APPLICATIONS INFORMATION

MANAGING NOISE LEVELS IN THE ACS75X CURRENT SENSORS

The minimum current that can be resolved by the ACS75x current sensors is limited by the noise present in the output of the sensors. The noise specifications vary among the families of ACS75x current sensors, as shown in table 1.

In general, resolution may be improved by the addition of external filters on the sensor output. However, beyond certain levels, such filtering limits the bandwidth and response time of the sensor.

This application note is a guide to evaluating the trade-off of resolution versus response time when using ACS75x current sensors. This information can help you to tailor the design of your application to manage output noise.

ON-BOARD FILTER LIMITATIONS

The ACS75x families have on-board filters on their outputs. However, due to the relatively loose tolerances to which resistors and capacitors can be fabricated on semiconductor die, the tolerance of these on-board filters is typically as large as ±25 to 30 percent.

To accommodate those tolerances, the center value of the filters on the ACS75x die are set at a value no less than 30% higher than the package-limited bandwidth of the sensor. As a result, the on-board filter never becomes a limiting factor in the response time of the sensor. In fact, in the case of the ACS752 family, the on-board filter value is significantly higher than this criterion. Table 2 shows the on-board filter values, tolerance limits, and package-limited bandwidth of ACS75x families.

Table 2. On-Board Filter Tolerance Range

Device Family	On-Board Filter Value (kHz)			Package-Limited Bandwidth (kHz)
	Min.	Nominal	Max.	
ACS750	14	20	26	13
ACS752	126	180	234	50
ACS754	56	80	104	40

The tolerance of the package-limited bandwidth, on the other hand, is very small. This is because it depends solely on mechanical tolerances.

IMPROVING RESOLUTION AND NOISE PERFORMANCE

The filtering tolerances achievable using discrete external filters can be much tighter than the tolerances available with on-board filters. The two types of filtering can be optimally configured to work together by using an external filter with a tight tolerance and a value close to or the same as the package-limited bandwidth.

With the two types of filtering working in tandem, the external filter can remove noise that

Table 1. ACS Family Comparison

	ACS750 Family			ACS752 Family		ACS754 Family				
	50A	75A	100A	50A	100A	50A	100A	130A	150A	200A
Noise[1] (mV)	14	7	7	93	64	70	46	43	38	36
Resolution[2] (%)	0.3	0.3	0.3	4.6	3.2	3.5	2.3	2.2	1.9	1.8

[1]Typical; average peak-to-peak
[2]Of full scale

passes through the on-board filters. In particular, this reduces or eliminates noise in those frequencies falling in the middle and upper-end of the distribution range of the on-board filters.

Such a filter combination, implemented by a passive R-C network, results in only a minimal reduction in sensor response time and bandwidth. When the more sophisticated active filters are used (such as Butterworth or Chebychev), there is almost no impact on sensor response time.

This improvement is most dramatically apparent in the ACS752 family. Table 3 shows the substantial reduction in noise, and minimal reduction in bandwidth, that results from placing a 50 kHz R-C filter on the ACS752 output.

Table 4 compares the effect of an external filter rated at the package bandwidth (40 kHz), and one rated just above the package bandwidth, at 50 kHz. The filter rated equivalent to the device bandwidth has minimal effect on the bandwidth, in comparison to the unfiltered case.

Noise can be further reduced and resolution increased by use of an external filter rated less than the package-limited bandwidth. However, in that case the filter becomes a limiting factor in the response time and bandwidth of the sensor circuit.

Table 3. Effect of External 50 kHz Filter on ACS752 Family Output

	ACS752-50		ACS752-100	
	Unfiltered	**Filtered[1]**	**Unfiltered**	**Filtered[1]**
Noise, average peak-to-peak[2] (mV)	93	50	64	27
Resolution (% of full scale)	4.6	2.5	3.2	1.4
Step Response Interval Range[2] (µs)	7.5 to 8	10 to 10.5	7 to 7.5	10 to 10.5
Bandwidth[2] (kHz)	47	35	50	35

[1]50 kHz external R-C filter: R = 316 Ω, C = 0.01 µF
[2]Typical

Table 4. Effect of External 40 kHz and 50 kHz Filters on ACS754 Family Output

ACS754 Device Type	**50A**	**100A**	**130A**	**150A**	**200A**
No external filtering					
Noise, peak-to-peak* (mV)	70	46	43	38	36
Resolution (% of full scale)	3.5	2.3	2.2	1.9	1.8
Step Response Interval* (µs)	12.5	10.5	10.5	10.5	10.0
Bandwidth* (kHz)	28	33	33	33	35
40 kHz External R-C filter, R = 392 Ω, C = 0.01 µF					
Noise, peak-to-peak* (mV)	39	19	16	12	12
Resolution (% of full scale)	2.0	1.0	0.8	0.6	0.6
Step Response Interval* (µs)	15.5	14.0	14.0	14.0	14.0
Bandwidth* (kHz)	23	23	23	23	23
50 kHz External R-C filter, R = 320 Ω, C = 0.01 µF					
Noise, peak-to-peak* (mV)	41	22	17	14	14
Resolution (% of full scale)	2.1	1.1	0.9	0.7	0.7
Step Response Interval* (µs)	14.0	13.0	13.0	12.5	12.5
Bandwidth* (kHz)	25	25	25	25	25

*Typical

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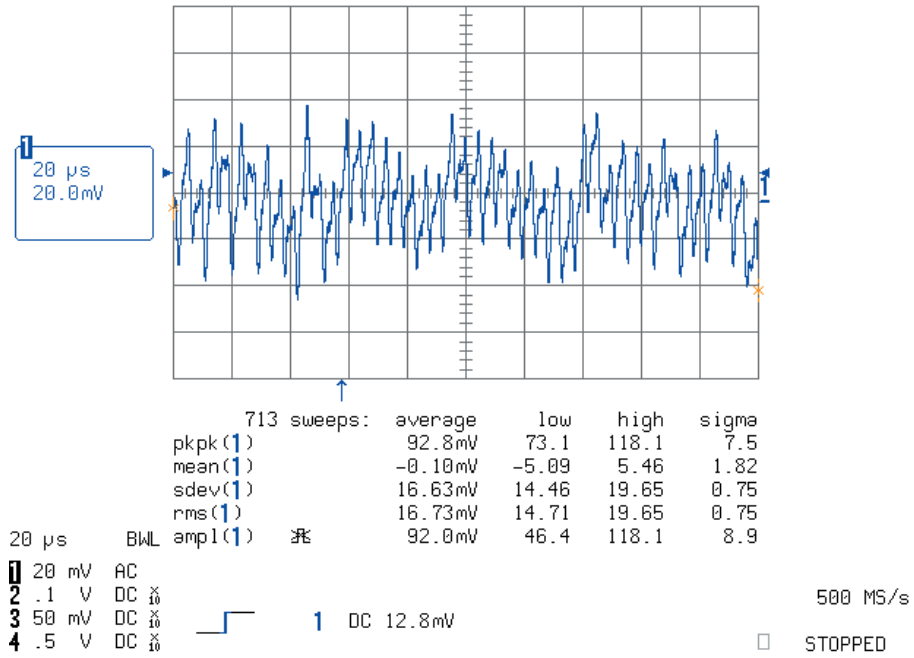

Figure 1. ACS752-050. Output noise, no filtering, ac-coupled.

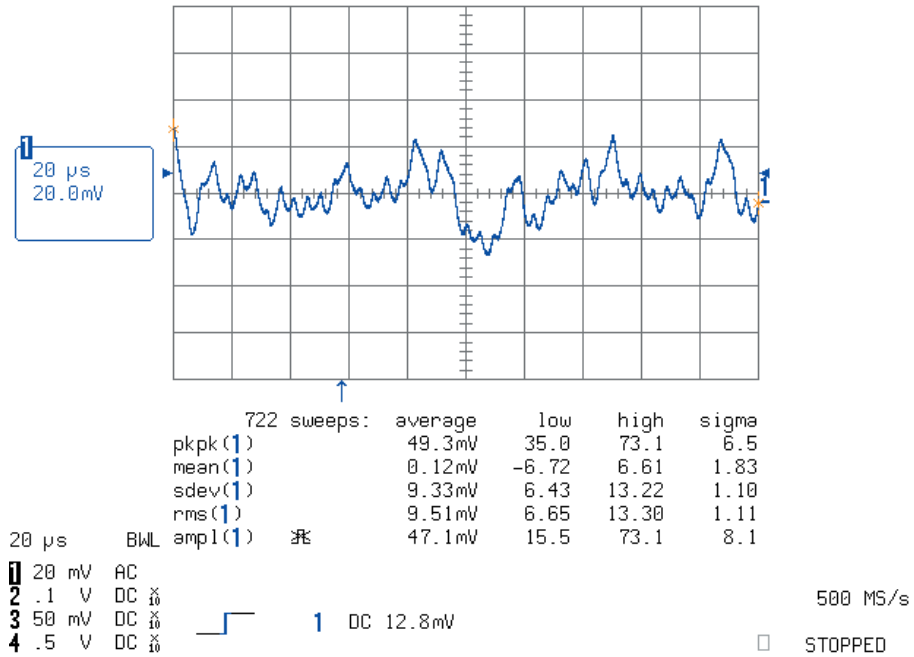

Figure 2. ACS752-050 Output noise, with 50 kHz filter (R = 316 Ω, C = 0.01 µF), ac-coupled.

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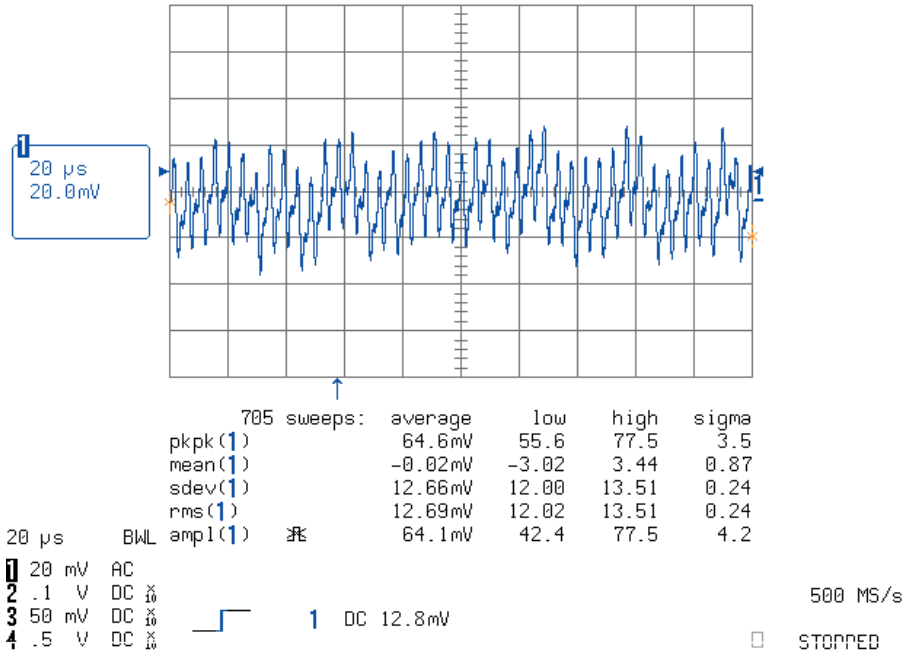

Figure 3. ACS752-100. Output noise, no filtering, ac-coupled.

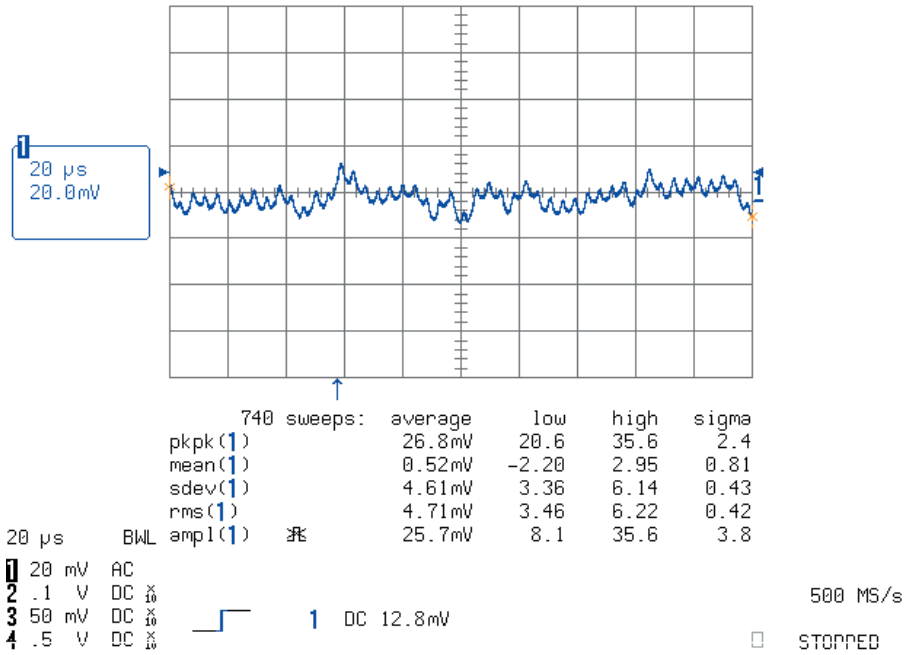

Figure 4. ACS752-100 Output noise, with 50 kHz filter (R = 316 Ω, C = 0.01 µF), ac-coupled.

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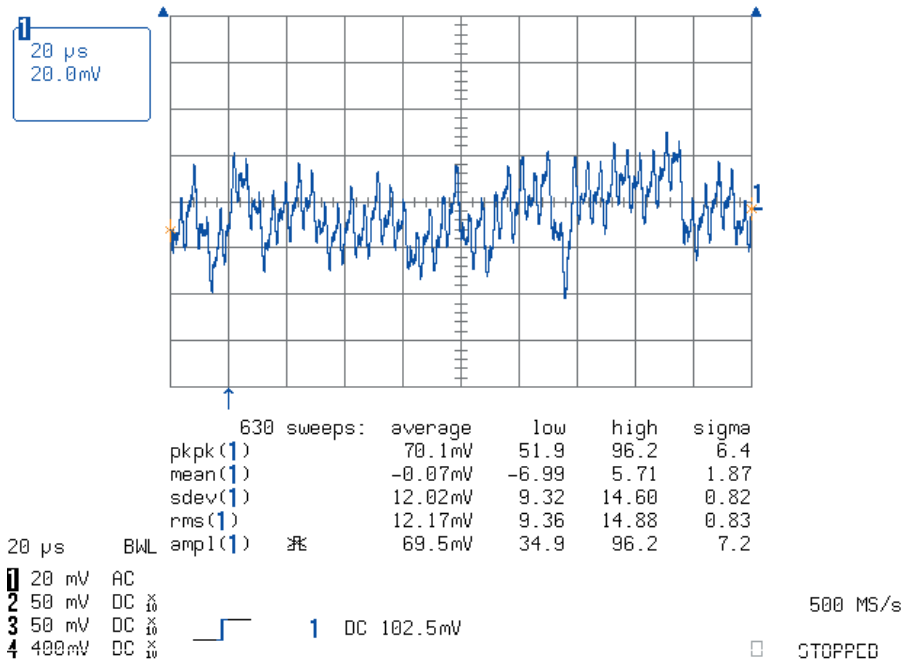

Figure 5. ACS754-050. Output noise, no filtering, ac-coupled.

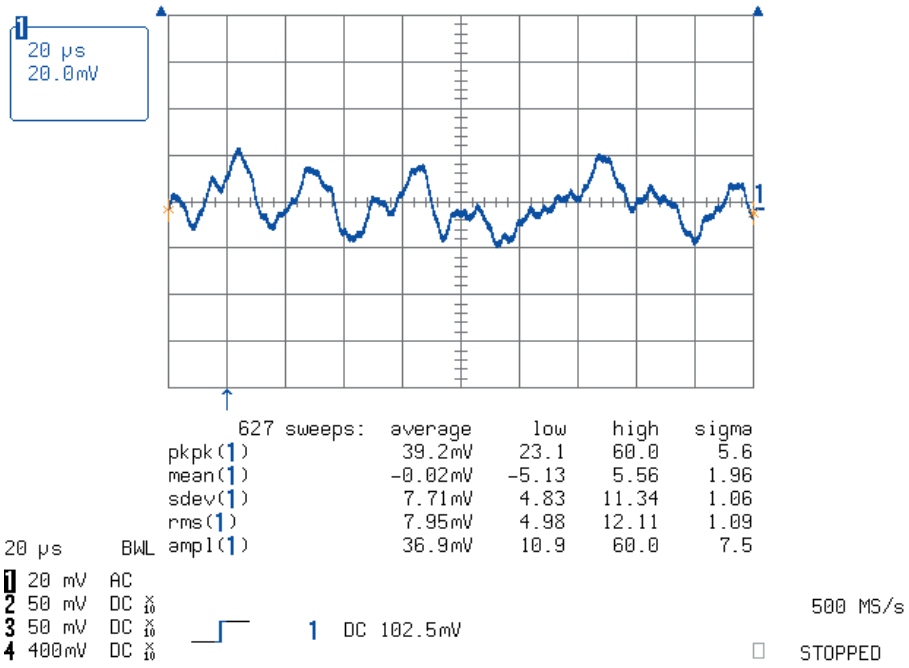

Figure 6. ACS754-050 Output noise, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

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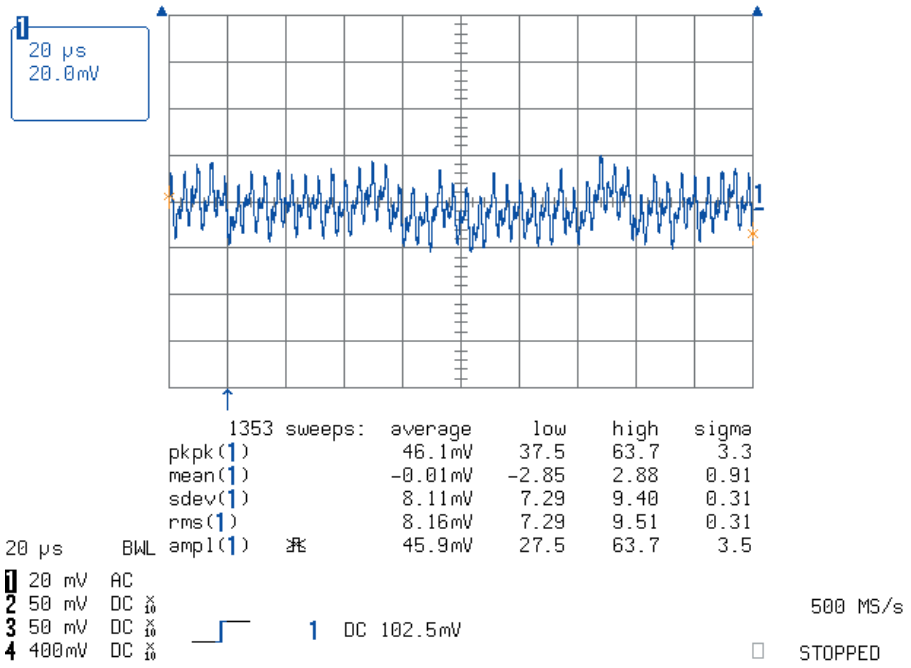

Figure 7. ACS754-100. Output noise, no filtering, ac-coupled.

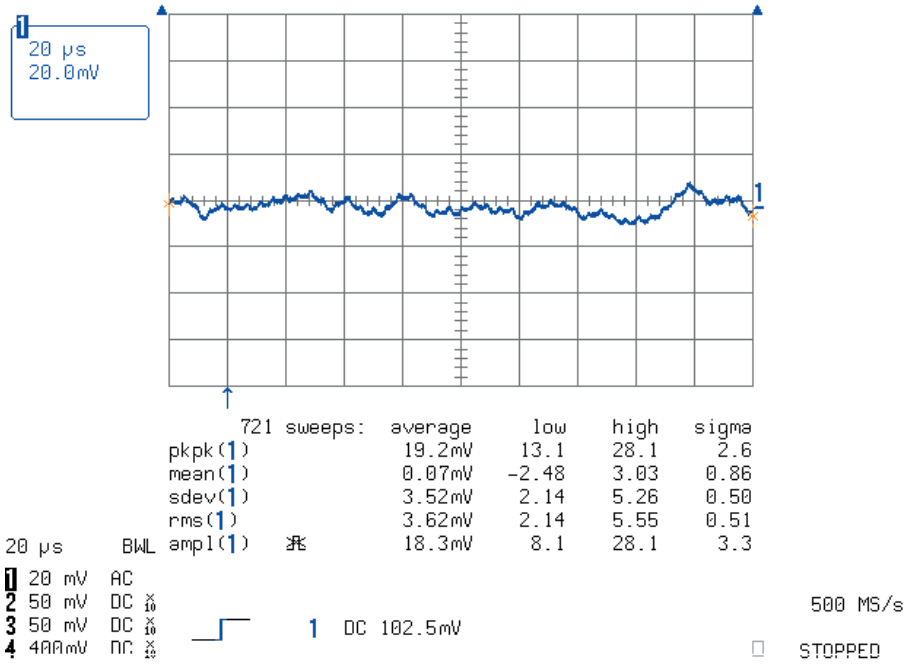

Figure 8. ACS754-100 Output noise, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

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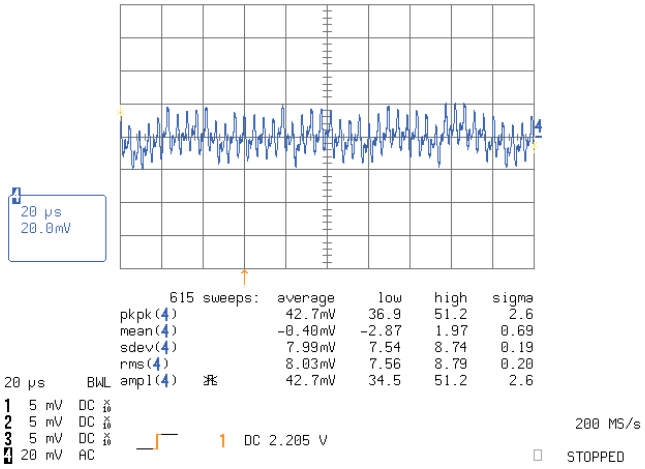

Figure 9. ACS754-130. Output noise, no filtering, ac-coupled.

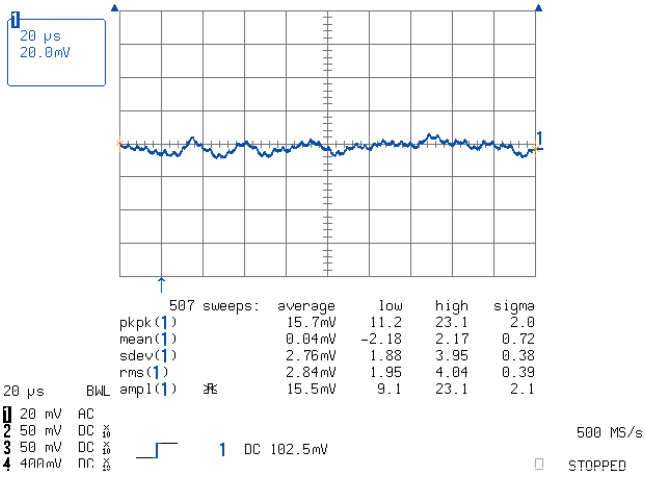

Figure 10. ACS754-130 Output noise, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

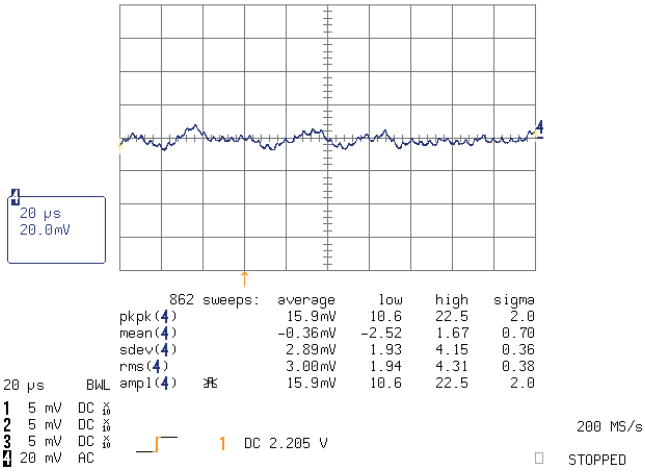

Figure 11. ACS754-130 Output noise, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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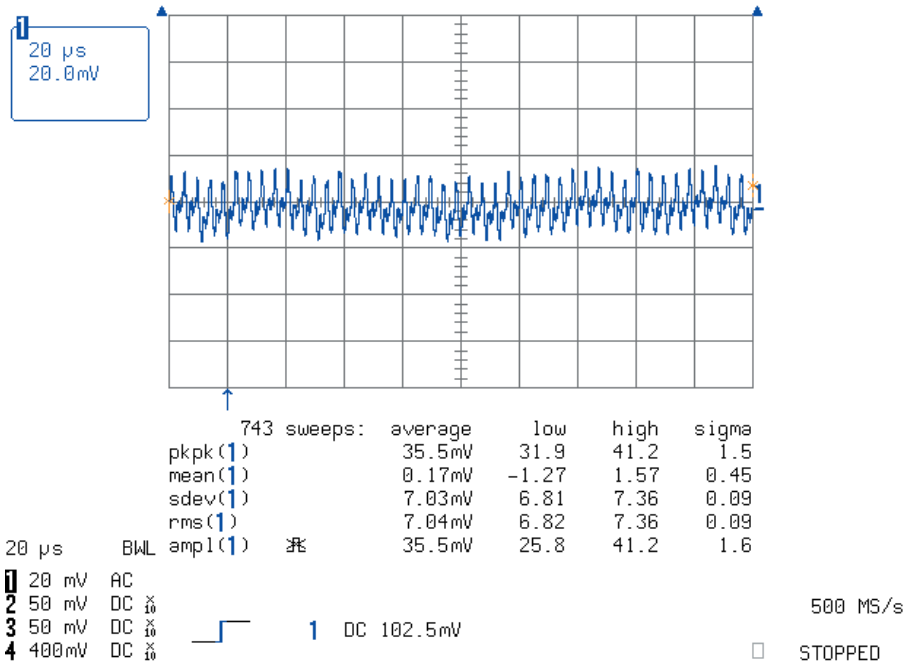

Figure 12. ACS754-150. Output noise, no filtering, ac-coupled.

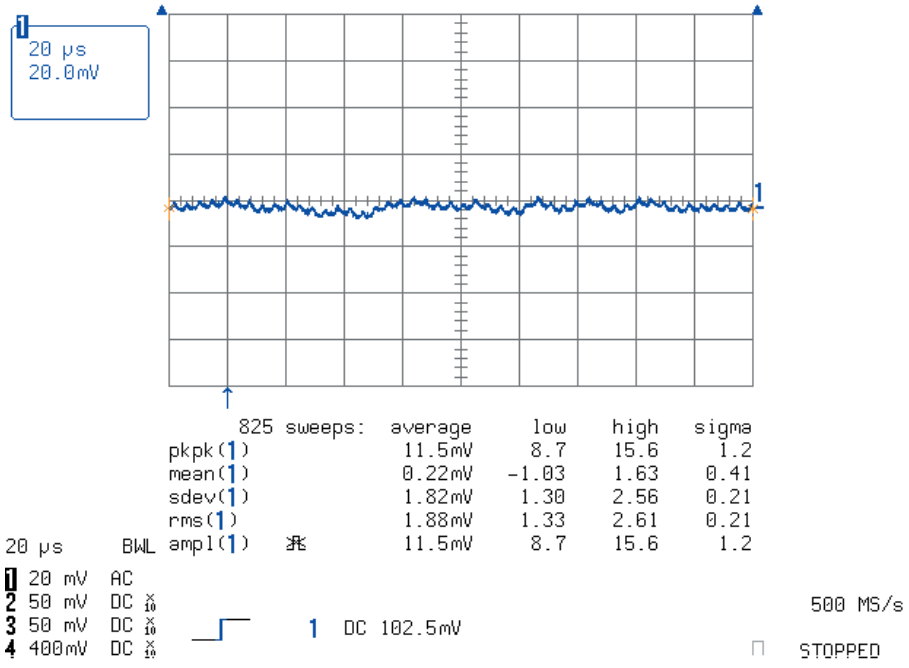

Figure 13. ACS754-150 Output noise, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

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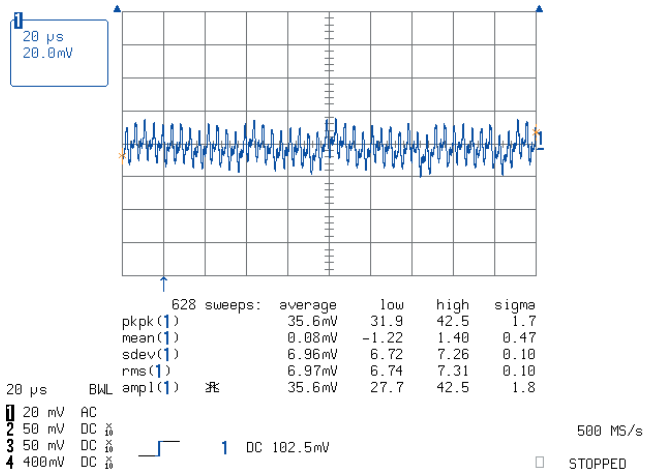

Figure 14. ACS754-200. Output noise, no filtering, ac-coupled.

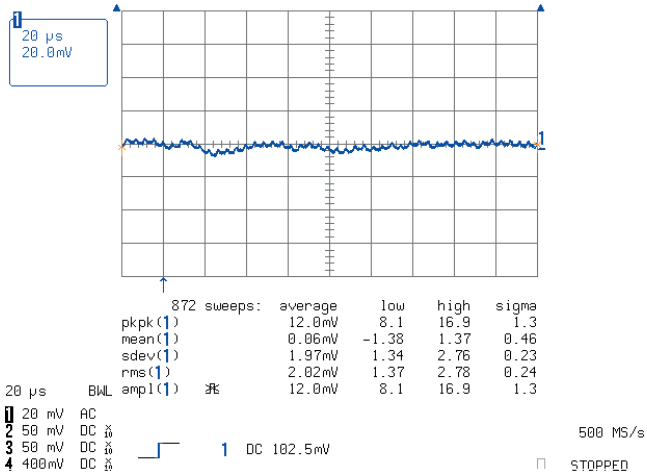

Figure 15. ACS754-200 Output noise, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

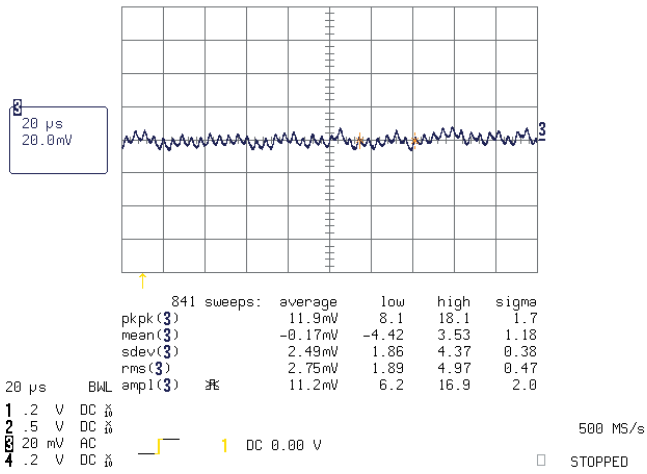

Figure 16. ACS754-200 Output noise, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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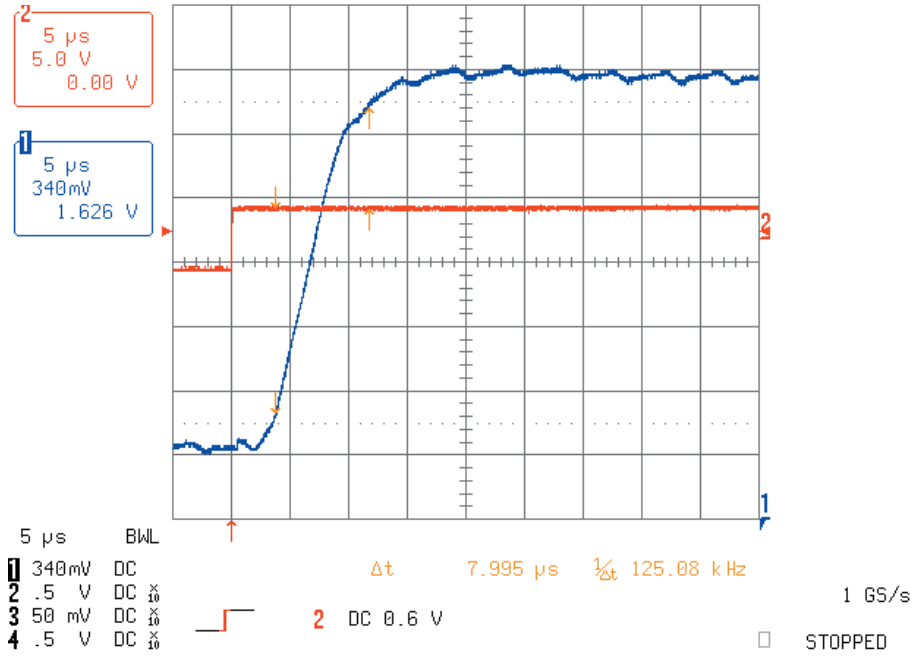

Figure 17. ACS752-050. Step response, no filtering, ac-coupled.

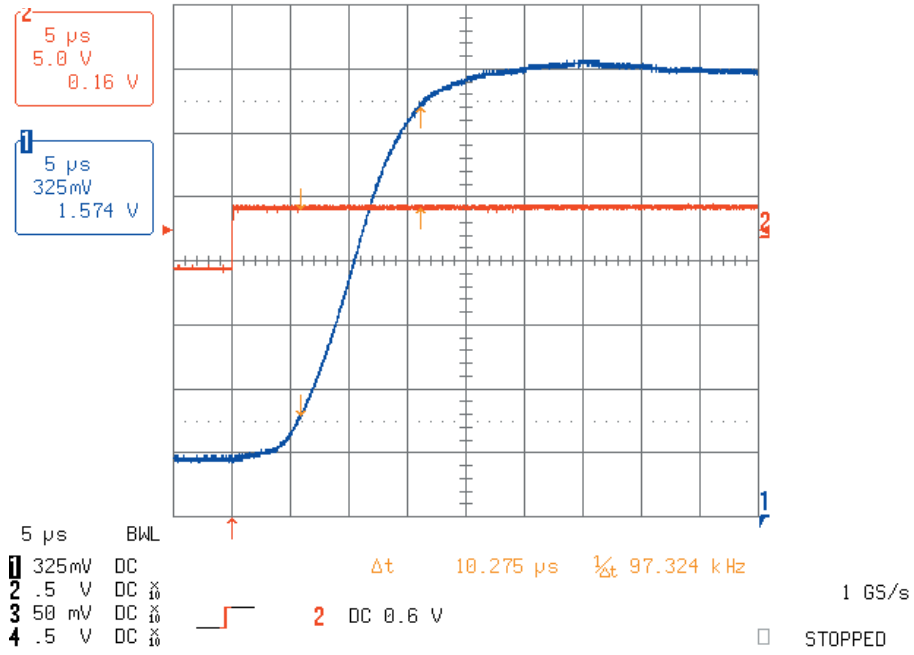

Figure 18. ACS752-050 Step response, with 50 kHz low-pass filter (R = 316 Ω, C = 0.01 µF), ac-coupled.

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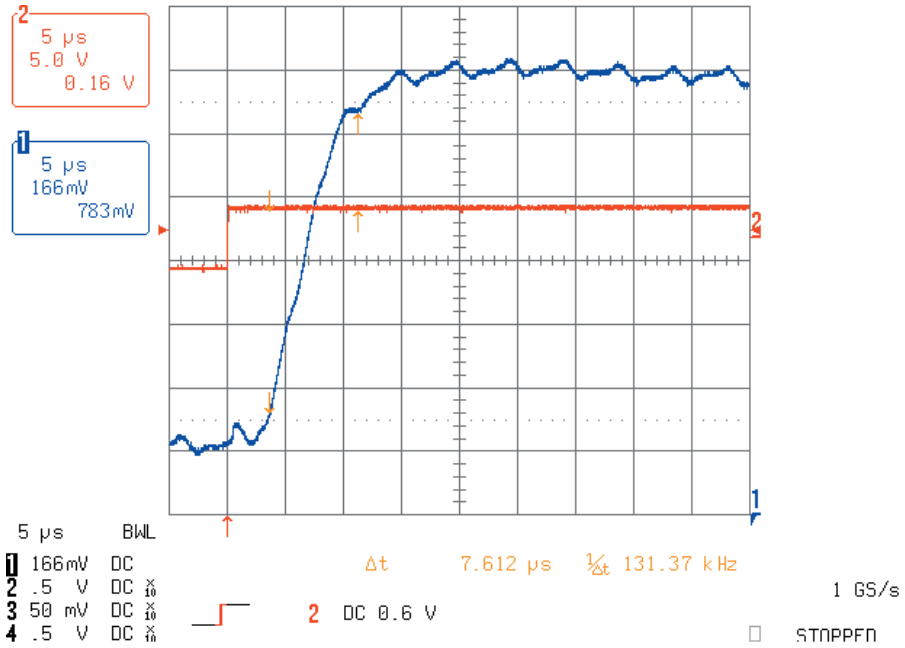

Figure 19. ACS752-100. Step response, no filtering, ac-coupled.

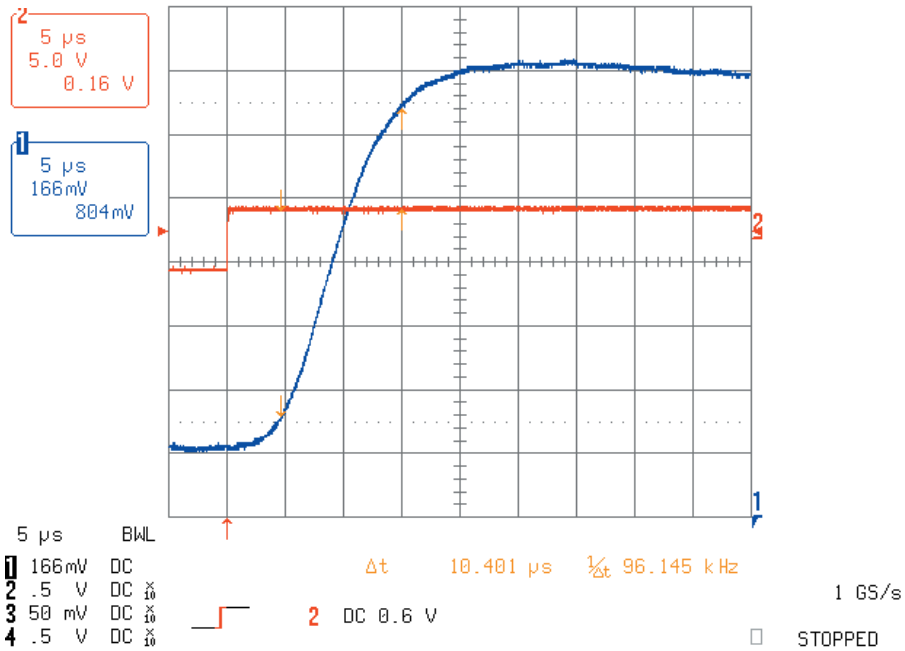

Figure 20. ACS752-100 Step response, with 50 kHz low-pass filter (R = 316 Ω, C = 0.01 µF), ac-coupled.

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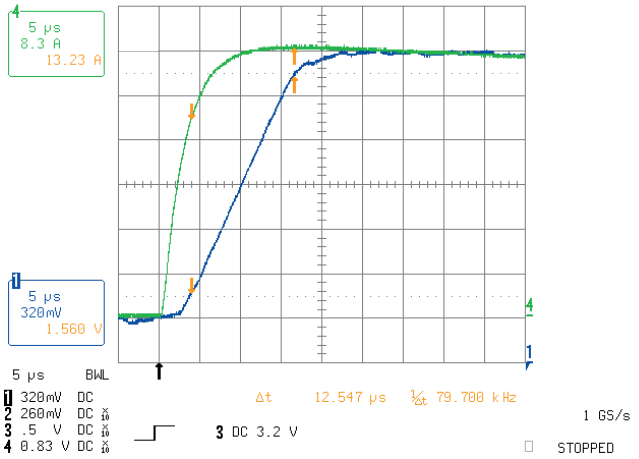

Figure 21. ACS754-050. Response to 50 A step, no filtering, ac-coupled.

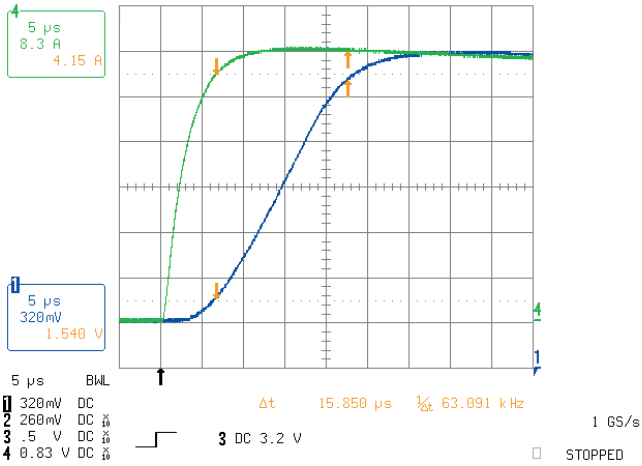

Figure 22. ACS754-050 Response to 50 A step, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

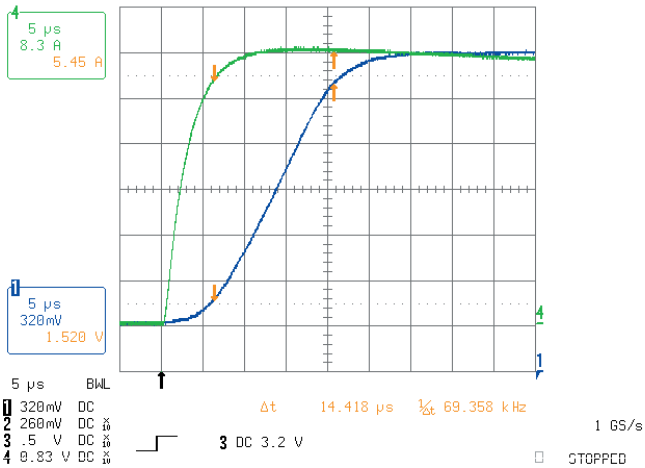

Figure 23. ACS754-050 Response to 50 A step, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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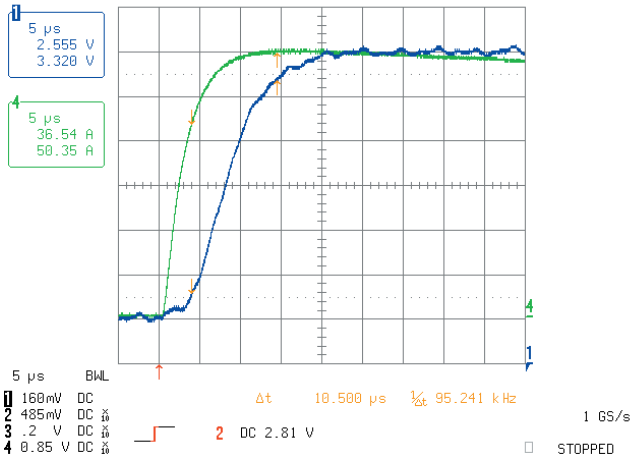

Figure 24. ACS754-100. Response to 50 A step, no filtering, ac-coupled.

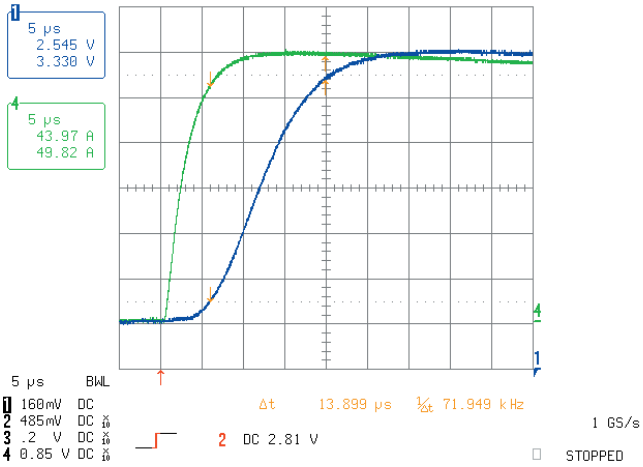

Figure 25. ACS754-100 Response to 50 A step, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

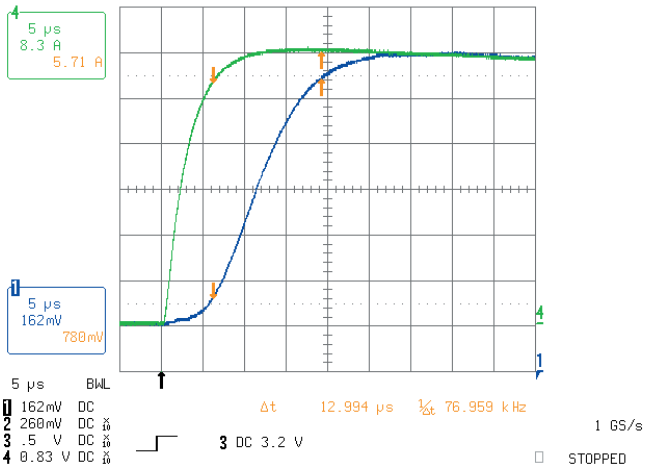

Figure 26. ACS754-100 Response to 50 A step, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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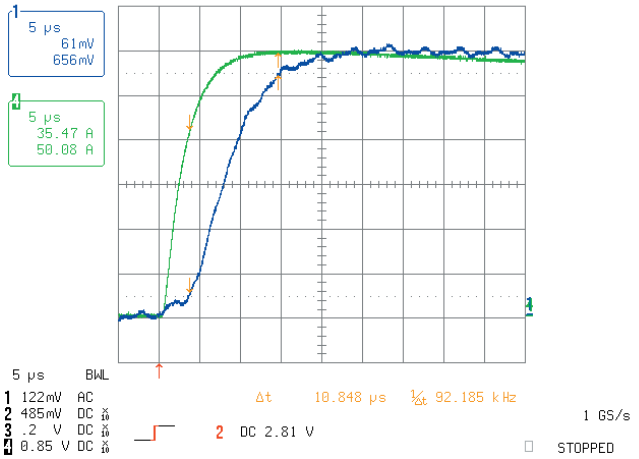

Figure 27. ACS754-130. Response to 50 A step, no filtering, ac-coupled.

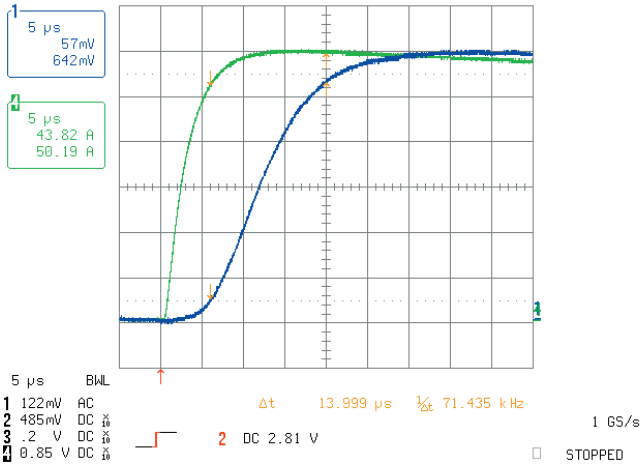

Figure 28. ACS754-130 Response to 50 A step, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

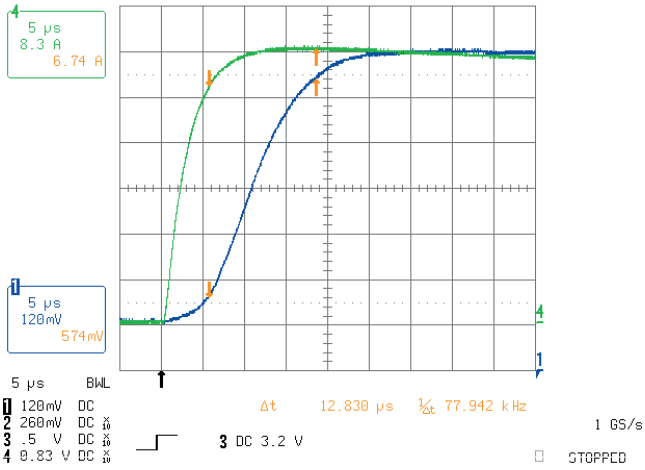

Figure 29. ACS754-130 Response to 50 A step, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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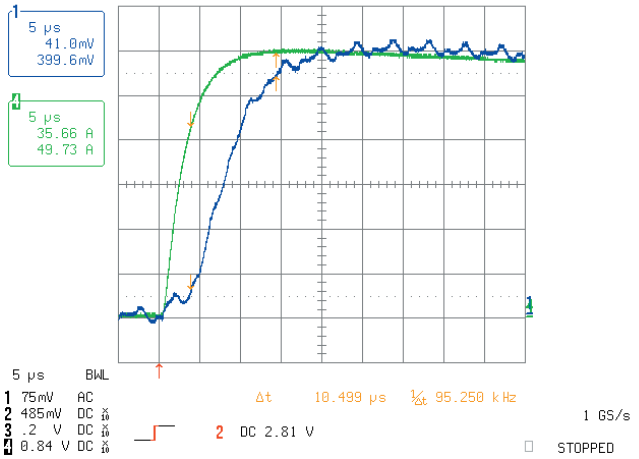

Figure 30. ACS754-150. Response to 50 A step, no filtering, ac-coupled.

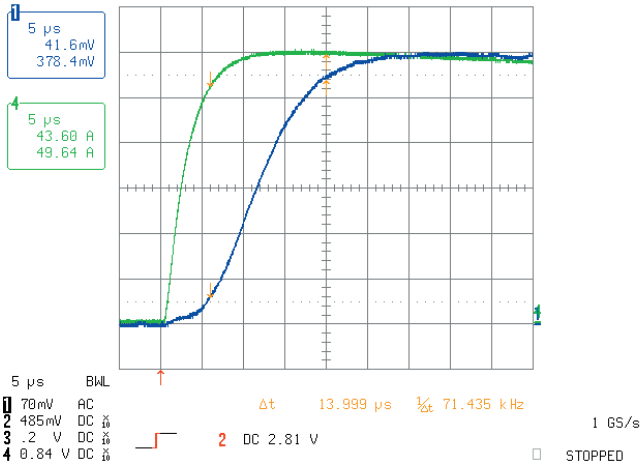

Figure 31. ACS754-150 Response to 50 A step, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

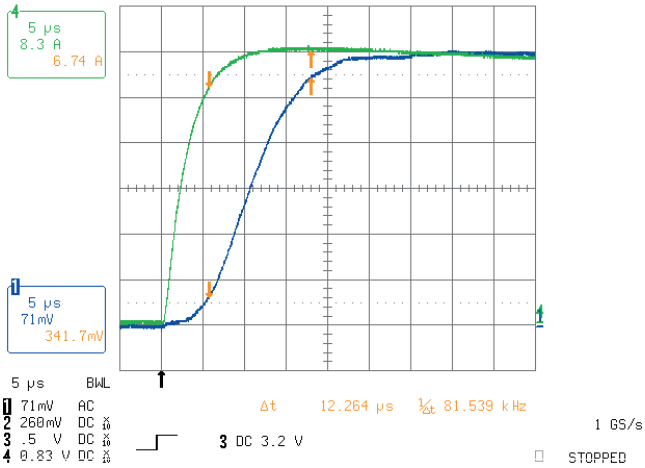

Figure 32. ACS754-150 Response to 50 A step, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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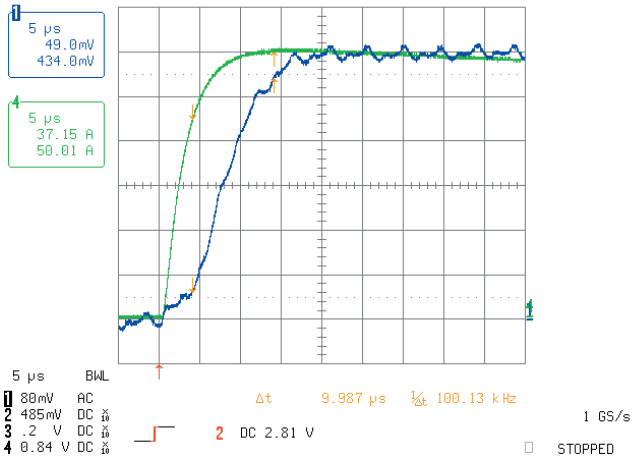

Figure 33. ACS754-200. Response to 50 A step, no filtering, ac-coupled.

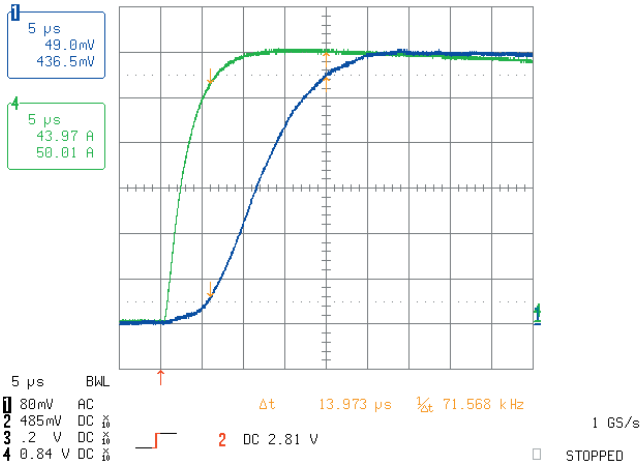

Figure 34. ACS754-200 Response to 50 A step, with 40 kHz filter (R = 392 Ω, C = 0.01 µF), ac-coupled.

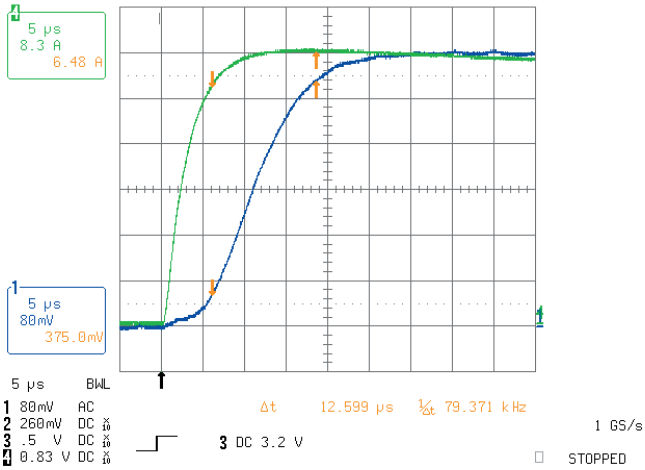

Figure 35. ACS754-200 Response to 50 A step, with 50 kHz filter (R = 320 Ω, C = 0.01 µF), ac-coupled.

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