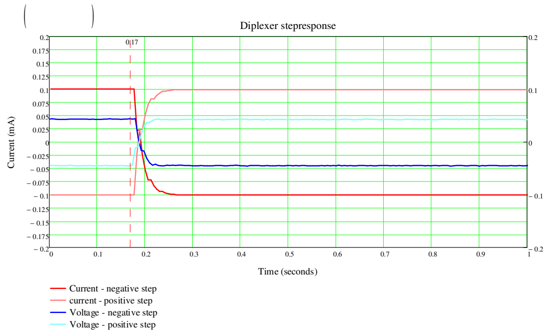


Band 4H

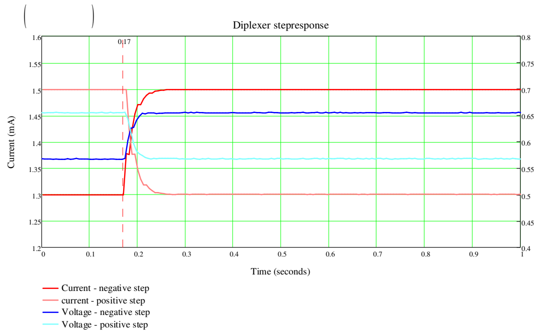
Filter = 9.6 Hz (158 raw)



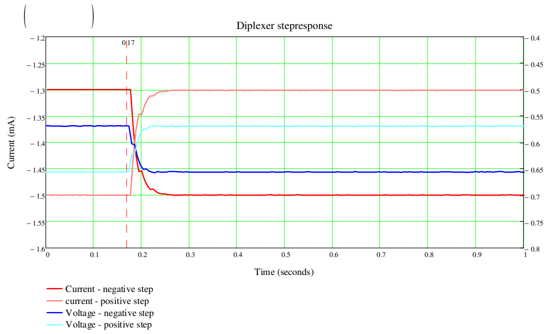
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

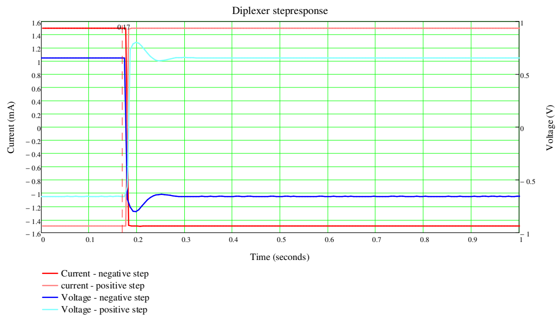


step= 3
curve= step+ 4 filter

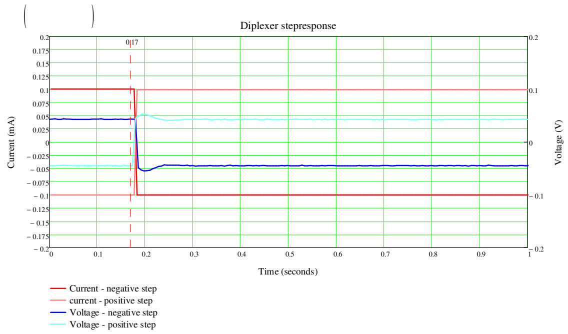


Band 4H

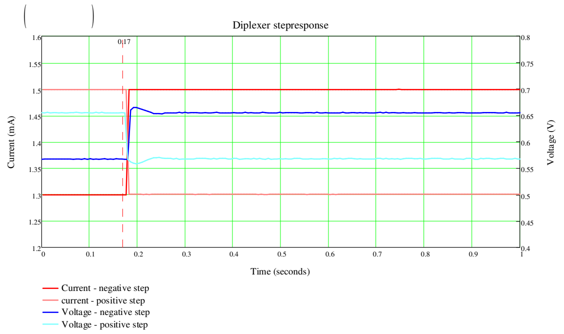
Filter = ~100 Hz (1 raw)



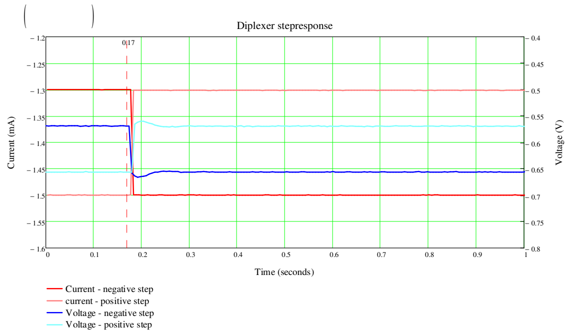
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

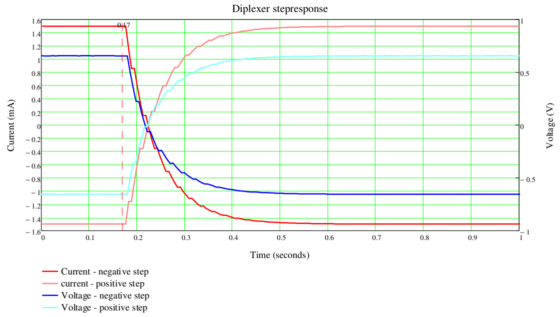


step= 3
curve= step+ 4 filter

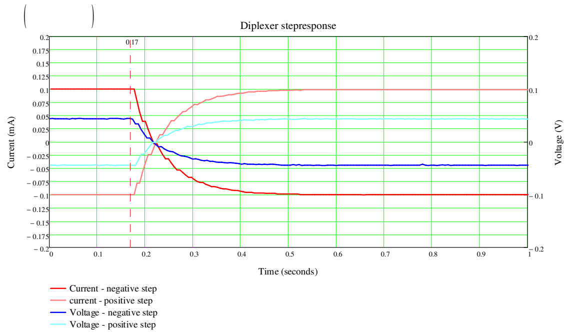


Band 4V

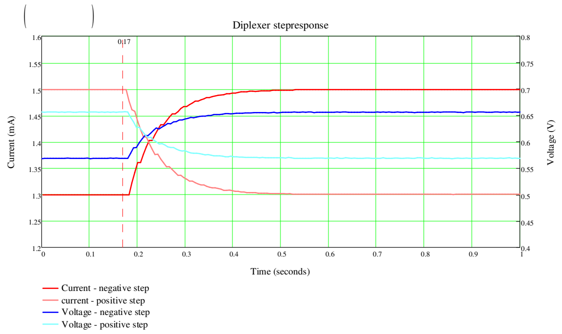
Filter = 2.4 Hz (227 raw)



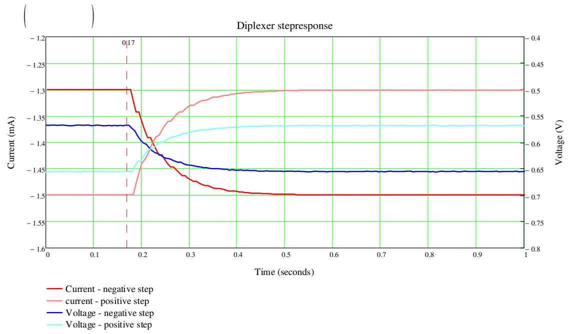
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

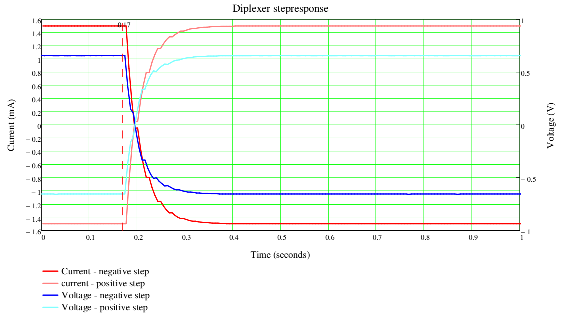


step= 3
curve= step+ 4 filter

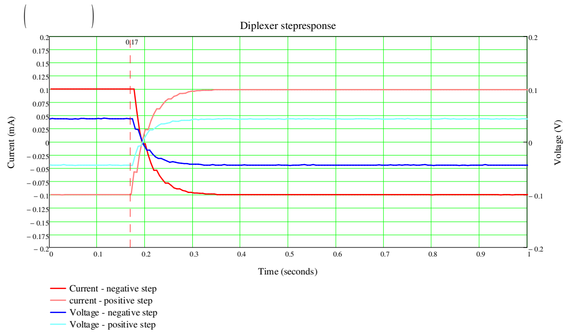


Band 4V

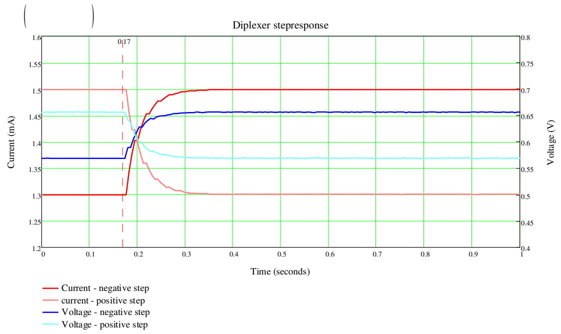
Filter = 4.8 Hz (201 raw)



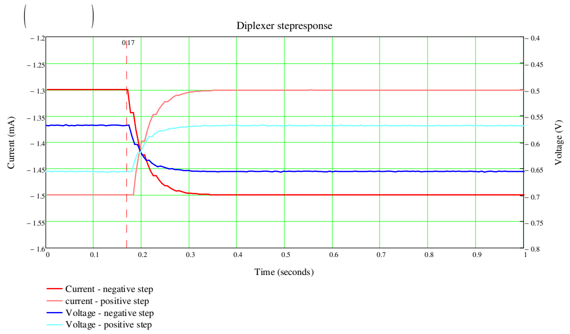
step = 1
curve = step + 4 filter



step = 2
curve = step + 4 filter

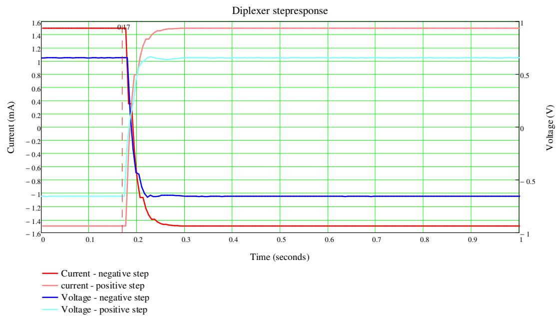


step = 3
curve = step + 4 filter

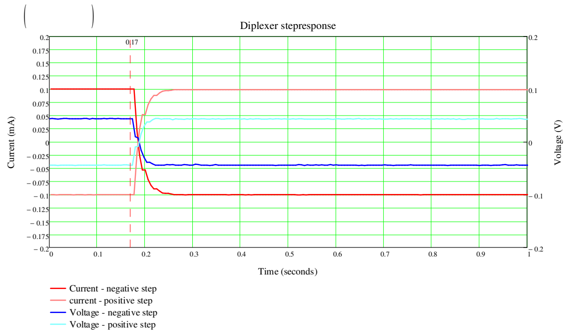


Band 4V

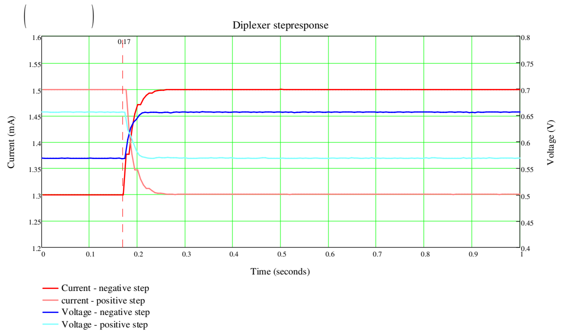
Filter = 9.6 Hz (158 raw)



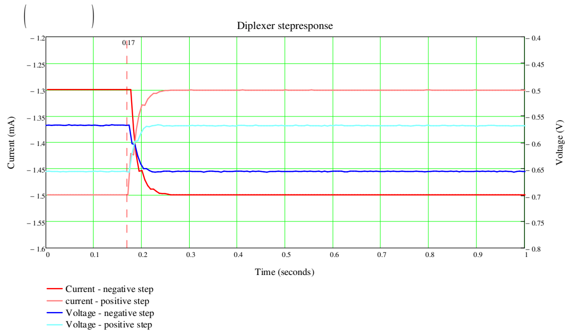
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

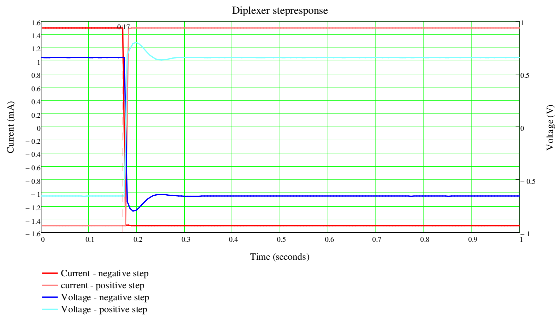


step= 3
curve= step+ 4 filter

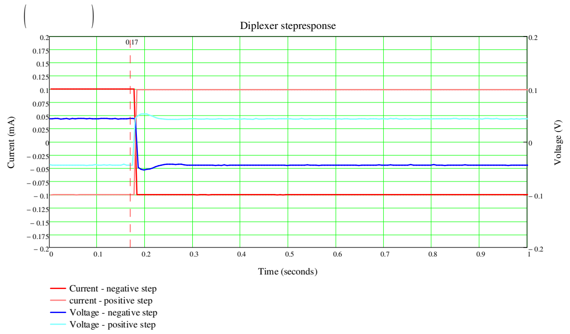


Band 4V

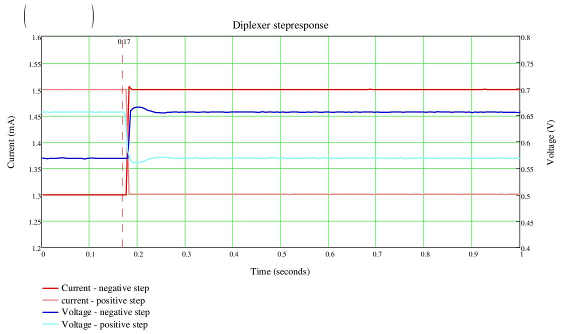
Filter = ~100 Hz (1 raw)



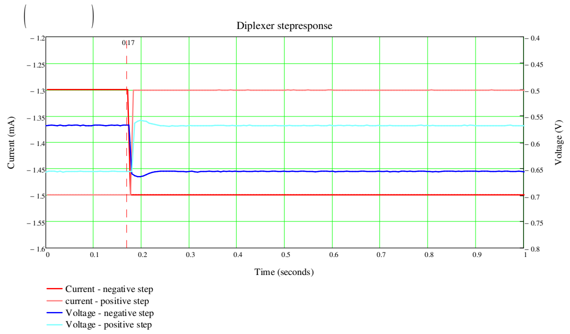
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

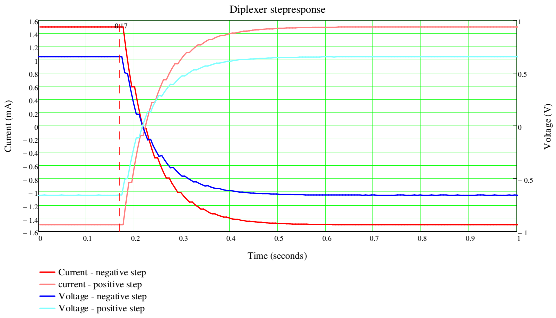


step= 3
curve= step+ 4 filter

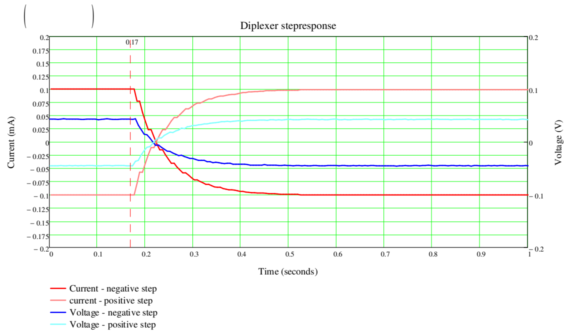


Band 6H

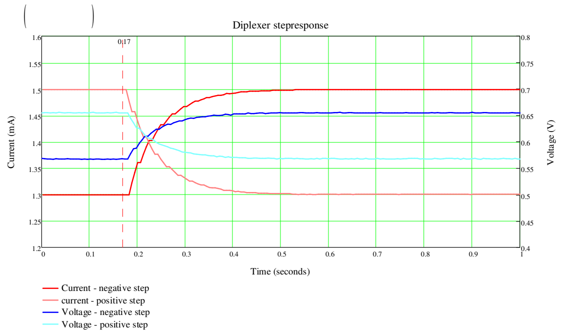
Filter = 2.4 Hz (227 raw)



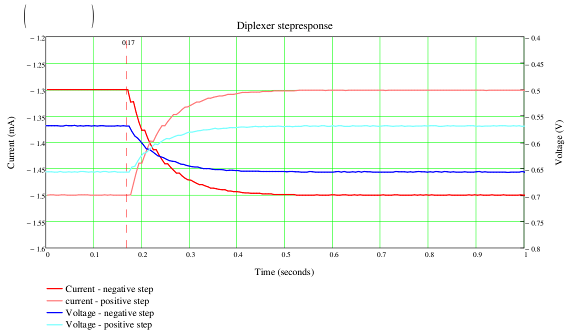
step= 1
curve= (step+ 4 filter)



step= 2
curve= (step+ 4 filter)

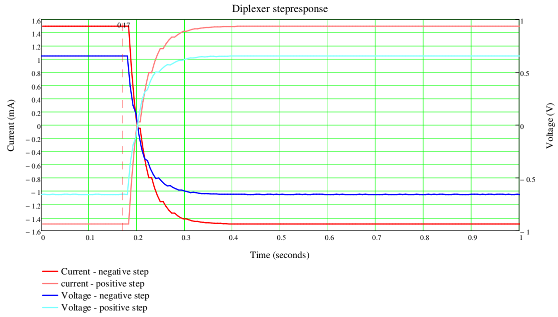


step= 3
curve= (step+ 4 filter)

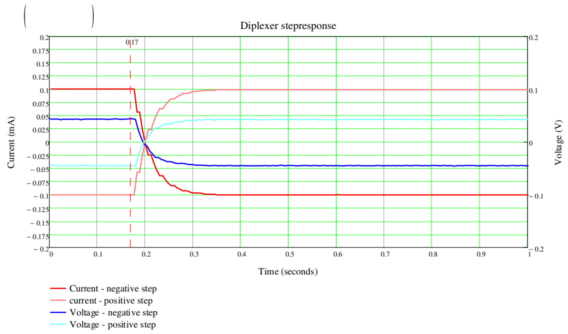


Band 6H

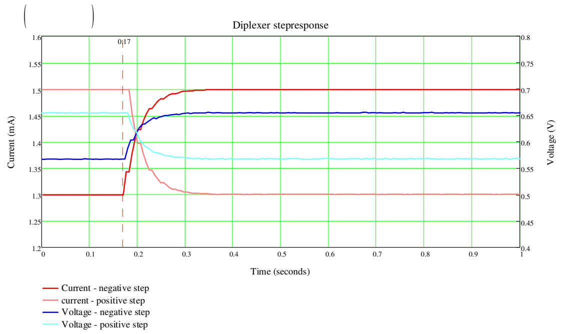
Filter = 4.8 Hz (201 raw)



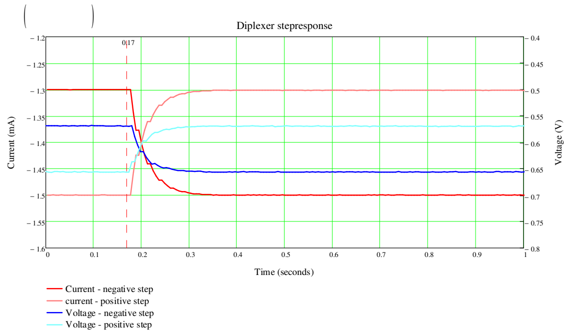
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

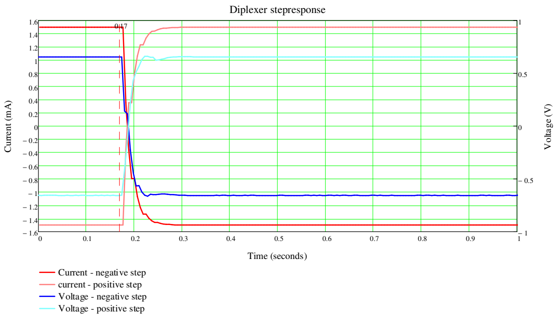


step= 3
curve= step+ 4 filter

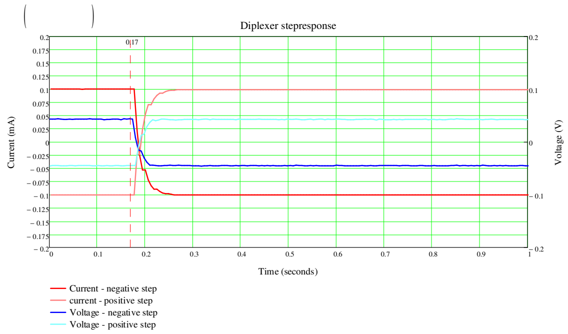


Band 6H

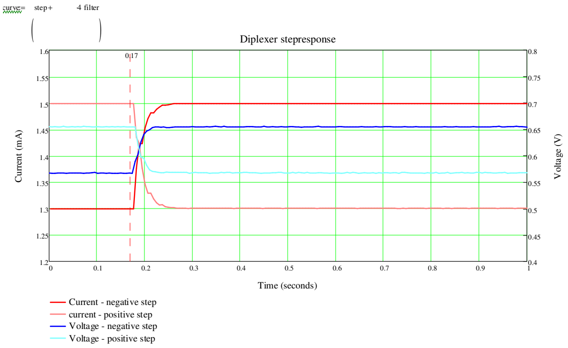
Filter = 9.6 Hz (158 raw)



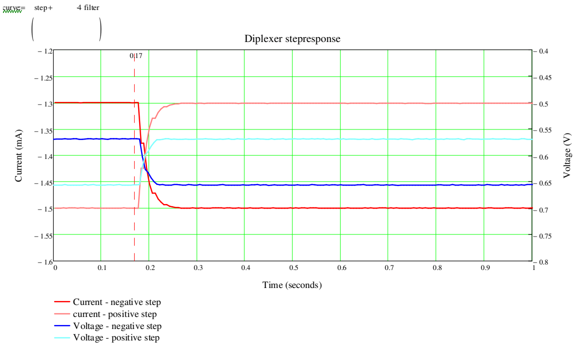
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

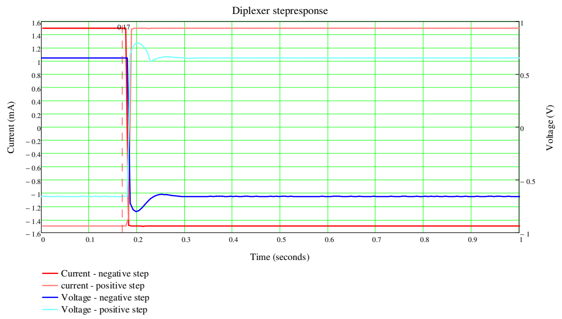


step= 3
curve= step+ 4 filter

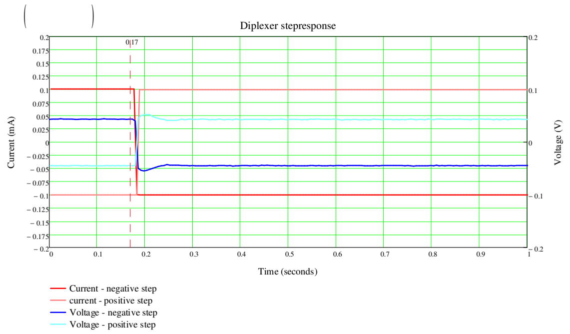


Band 6H

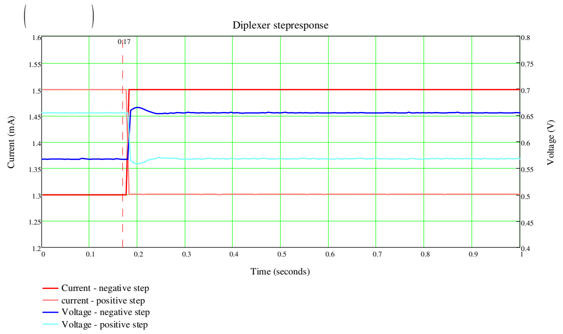
Filter = ~100 Hz (1 raw)



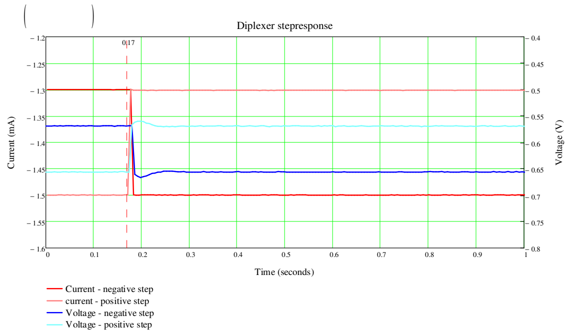
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

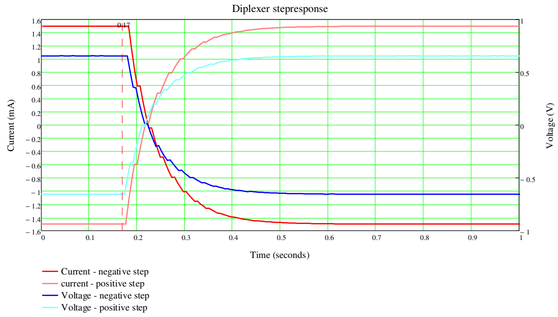


step= 3
curve= step+ 4 filter

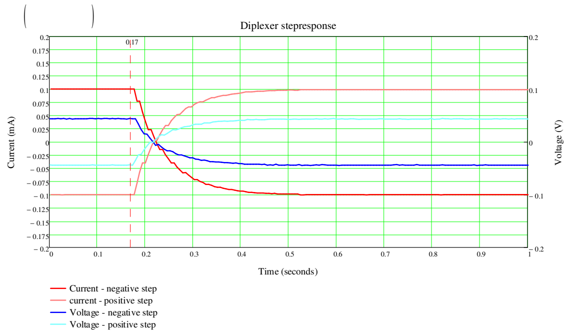


Band 6V

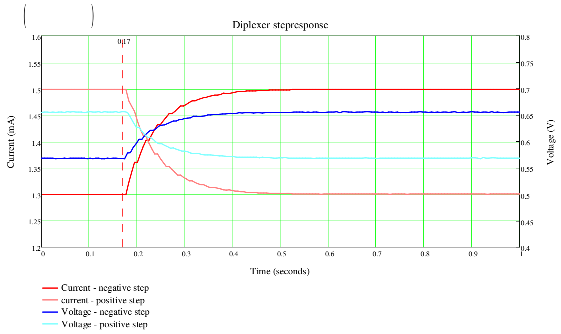
Filter = 2.4 Hz (227 raw)



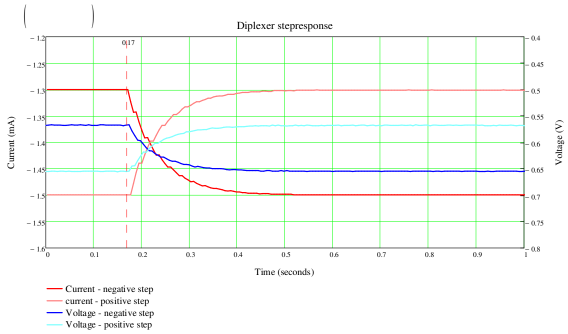
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

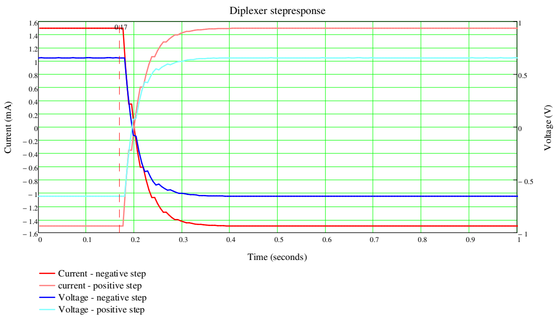


step= 3
curve= step+ 4 filter

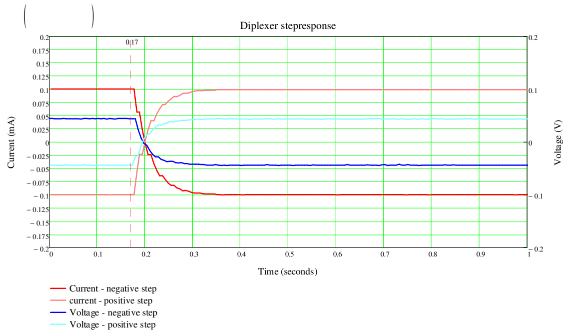


Band 6V

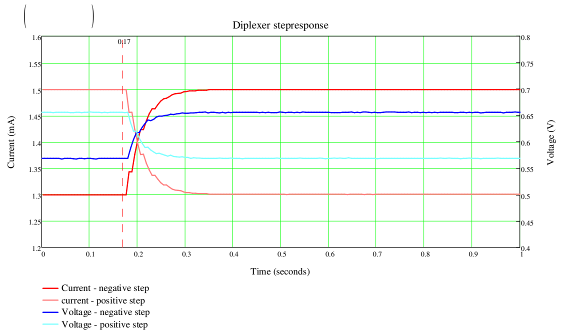
Filter = 4.8 Hz (201 raw)



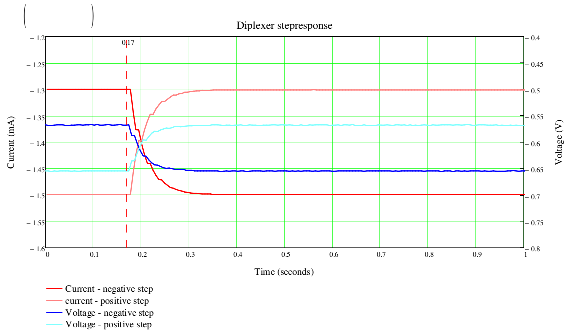
step= 1
curve= (step+ 4 filter)



step= 2
curve= (step+ 4 filter)

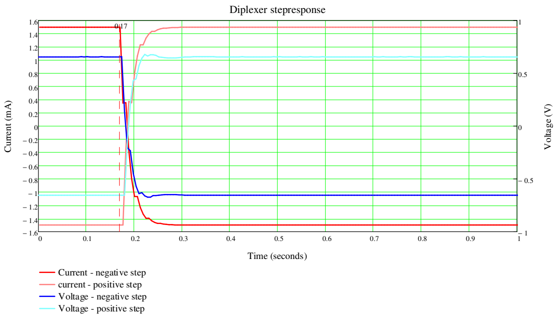


step= 3
curve= (step+ 4 filter)

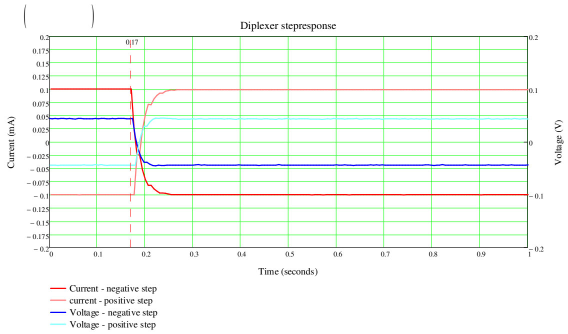


Band 6V

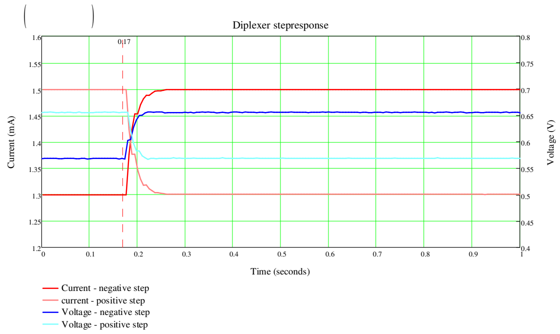
Filter = 9.6 Hz (158 raw)



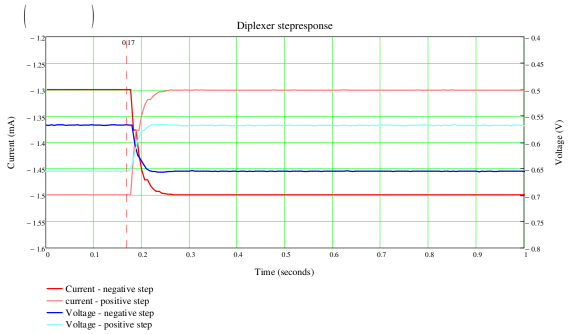
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

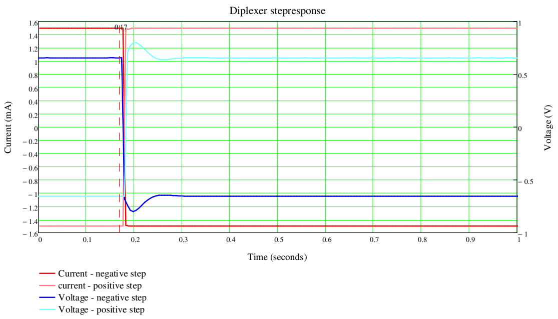


step= 3
curve= step+ 4 filter

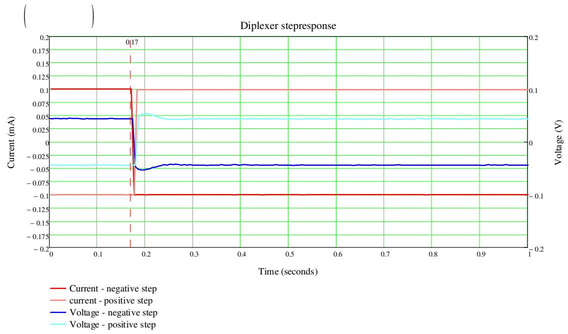


Band 6V

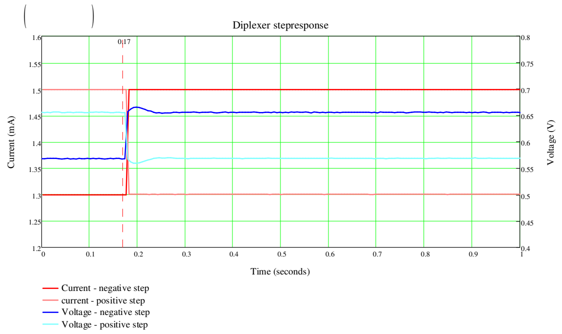
Filter = ~100 Hz (1 raw)



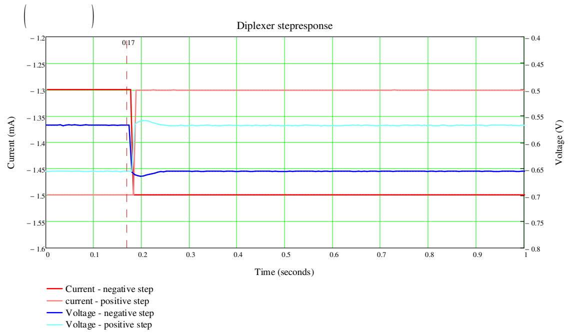
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

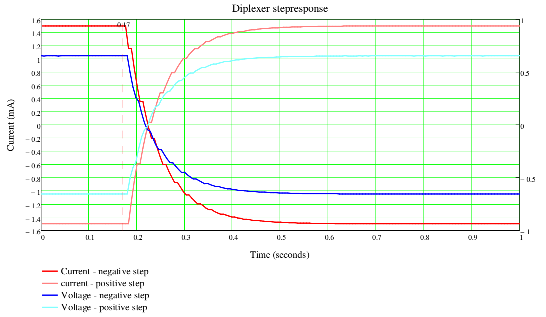


step= 3
curve= step+ 4 filter

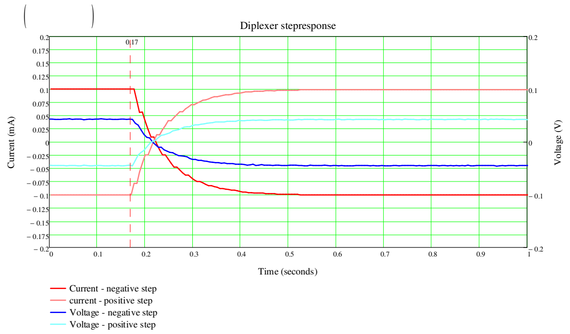


Band 7H

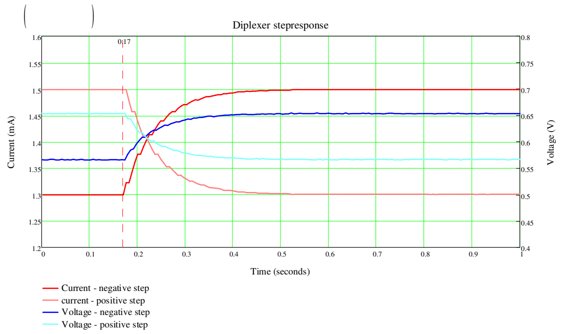
Filter = 2.4 Hz (227 raw)



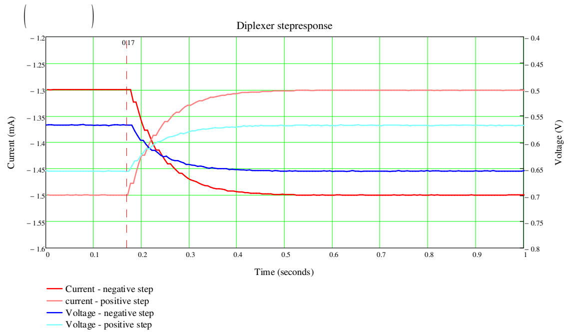
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

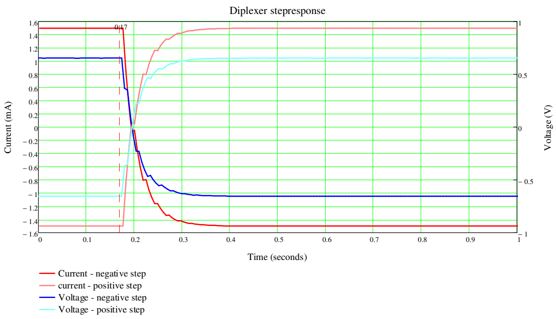


step= 3
curve= step+ 4 filter

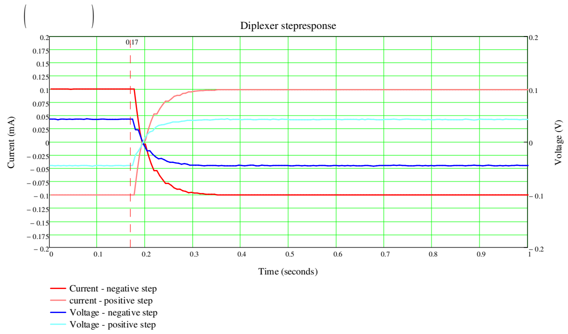


Band 7H

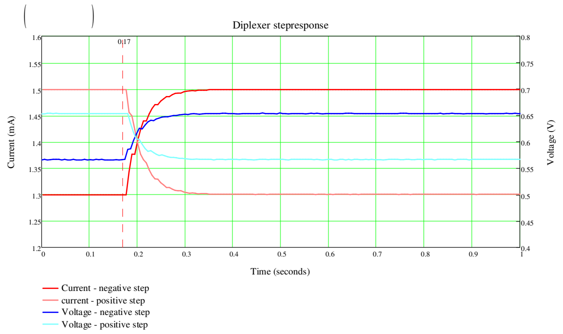
Filter = 4.8 Hz (201 raw)



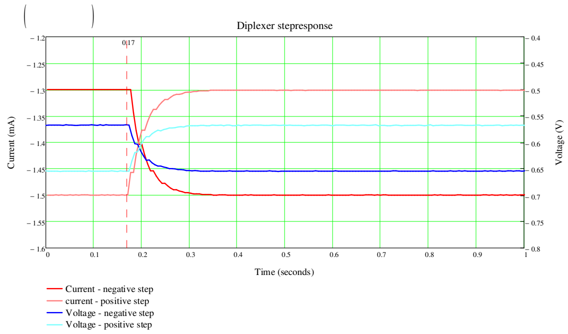
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

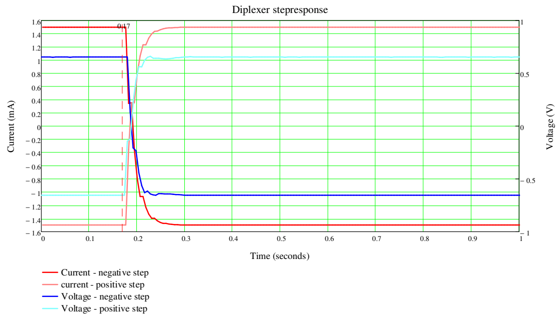


step= 3
curve= step+ 4 filter

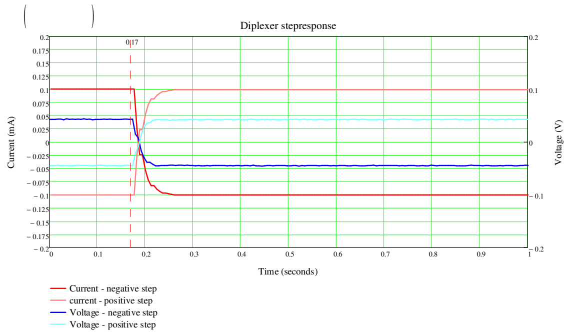


Band 7H

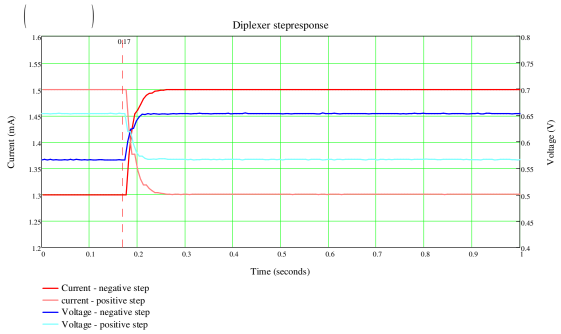
Filter = 9.6 Hz (158 raw)



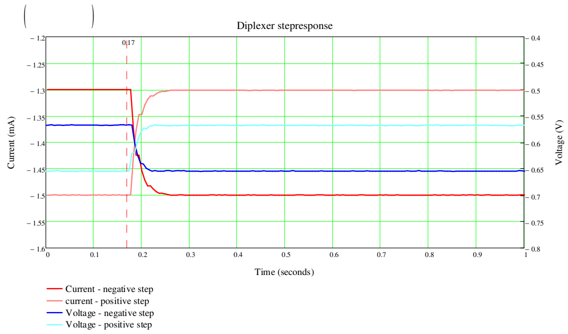
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

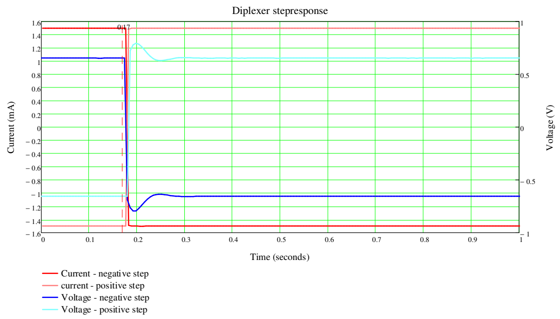


step= 3
curve= step+ 4 filter

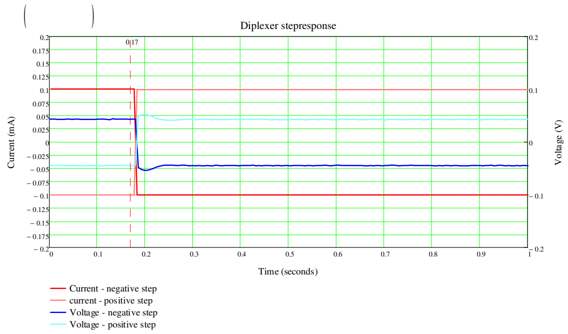


Band 7H

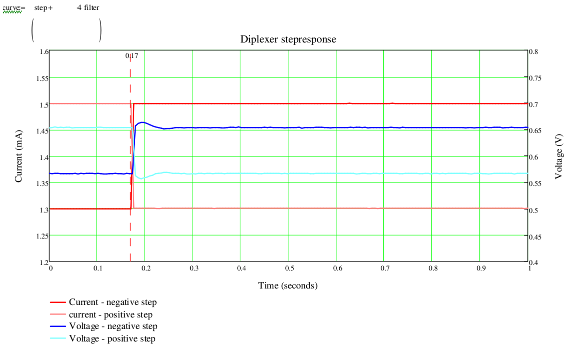
Filter = ~100 Hz (1 raw)



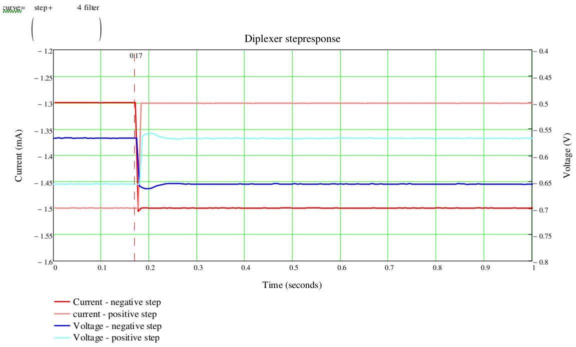
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

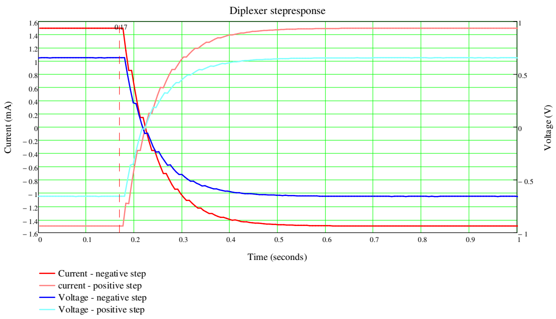


step= 3
curve= step+ 4 filter

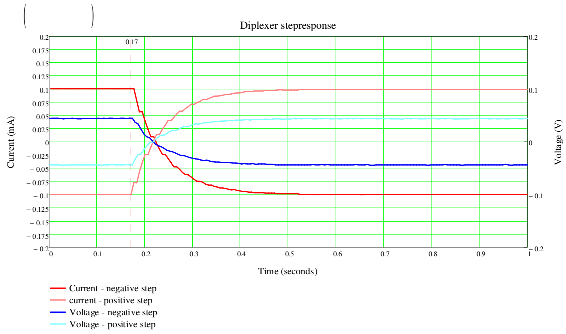


Band 7V

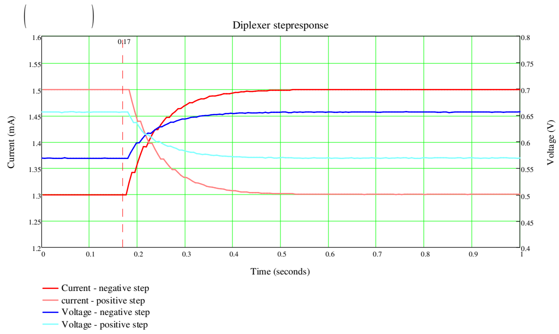
Filter = 2.4 Hz (227 raw)



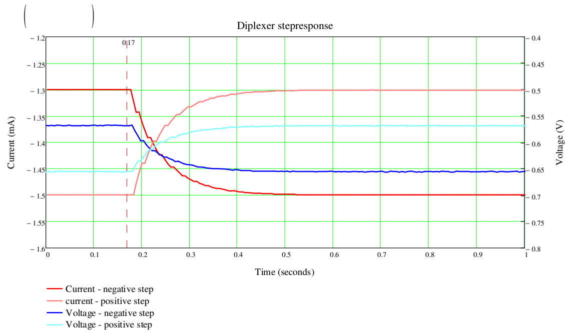
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

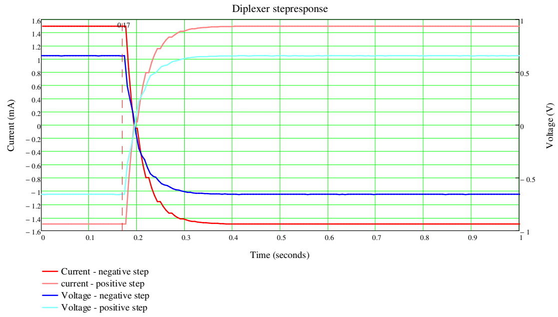


step= 3
curve= step+ 4 filter

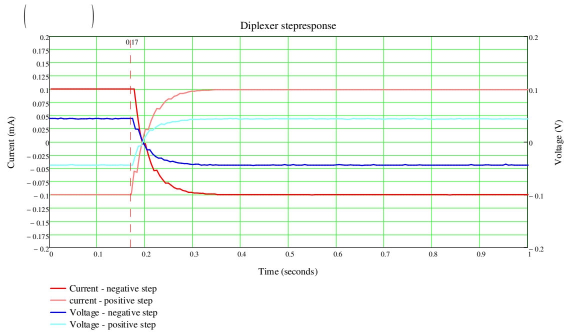


Band 7V

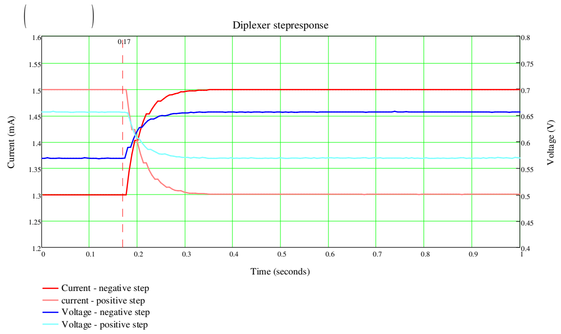
Filter = 4.8 Hz (201 raw)



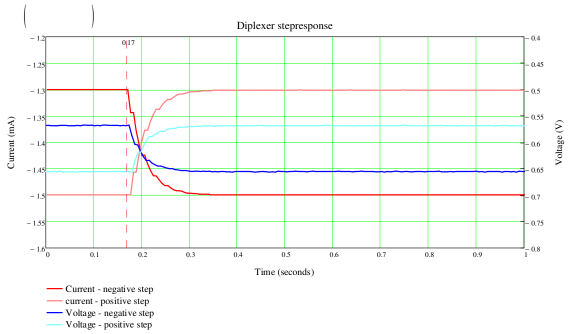
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

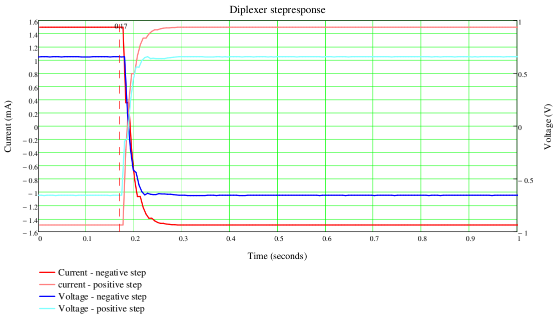


step= 3
curve= step+ 4 filter

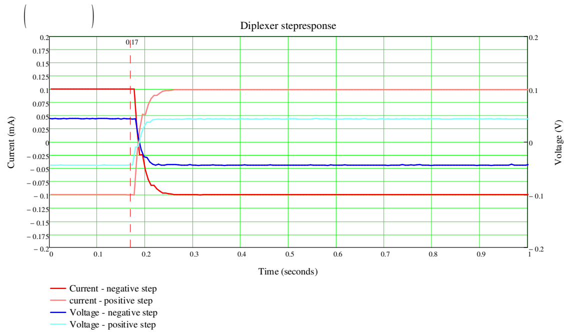


Band 7V

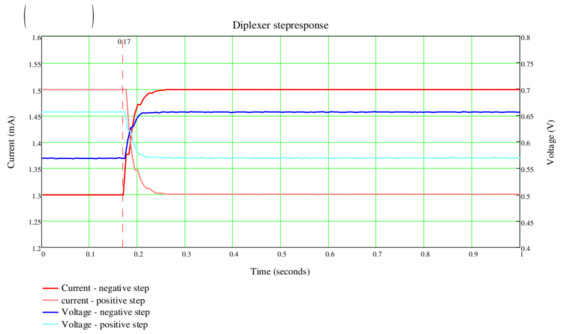
Filter = 9.6 Hz (158 raw)



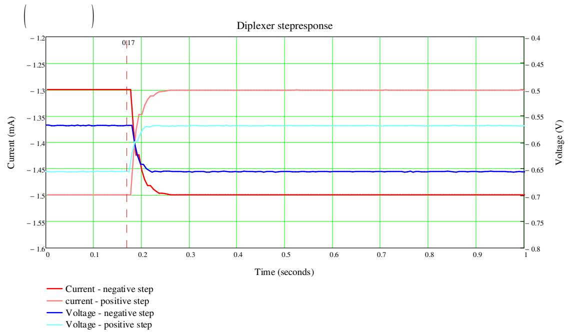
step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter

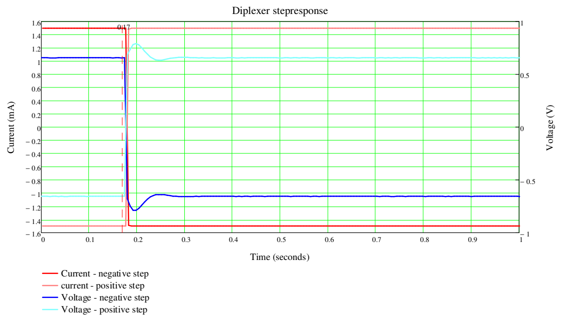


step= 3
curve= step+ 4 filter

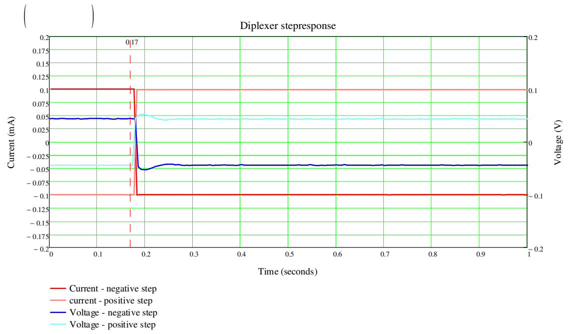


Band 7V

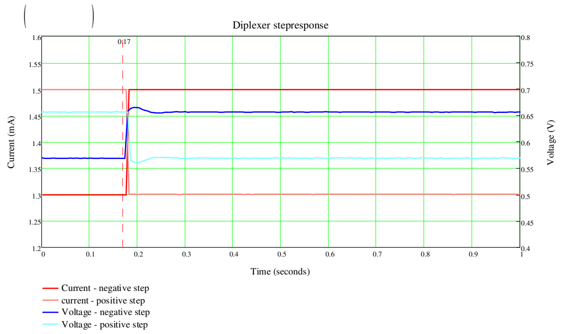
Filter = ~100 Hz (1 raw)



step= 1
curve= step+ 4 filter



step= 2
curve= step+ 4 filter



step= 3
curve= step+ 4 filter