POWERTECH LABS INC

Test Report Nº PL-26017- REV1

TESTS FOR
VERIFICATION OF INTERRUPTING PERFORMANCE
ON FUSE LINKS MANUFACTURED BY
TECFUSE INDÚSTRIA ELÉCTRICA LTDA.

ABSTRACT

At the request of Tecfuse, 6K, 25K, 30K and 50K fuse links manufactured by Tecfuse Indústria Elétrica Ltda., rated 6 A_{rms}, 25 A_{rms}, 30 A_{rms} and 50 A_{rms} respectively, were subjected to a series of interrupting performance tests. The tests and assessment were performed in accordance with the customer's specifications and using IEC Standard 60282-2, 2008, Section 8.6 and Table 6 as guide. This report summarizes the results of the tests performed.

Prepared by: K. Tabarraee, M.A.Sc., P.Eng May 2016

Test Report № PL-26017- REV1

Client:	Tecfuse Indústria Elétrica Ltda. Av. José Agostinho Rossi, 1.030 CEP 16.203-059 Birigüi SP, Brasil	
Project №:	80024618 PL-26005 PL-26017	**Test Dates:** 8 March 2013 27 June 2013 18 September 2013
Tested Devices:	6K, 25K, 30 K and 50K fuse links, tested with a 100 A_{rms} continuous, 7.1 kA_{rms} symmetrical-interrupting rated distribution-class A fuse cutout	
Type:	Tecfuse, CAT #T-EF-10-01, 500 mm	
Identification:	Support Porcelain, Maurizio type MZ-89021, 15 kV, 300 A, 110 kV BIL Holder Maurizio & CIA. Ltda., type MZ-9021, 15 kV, 100 A_{rms} continuous, 7.1 kA_{rms} symmetrical, 10 kA_{rms} asymmetrical interrupting used with no arc shortening rod	
Tests performed:	Verification of interrupting performance per the customer's specifications and using IEC Standard 60282-2, 2008, Section 8.6 and Table 6 as guide.	
Test witness:	Mr. Manoel Esteves	Tecfuse Indústria Elétrica Ltda.
Remarks:	• The identification of the tested fuse links, cutout holders and insulating supports was based on the markings on the samples. • As requested by the customer, the fuse links were tested in circuits configured for interrupting performance test duties #1, #4 and #5 (refer to IEC Standard 60282-2, 2008, Section 8.6 and Table 6). • The tested fuse links successfully operated during the entire interrupting tests performed. • During one shot of test duty #1 at 140° closing angle, the fuse holder did not drop-out after successful interruption. • The insulating support design used for the tests is intended for installations with an external conductor connected at a 90° angle to the fuse link holder.	

Tested by:

K. Tabarraee M.A.Sc., P.Eng.
Project Leader, T&D Services

Reviewed by:

Logan Connaughton, P. Eng.
Manager, High Power Lab

TABLE OF CONTENTS

1.0 INTRODUCTION

At the request of Tecfuse Indústria Elétrica Ltda., a series of interrupting performance tests were performed on 6K, 25K, 30K and 50K fuse links manufactured by Tecfuse at the High Power Laboratory of Powertech Labs Inc. The tests were performed with a 15 kV, 100 A_{rms} continuous, 7.1 kA_{rms} symmetrical-interrupting rated distribution-class A fuse cutout, in accordance with the customer's requirements and using IEC Standard 60282-2, 2008, Section 8.6 and Table 6 as guide.

The Powertech High Power Laboratory is a member of the Short-Circuit Testing Liaison North America (STLNA). STLNA is the North American Member of STL. The High Power Lab is accredited by the Standards Council of Canada to ISO 17025. The tests included in this report are within the scope of this accreditation. The results apply only to the samples tested.

2.0 TEST PROCEDURE

The identification of the tested fuse links, cutout holders and insulating supports was based on the markings on the samples as follows:

Fuse Links
Tecfuse, CAT #T-EF-10-01, 500 mm

Support
Porcelain, Maurizio type MZ-89021
15 kV, 300 A, 110 kV BIL

Holder
Maurizio & CIA. Ltda., type MZ-9021
15 kV, 100 A_{rms} continuous, 7.1 kA_{rms} symmetrical, 10 kA_{rms} asymmetrical interrupting;
used with no arc shortening rod

As requested by the client, the fuse links were tested in circuits configured for interrupting performance test duties #1, #4 and #5 as described in IEC Standard 60282-2, 2008, Section 8.6 and Table 6. The details of the test circuits are provided below. Before the tests, the TRV for circuits configured for test duties #1 and #4 was adjusted in accordance with the requirements of Table 6 and Table 8 of IEC 60282-2 using a current injection method. The TRV for test duty #5 was adjusted to be critically damped per Note (7) of Table 6 of the IEC 60282-2.

The detailed test results are provided in Table 1.

The following test circuits were configured:

2.1 Test Duty #1

• Prospective current (symmetrical)	7.17 kA_{rms} (≥ 7.1 kA_{rms} is required)
• Prospective current (asymmetrical)	11.3 kA_{rms}
• TRV peak factor	1.36 (1.3 to 1.43 is required)
• TRV time, t_3	180 µs (≤ 187 µs is required)
• TRV waveform	Refer to Figure 4
• Test circuit	Refer to Figure 1
• X/R ratio	9.7 (≥ 6.6 is required)
• Test results	Refer to Table 1 - Tests 1 to 12
• Test waveforms	Refer to Figures 6 to 17

2.2 Test Duty #4

• Prospective current (symmetrical)	405 A_{rms} (400 to 500 A_{rms} is required)
• TRV peak factor	1.58 (1.5 to 1.65 is required)
• TRV time, t_3	17.8 µs (≤ 18.0 µs is required)
• TRV waveform	Refer to Figure 5
• Test circuit	Refer to Figure 2
• X/R ratio	2.35 (1.98 to 2.67 is required)
• Test results	Refer to Table 1 - Tests 13 to 20
• Test waveforms	Refer to Figures 18 to 25

2.3 Test Duty #5- 6K Link

• Prospective current (symmetrical)	20.5 A_{rms} [1)] (16.2 to 19.8 A_{rms} is required)
• TRV	critically damped
• Test circuit	Refer to Figure 3
• X/R ratio	0.87 (0.75 to 1.33 is required)
• Test results	Refer to Table 1 - Tests 21 and 22
• Test waveforms	Refer to Figures 26 and 27

2.4 Test Duty #5- 25K Link

• Prospective current (symmetrical)	93.2 A_{rms} [1)] (67.5 to 82.7 A_{rms} is required)
• TRV	critically damped
• Test circuit	Refer to Figure 3
• X/R ratio	1.05 (0.75 to 1.33 is required)
• Test results	Refer to Table 1 - Tests 23 and 24
• Test waveforms	Refer to Figures 28 and 29

2.5 Test Duty #5- 30K Link

• Prospective current (symmetrical)	132 A_{rms} [1)] (81 to 99 A_{rms} is required)
• TRV	critically damped
• Test circuit	Refer to Figure 3
• X/R ratio	1.05 (0.75 to 1.33 is required)
• Test results	Refer to Table 1 - Tests 25 and 26
• Test waveforms	Refer to Figures 30 and 31

2.6 Test Duty #5- 50K Link

• Prospective current (symmetrical)	227 A_{rms} [1)] (135 to 165 A_{rms} is required)
• TRV	critically damped
• Test circuit	Refer to Figure 3
• X/R ratio	1.09 (0.75 to 1.33 is required)
• Test results	Refer to Table 1 - Tests 27 and 28
• Test waveforms	Refer to Figures 32 and 33

Note:
[1)] According to Note (1) of Table 6 of IEC Standard 60282-2, 2008, the test duty #5 may be performed in a circuit with higher (than required value) prospective current in order to limit the operating time of the fuse link to less than 2 seconds.

3.0 CONCLUSION

6K, 25K, 30K and 50K fuse links manufactured by Tecfuse Indústria Elétrica Ltda., rated 6 A_{rms}, 25 A_{rms}, 30 A_{rms} and 50 A_{rms} respectively, were subjected to verification of interrupting performance tests. The tests and assessment were performed in accordance with the customer's specifications and using IEC Standard 60282-2, 2008, Section 8.6 and Table 6 as guide. The tests were performed with a 15 kV, 100 A_{rms} continuous, 7.1 kA_{rms} symmetrical-interrupting rated distribution-class A fuse cutout.

The tested fuse links, cutout holders and insulating supports were identified based on the markings on the samples as follows:

Fuse Links
Tecfuse, CAT #T-EF-10-01, 500 mm
Support
Porcelain, Maurizio type MZ-89021
15 kV, 300 A, 110 kV BIL
Holder
Maurizio & CIA. Ltda., type MZ-9021
15 kV, 100 A_{rms} continuous, 7.1 kA_{rms} symmetrical, 10 kA_{rms} asymmetrical interrupting; used with no arc shortening rod

As required by the client, the fuse links were tested in test circuits configured based on interrupting performance test duties #1, #4 and #5 of Table 6 of IEC Standard 60282-2, 2008.

The tested fuse links successfully operated during all the above tests; however in one shot of test duty #1 at 140° closing angle, the fuse holder did not drop out after successful interruption.

TABLE 1*

Results of verification of interrupting time tests on 6K, 25K, 30K and 50K fuse links manufactured by Tecfuse

Test No.	Test Series	Fuse Support	Fuse Holder	Fuse Link[1)]	Closing Angle	Current Peak	Melting Time	Current Duration	Peak Voltage	Test Result
#	#	#	#	-	°	kA_{peak}	ms	ms	kV_{peak}	Pass/Fail
1	1	D	6	6K	0.0	14.3	1.13	12.6	32.8	Pass
2					90.0	7.46	0.42	7.05	30.5	Pass
3					140.0	2.14	0.61	3.18	21.6	See Notes[1)]
4		D	5	25K	0.0	15.3	1.56	19.3	28.8	Pass
5					90.0	7.99	1.31	7.12	30.6	Pass
6					140.0	13.8	3.50	63.2	31.5	Pass
7		E	7	30K	0.0	16.0	2.84	19.0	28.8	Pass
8					90.0	8.74	1.72	7.26	31.1	Pass
9					140.0	14.3	5.38	22.0	30.3	Pass
10		F	8	50K	0.0	16.1	3.57	12.8	32.1	Pass
11					90.0	9.01	2.33	7.45	31.1	Pass
12					140.0	14.9	5.96	21.3	29.5	Pass

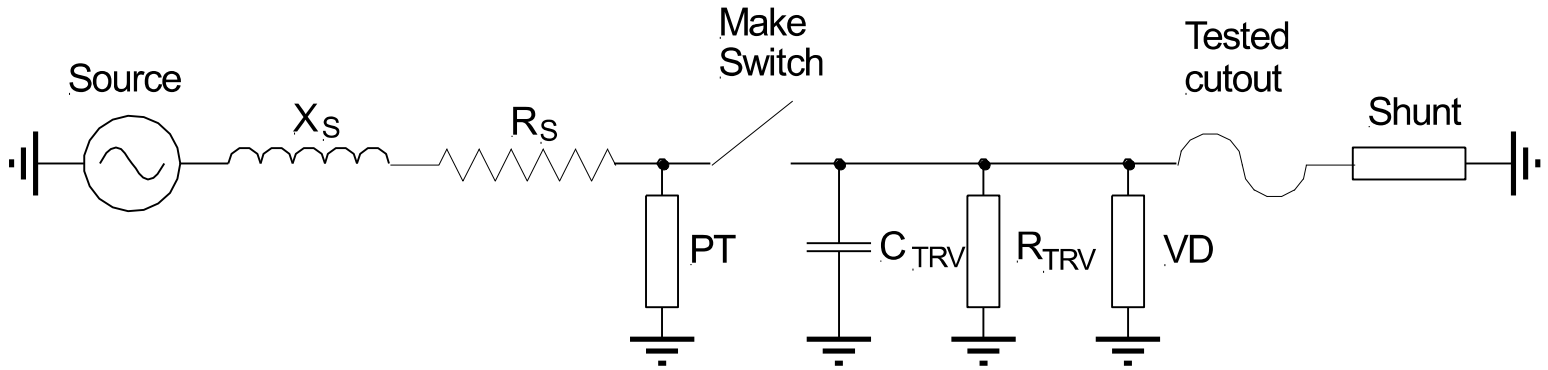
* See notes on the next page.

TABLE 1 (continued)

Results of verification of interrupting time tests on 6K, 25K, 30K and 50K fuse links manufactured by Tecfuse

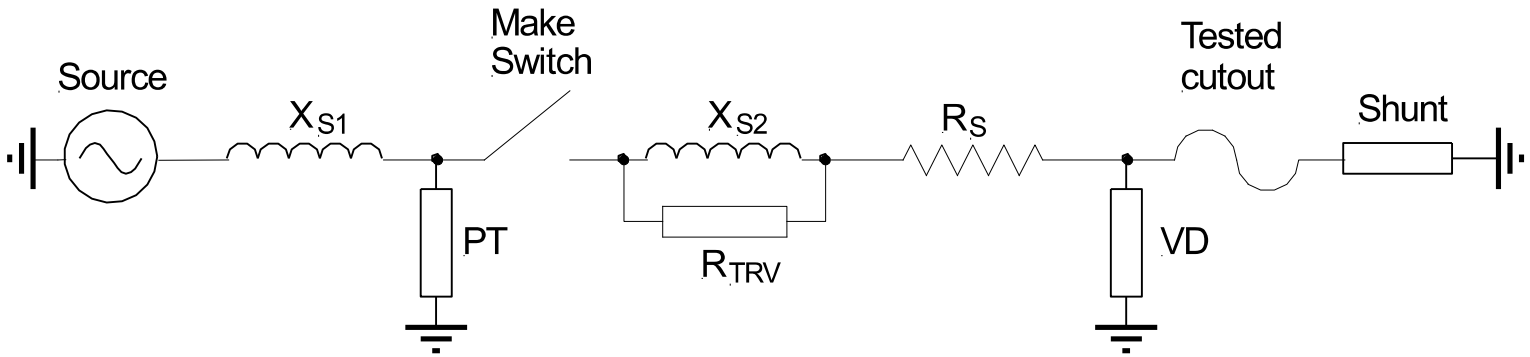
13	4	4-A	4-1	6K	0.0	0.75	5.67	10.7	28.7	Pass
14					90.0	0.59	8.08	14.5	28.0	Pass
15			4-2	25K	0.0	0.73	66.9	76.7	24.2	Pass
16					90.0	0.61	73.5	81.0	23.4	Pass
17		4-B	4-3	30K	0.0	0.74	165	176	23.8	Pass
18					90.0	0.61	172	181	28.4	Pass
19			4-4	50K	0.0	0.74	411	419	23.8	Pass
20					90.0	0.62	420	431	22.8	Pass
21	5[2)]	4-A	4-1	6K	Random	N/M[3)]	1300	1320	21.8	Pass
22							1320	1340	21.8	Pass
23			4-2	25K	Random	N/M	1790	1810	21.8	Pass
24							1770	1800	21.8	Pass
25		4-B	4-3	30K	Random	N/M	1980	2010	21.8	Pass
26							1930	1950	21.8	Pass
27			4-4	50K	Random	N/M	1650	1670	21.8	Pass
28							1320	1340	21.8	Pass

Notes:
[1)] Fuse holder did not drop out after successful interruption
[2)] According to Note (1) of Table 6 of IEC Standard 60282-2, 2008, the test duty #5 may be performed in a circuit with higher (than required value) prospective current in order to limit the operating time of the fuse link to less than 2 seconds.
[3)] Peak current values in test duty #5 were not measured.



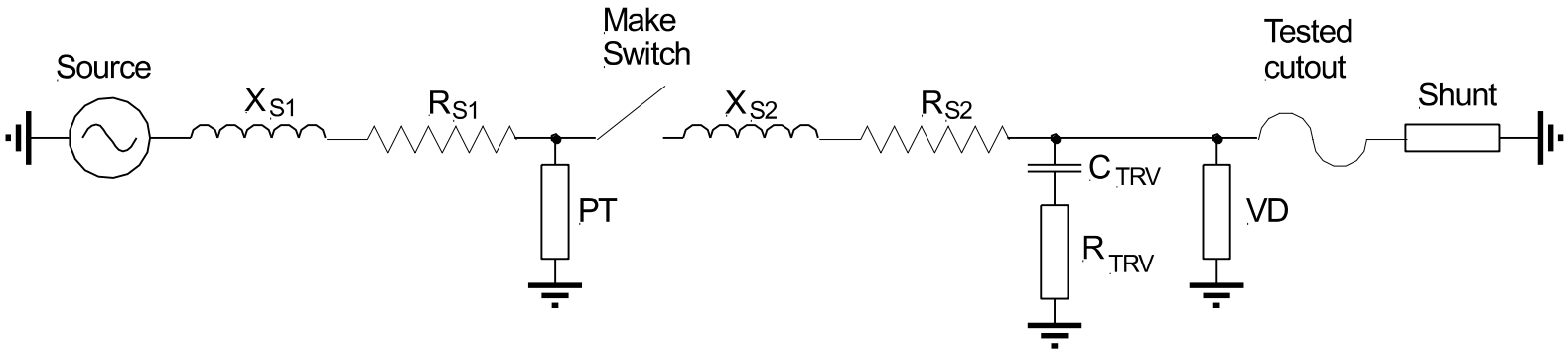
Notes:
1. X_S - Source Reactance
2. R_S - Source Resistance
3. R_{TRV}, C_{TRV} - TRV Components
4. VD - Voltage Divider
5. PT - Potential Transformer (U_S phase angle measurements)

Figure 1. Test circuit for test duty #1 (tests #1-12 in Table 1)



Notes:
1. $X_{S1,}$ X_{S2} - Source Reactances
2. R_S - Source Resistance
3. VD - Voltage Divider
4. PT - Potential Transformer (U_S phase angle measurements)

Figure 2. Test circuit for test duty #4 (tests #13-20 in Table 1).



Notes:
1. $X_{S1,}X_{S2}$ - Source Reactances
2. $R_{S1,}R_{S2}$ - Source Resistances
3. VD - Voltage Divider
4. PT - Potential Transformer (U_S phase angle measurements)
5. C_{TRV}, R_{TRV} – TRV components

Figure 3. Test circuit for test duty #5 (tests #21-28 in Table 1).

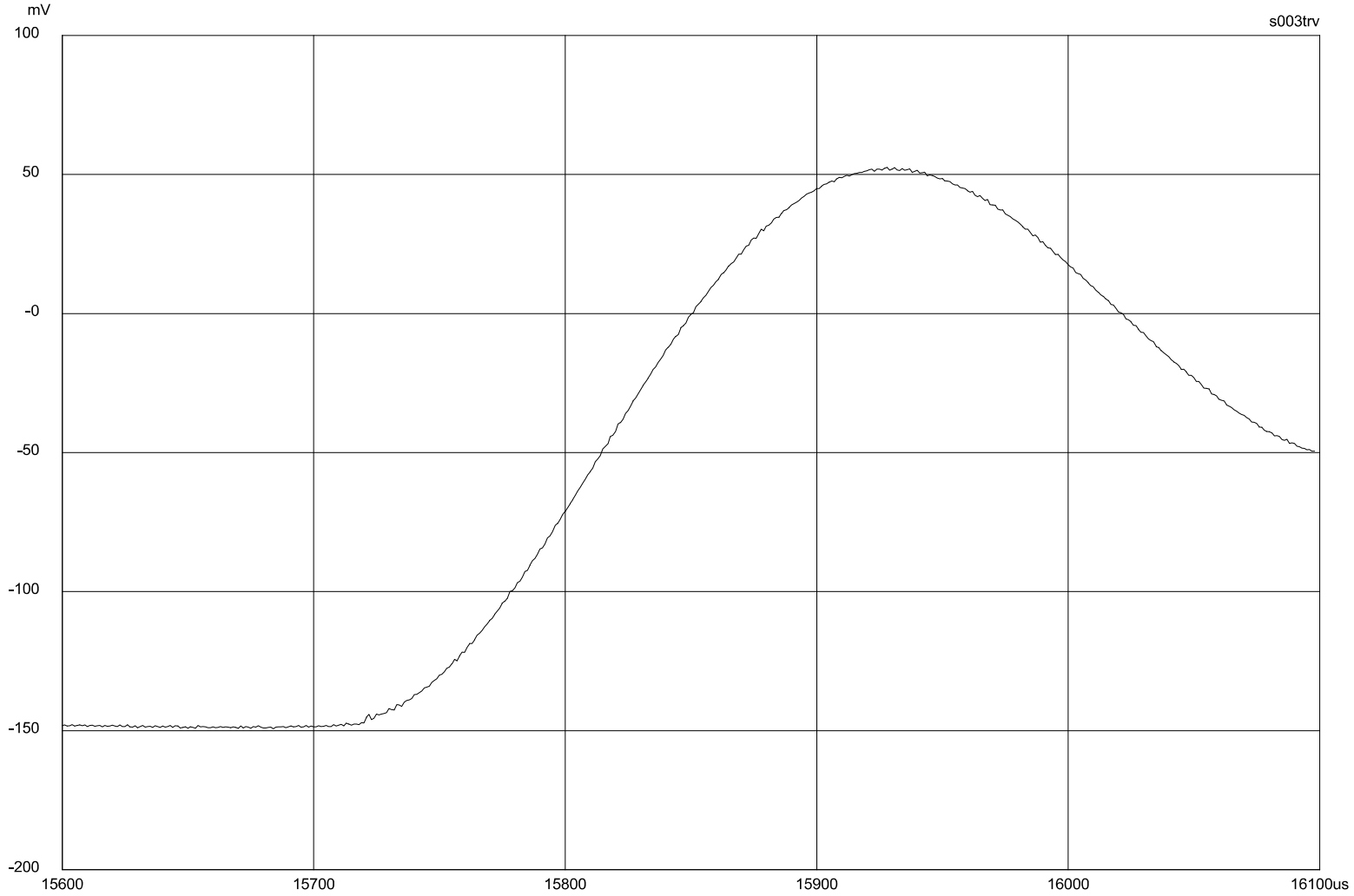


Figure 4. TRV waveform for test duty #1.

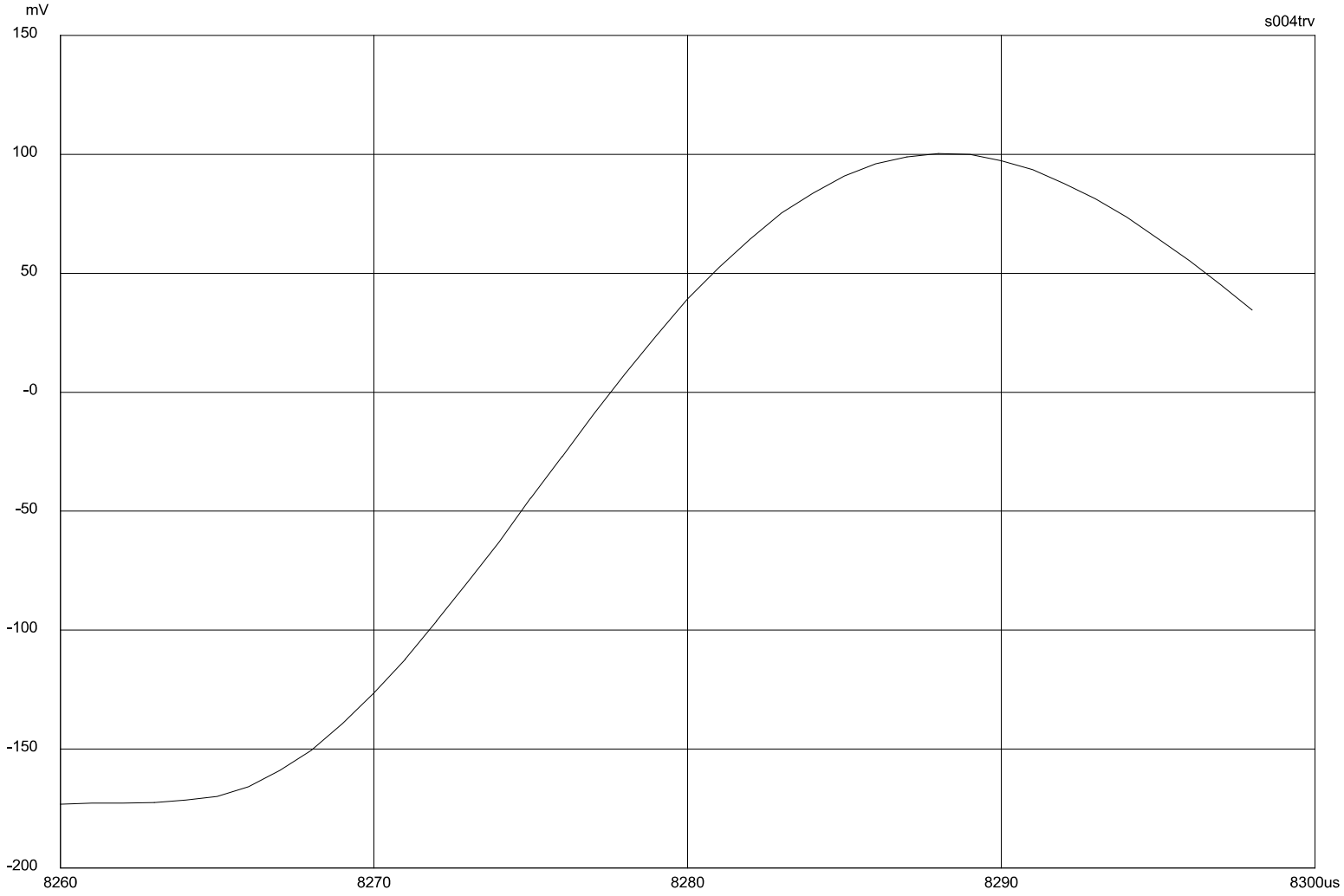


Figure 5. TRV waveform for test duty #4.

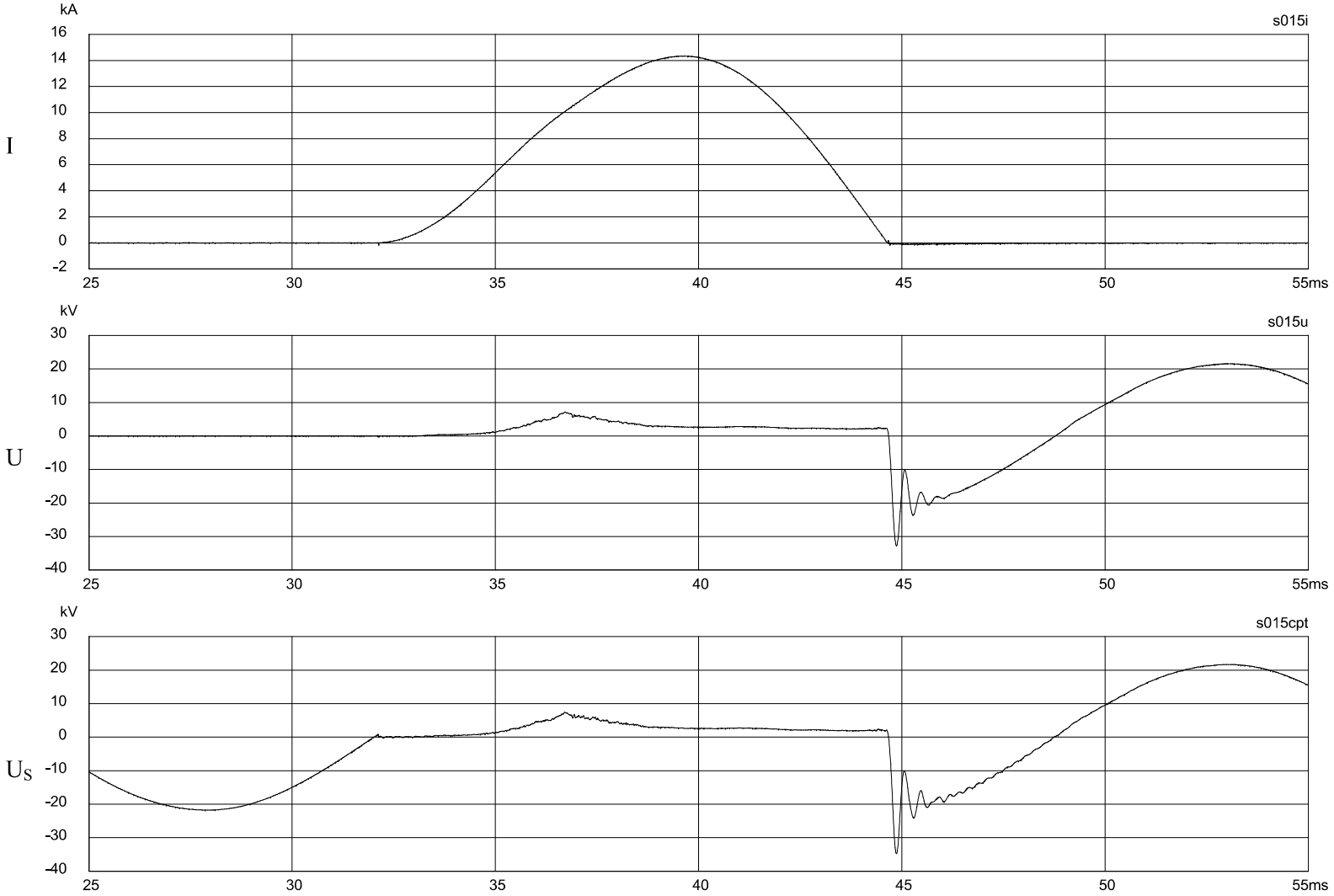


Figure 6. Test #1 waveforms.

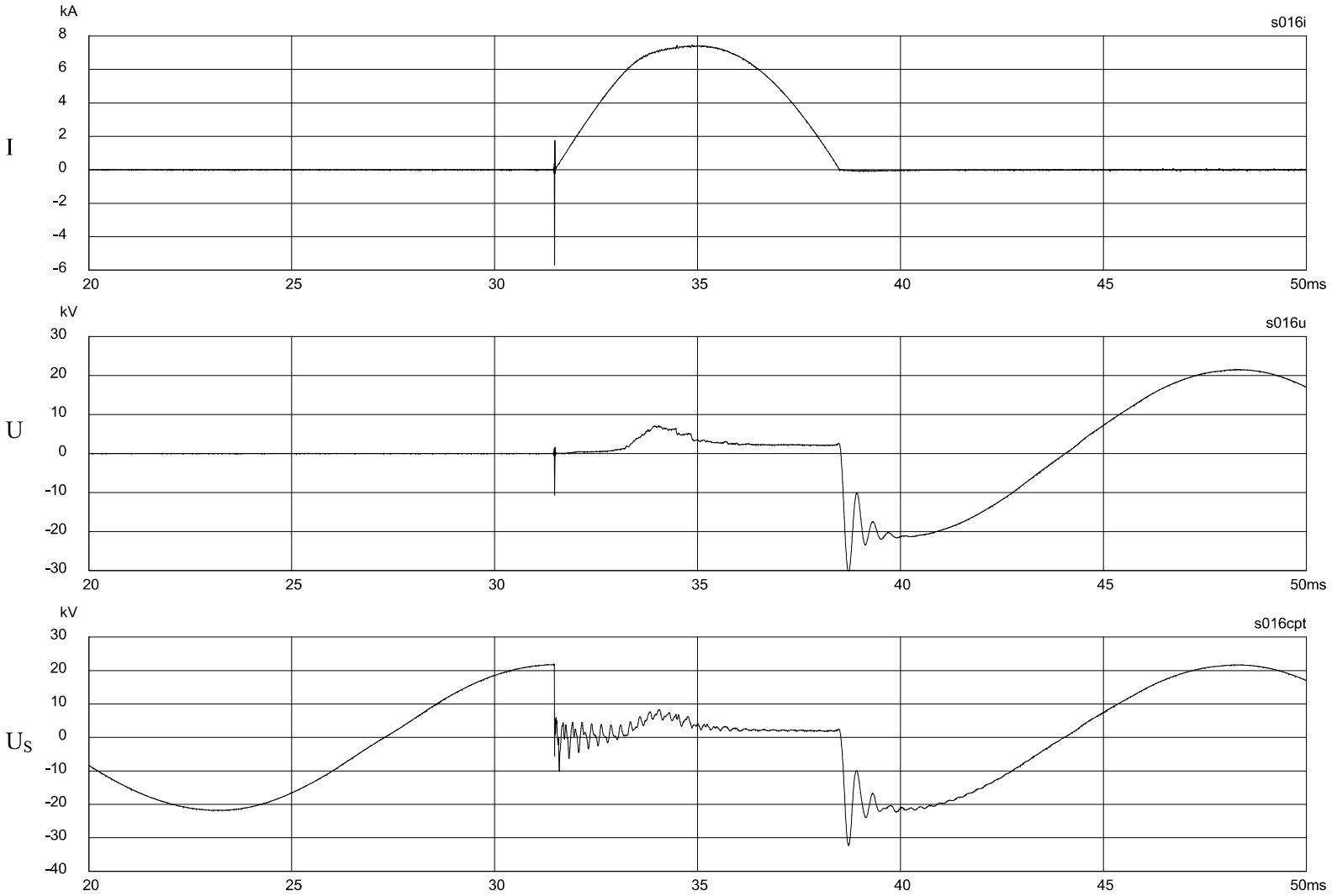


Figure 7. Test #2 waveforms.

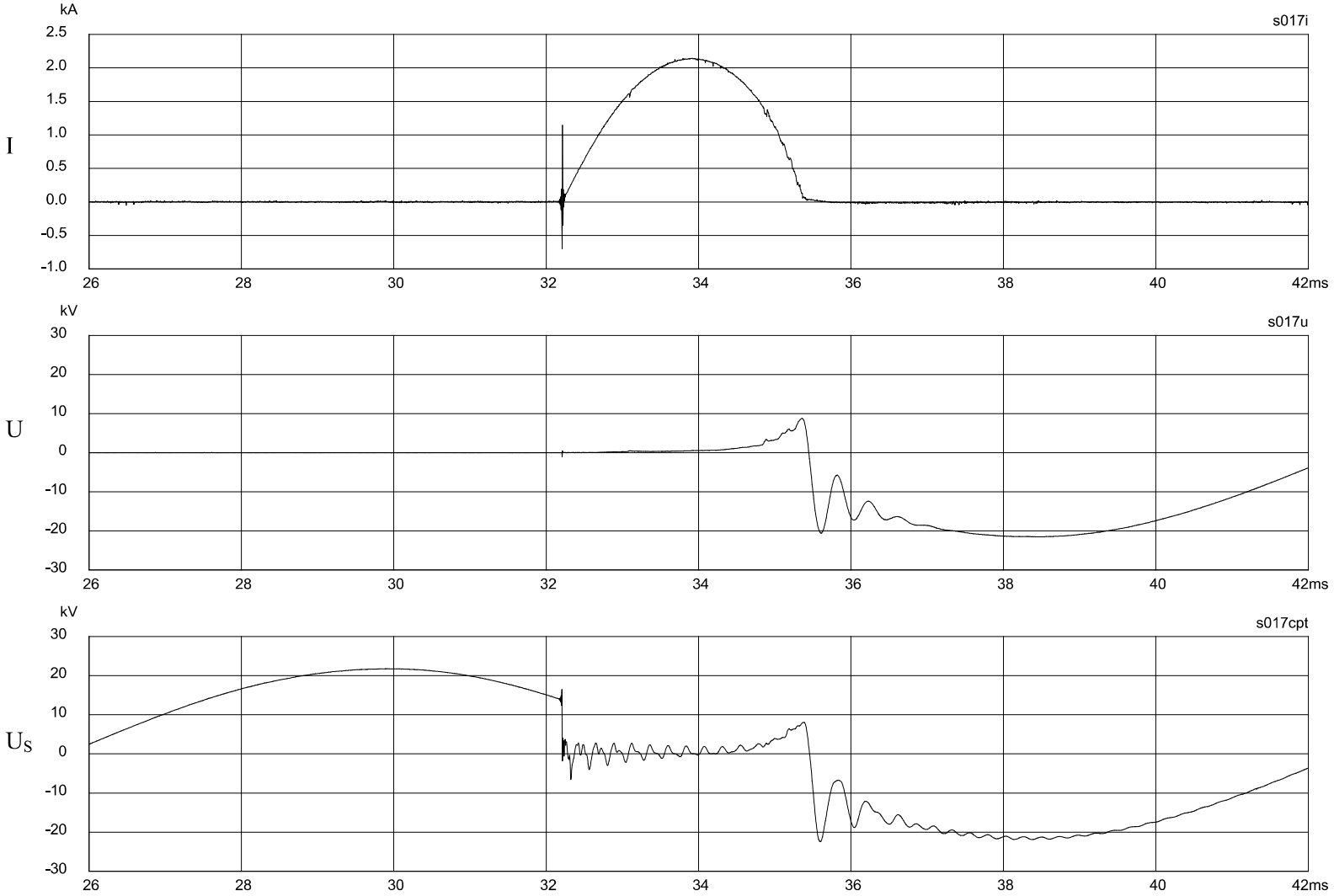


Figure 8. Test #3 waveforms.

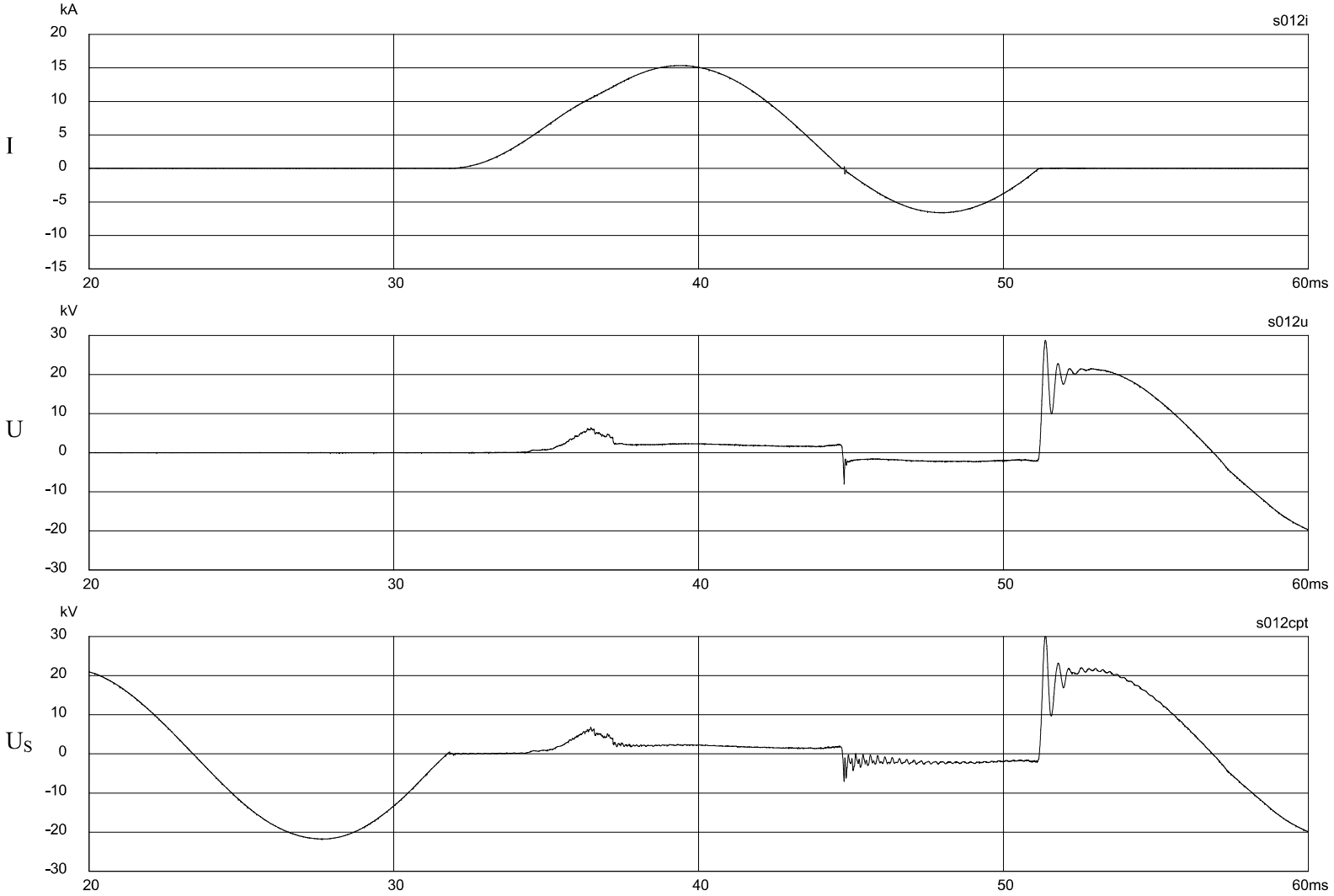


Figure 9. Test #4 waveforms.

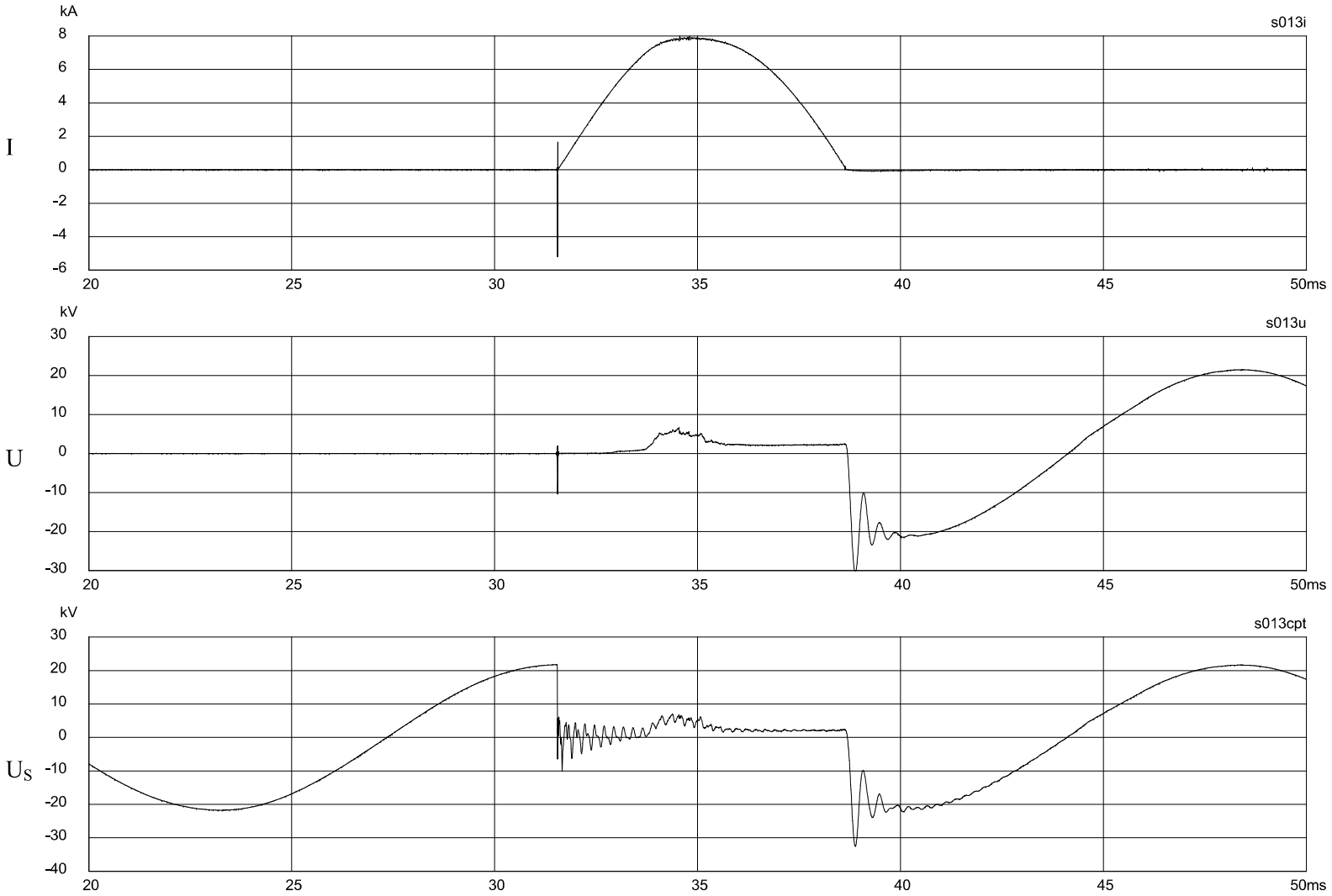


Figure 10. Test #5 waveforms.

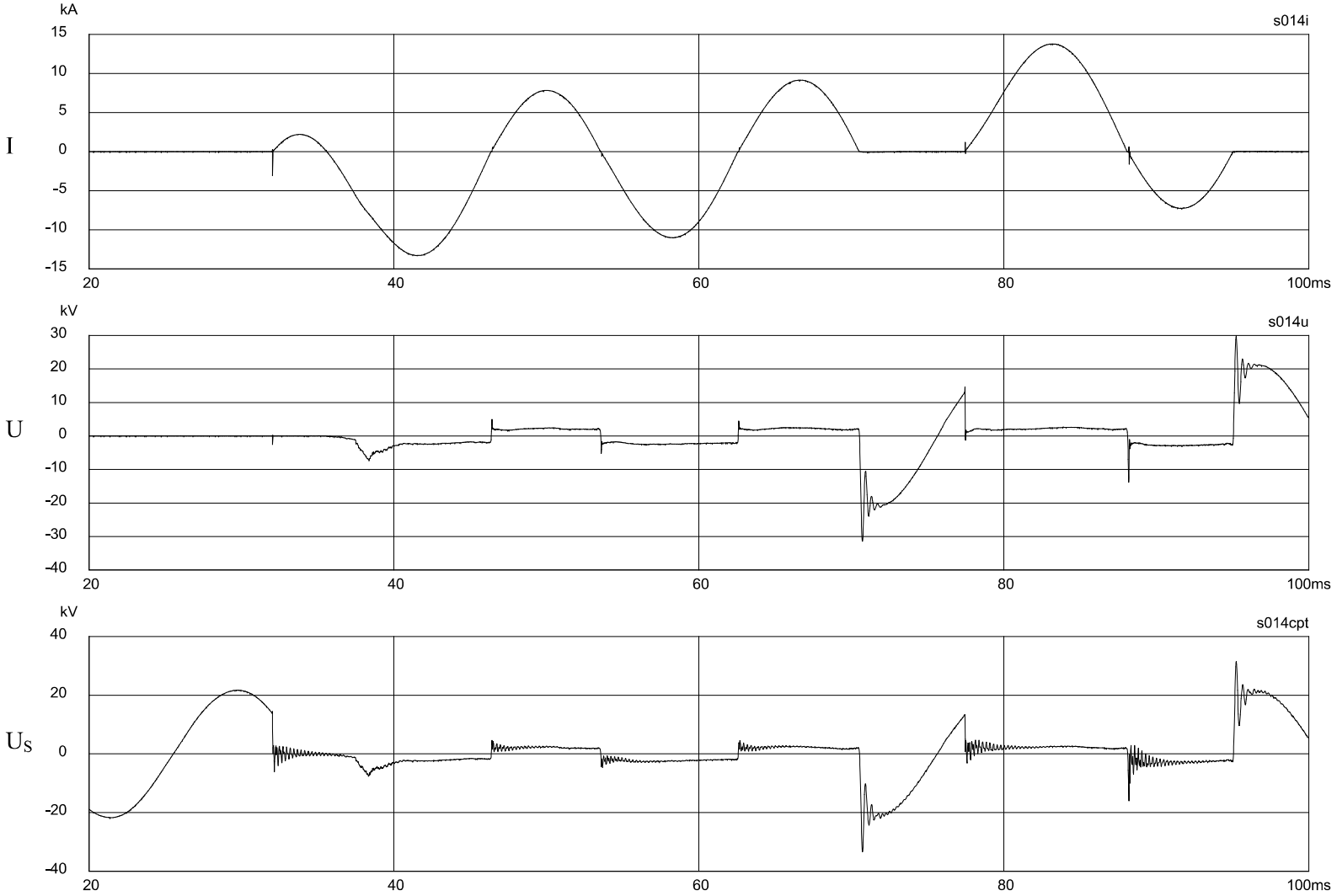


Figure 11. Test #6 waveforms.

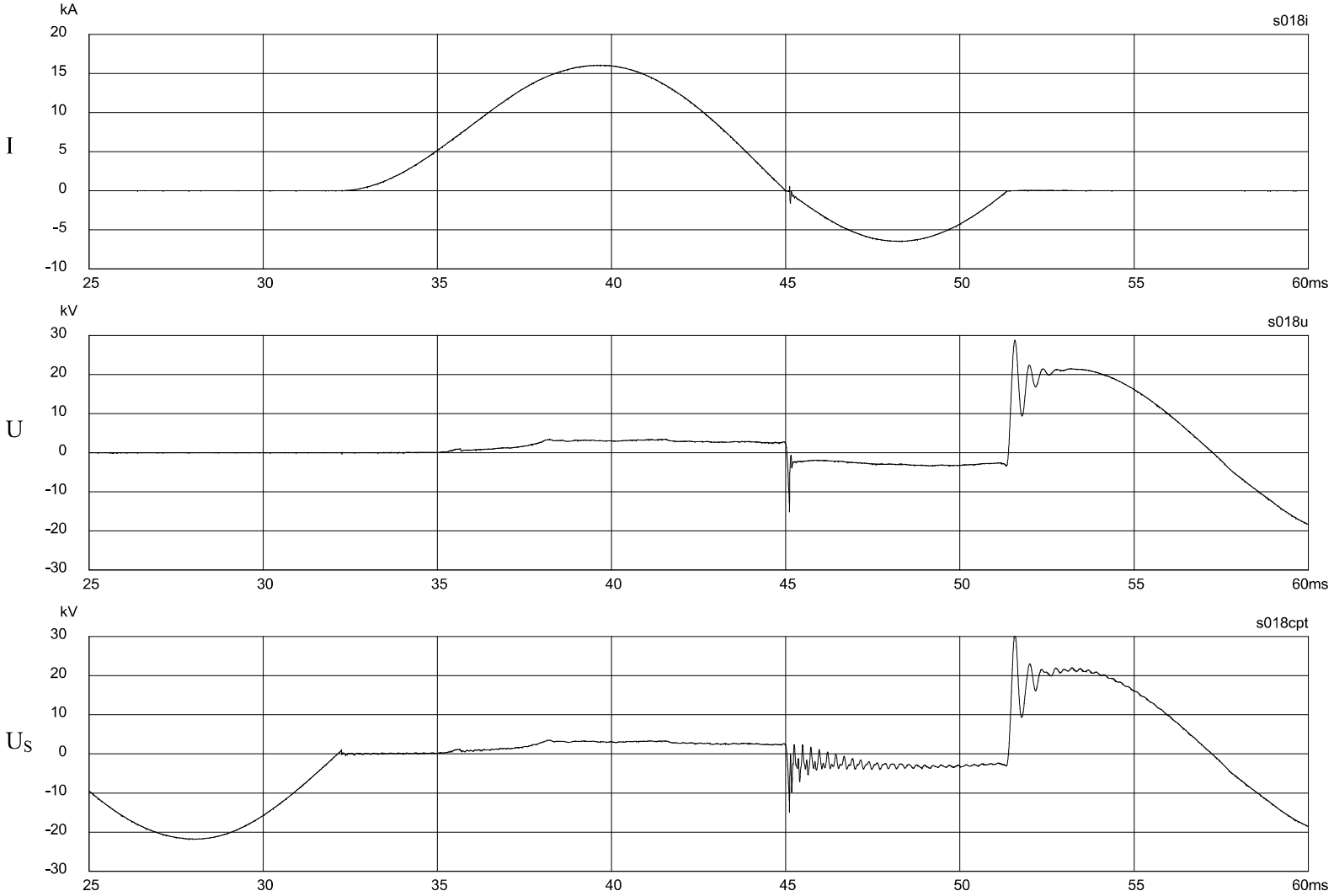


Figure 12. Test #7 waveforms.

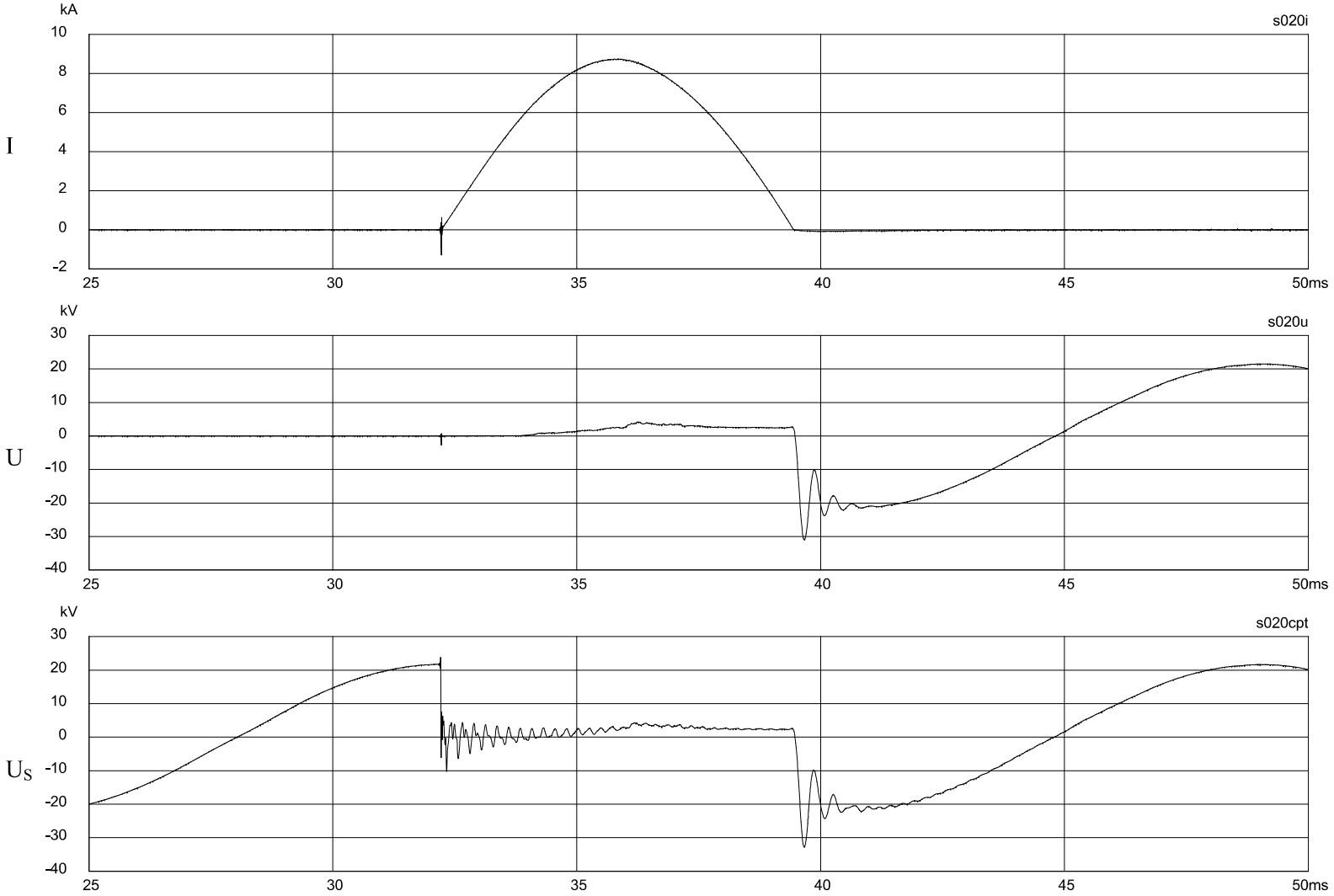


Figure 13. Test #8 waveforms.

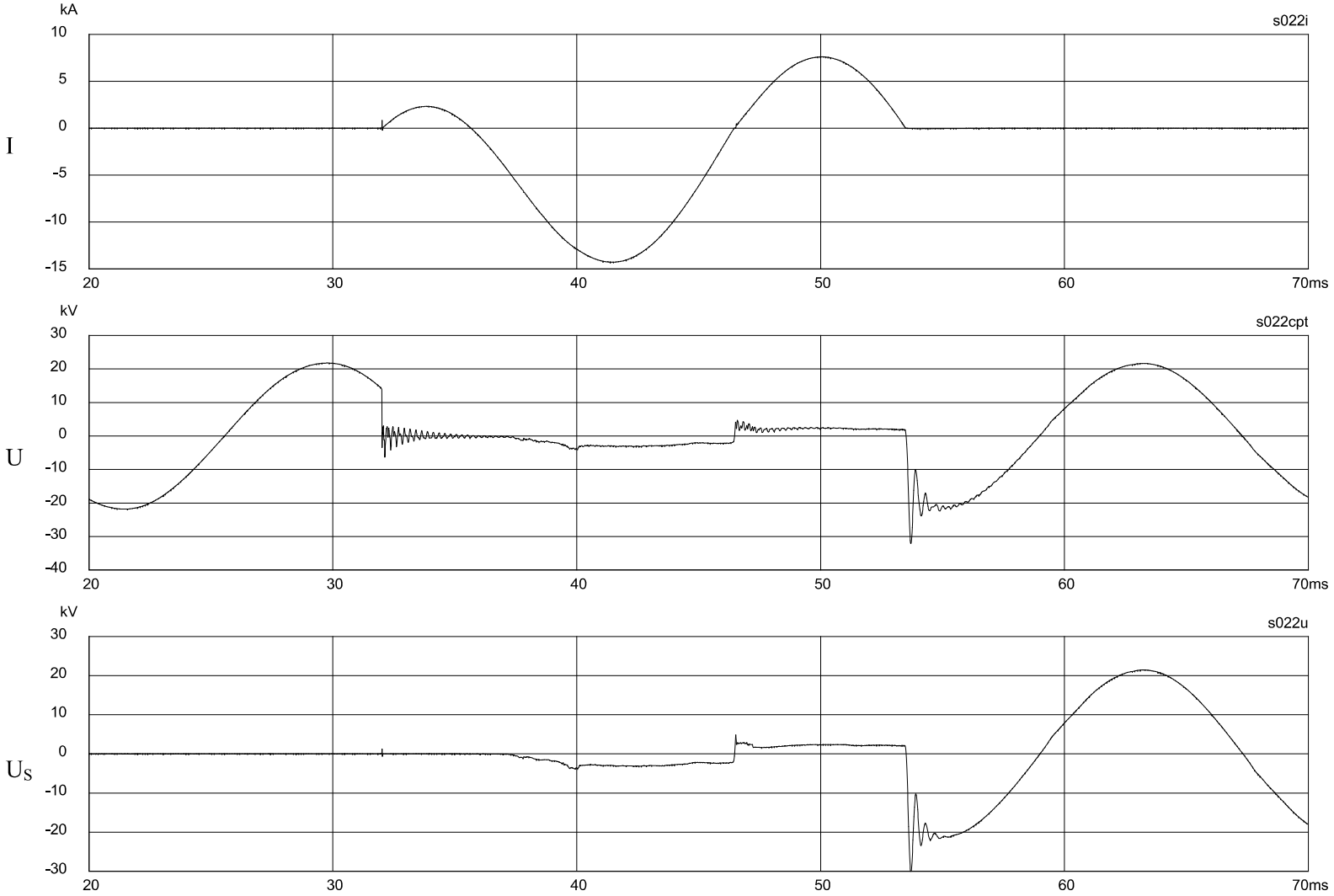


Figure 14. Test #9 waveforms.

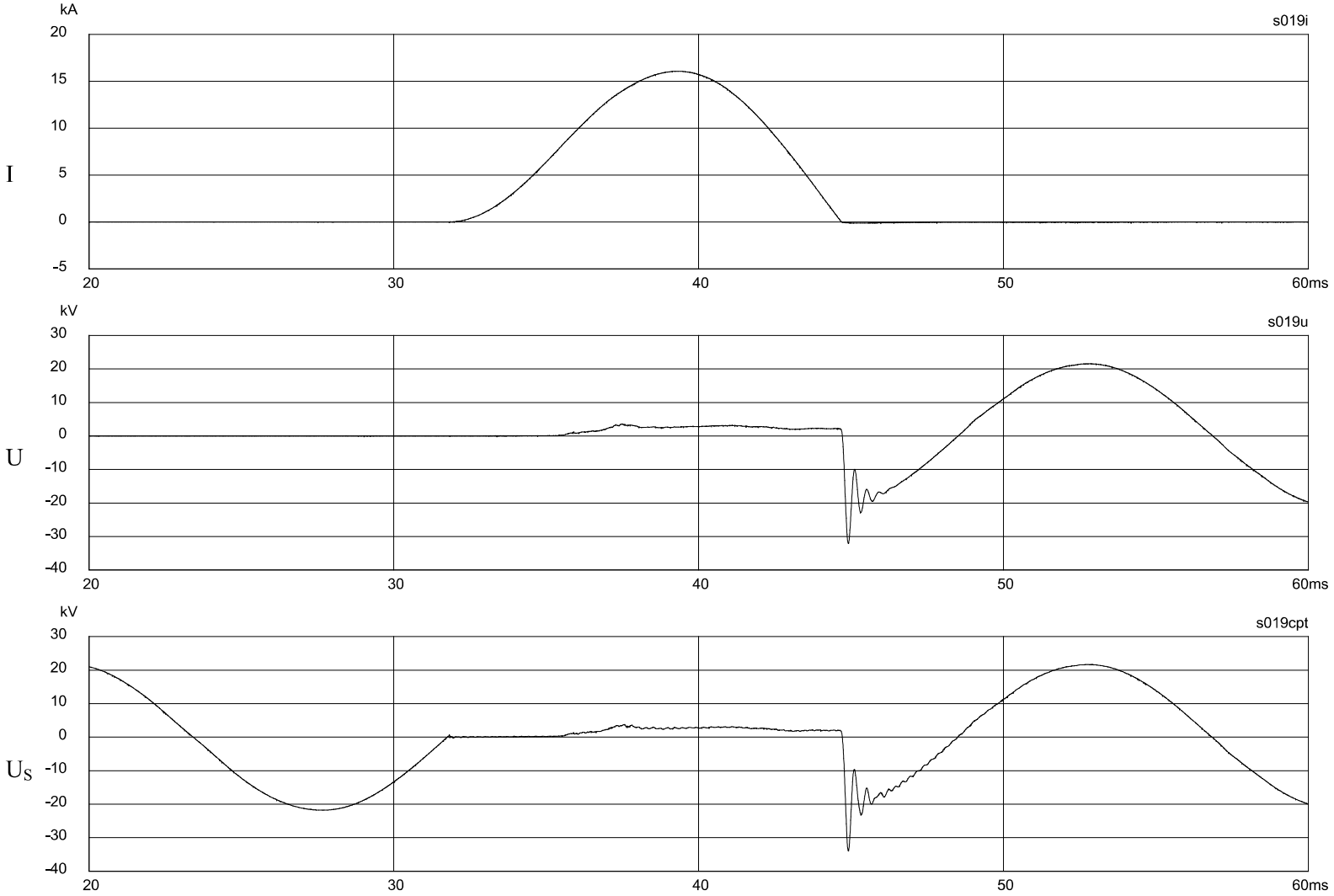


Figure 15. Test #10 waveforms.

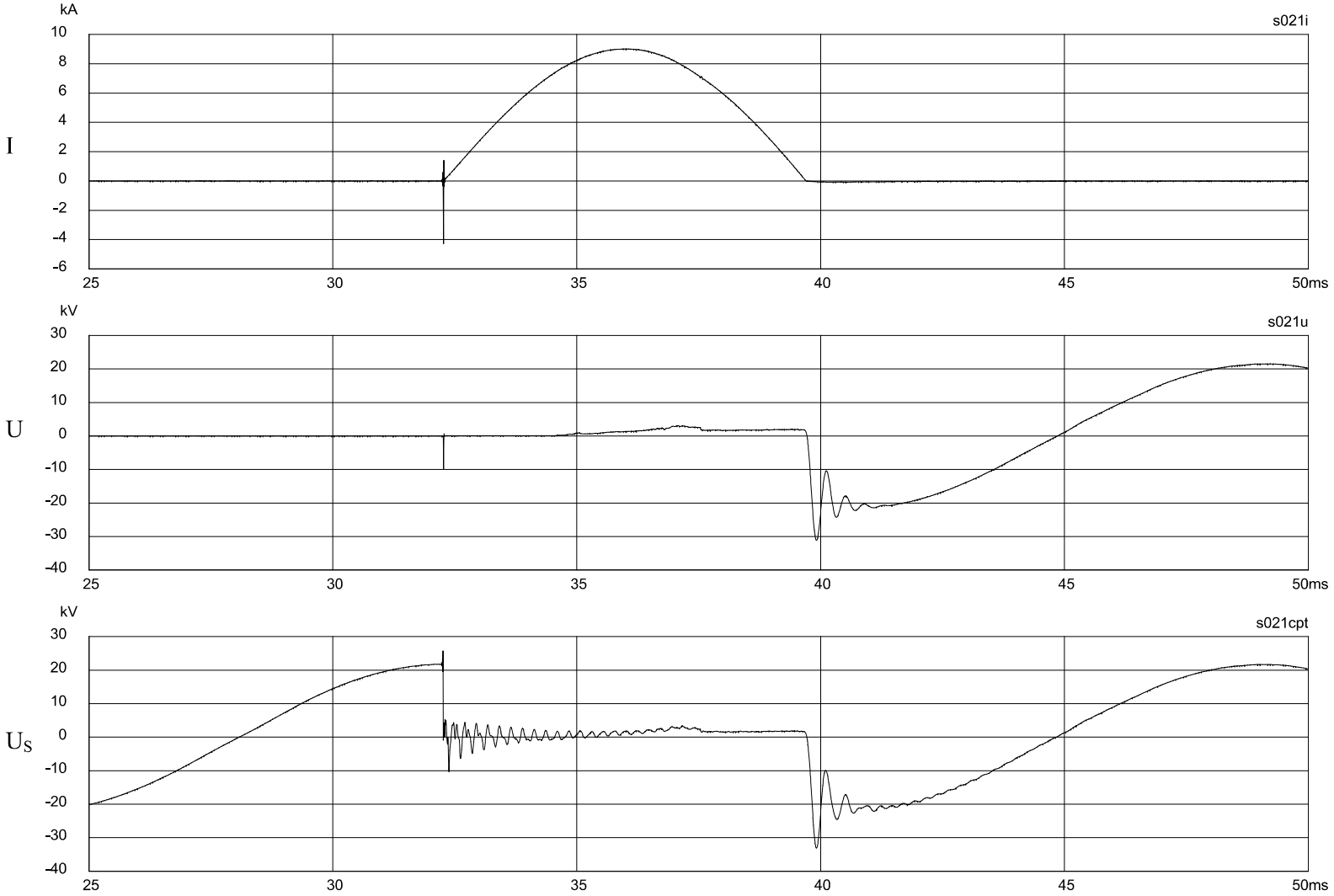


Figure 16. Test #11 waveforms.

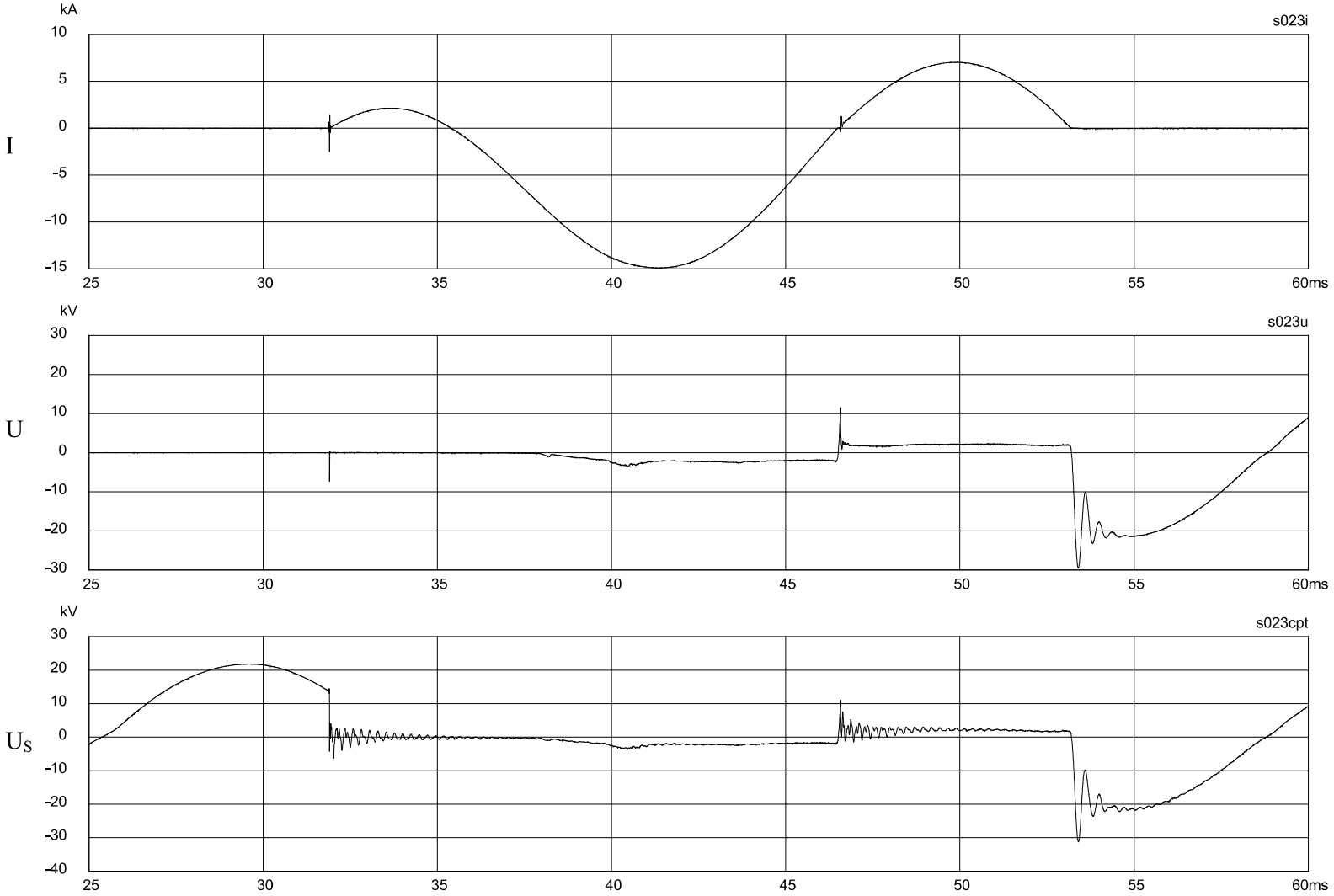


Figure 17. Test #12 waveforms.

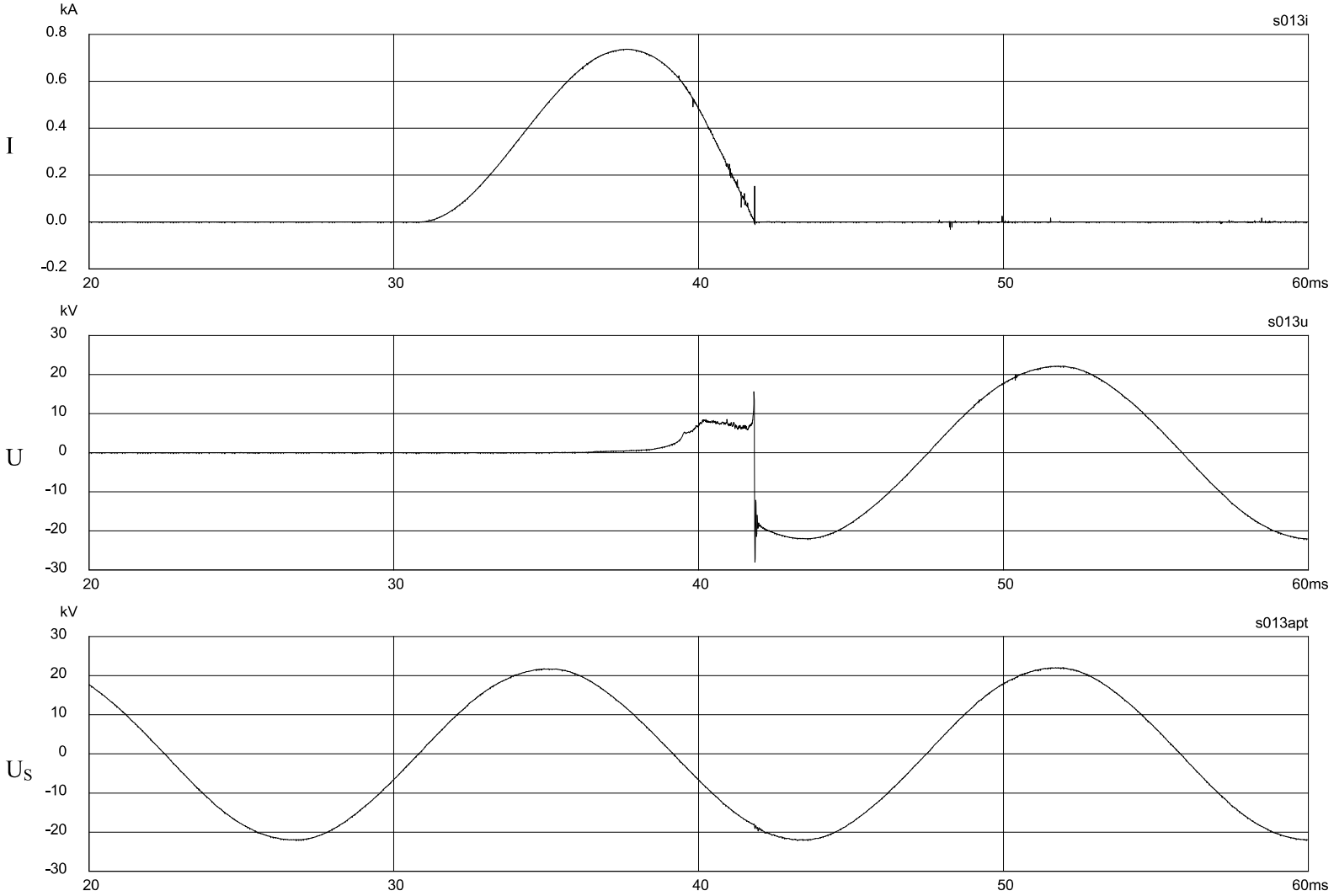


Figure 18. Test #13 waveforms.

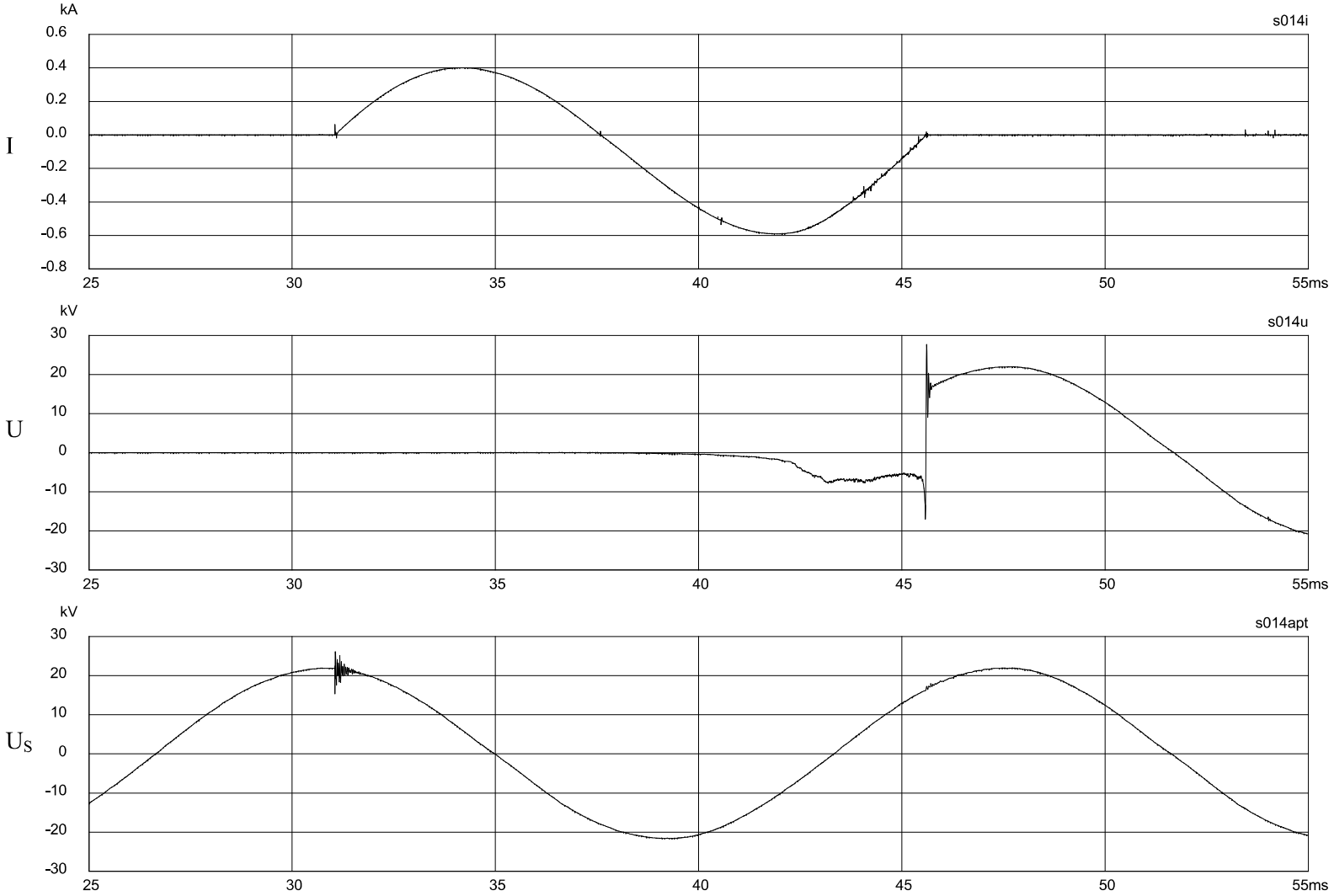


Figure 19. Test #14 waveforms.

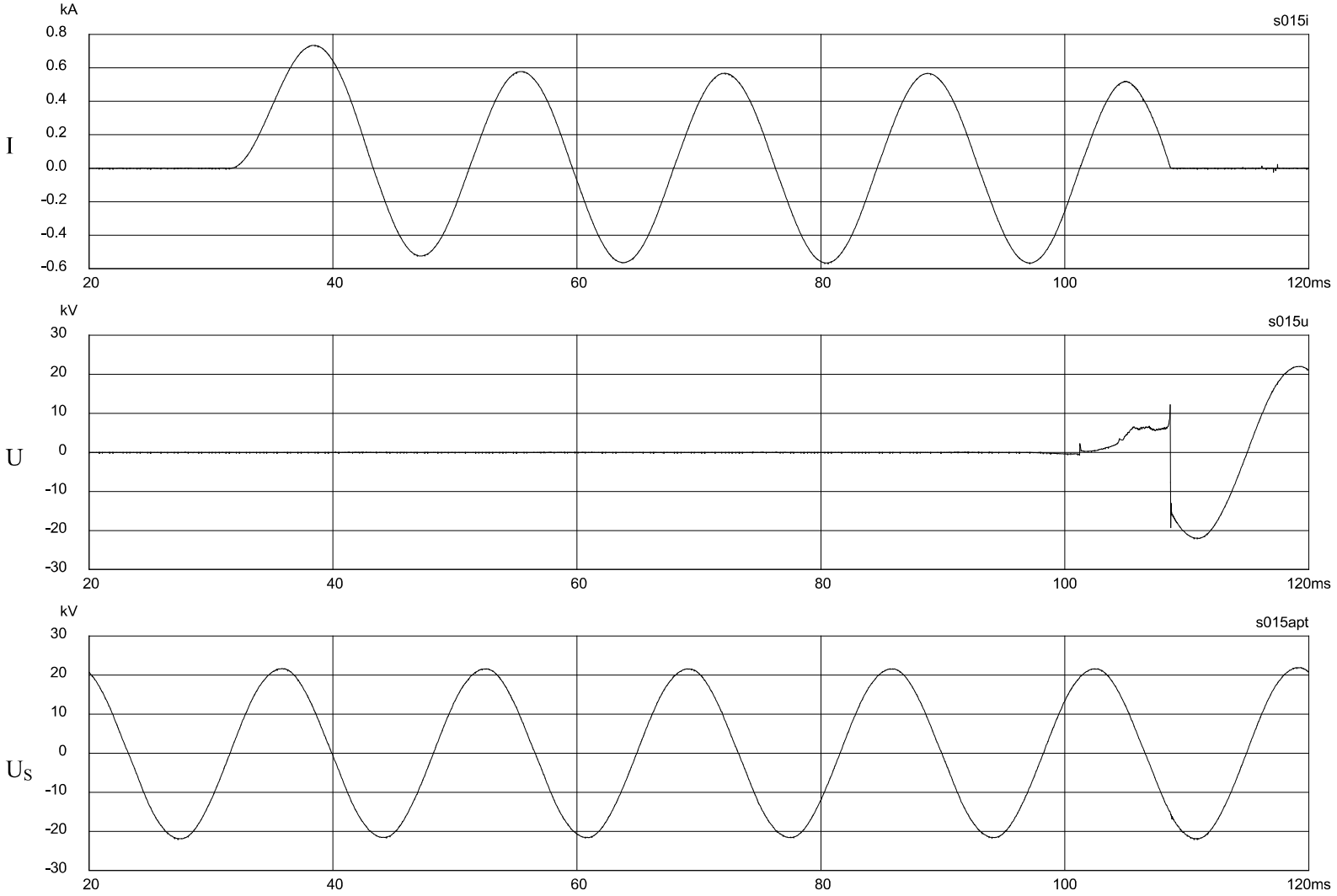


Figure 20. Test #15 waveforms.

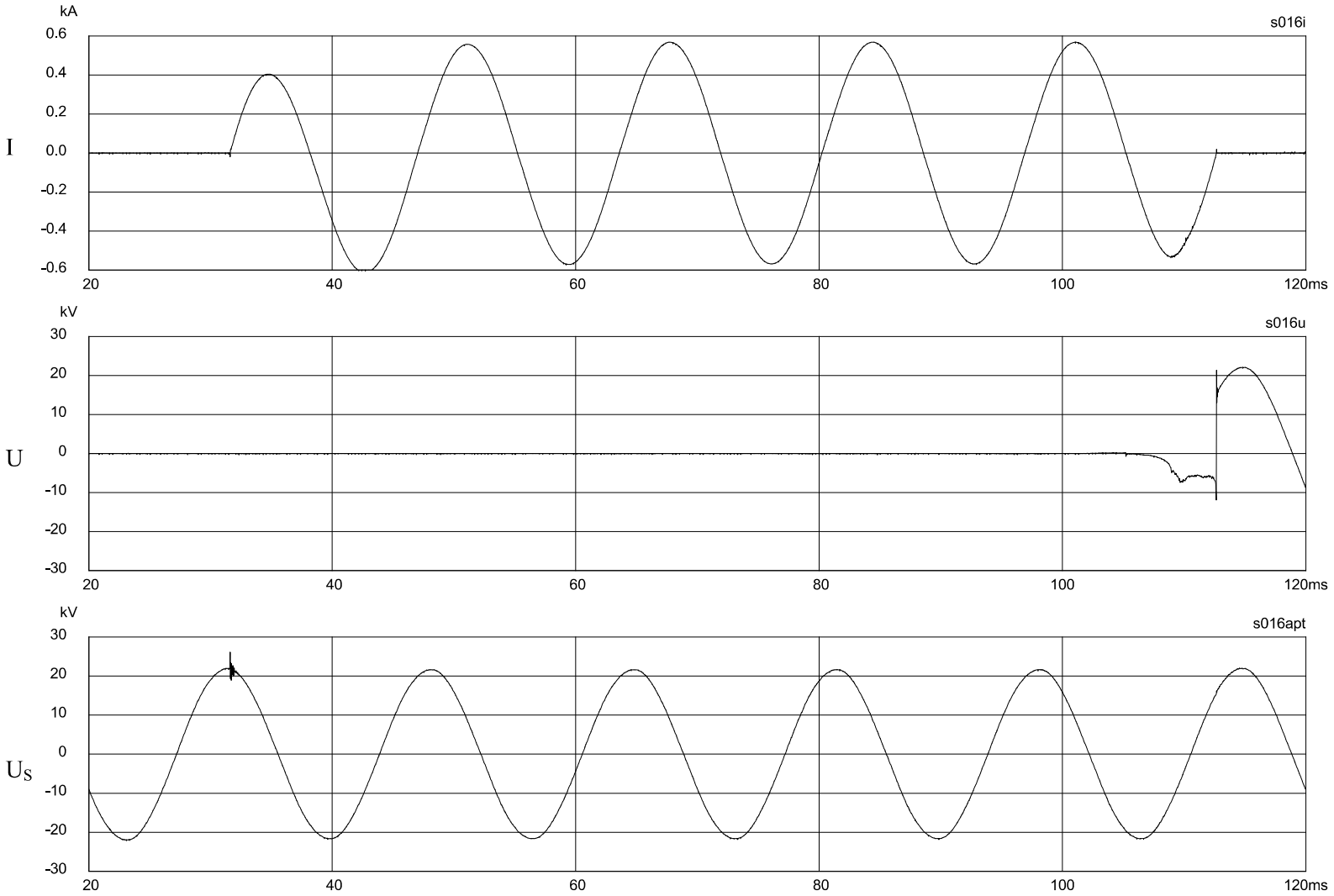


Figure 21. Test #16 waveforms.

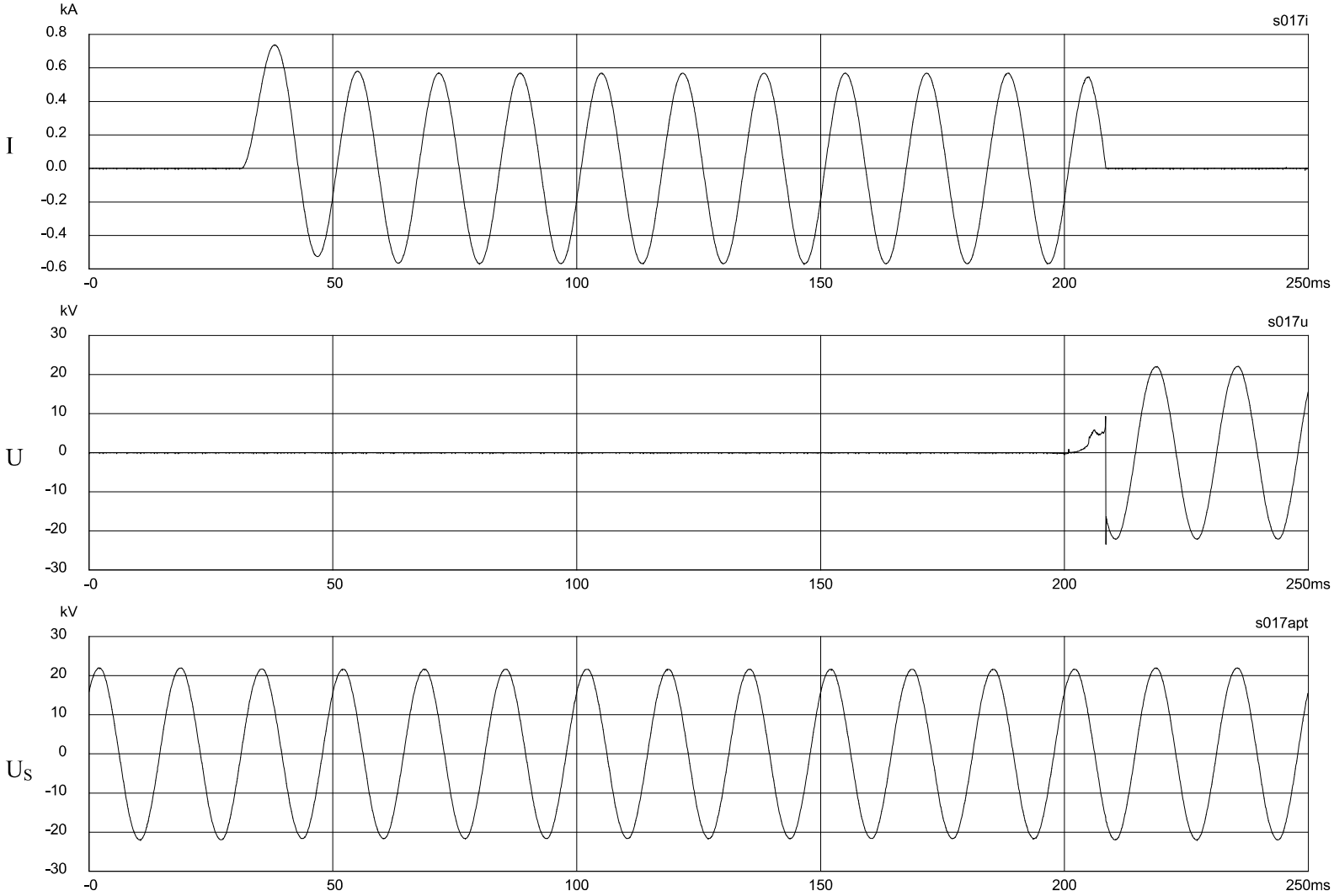


Figure 22. Test #17 waveforms.

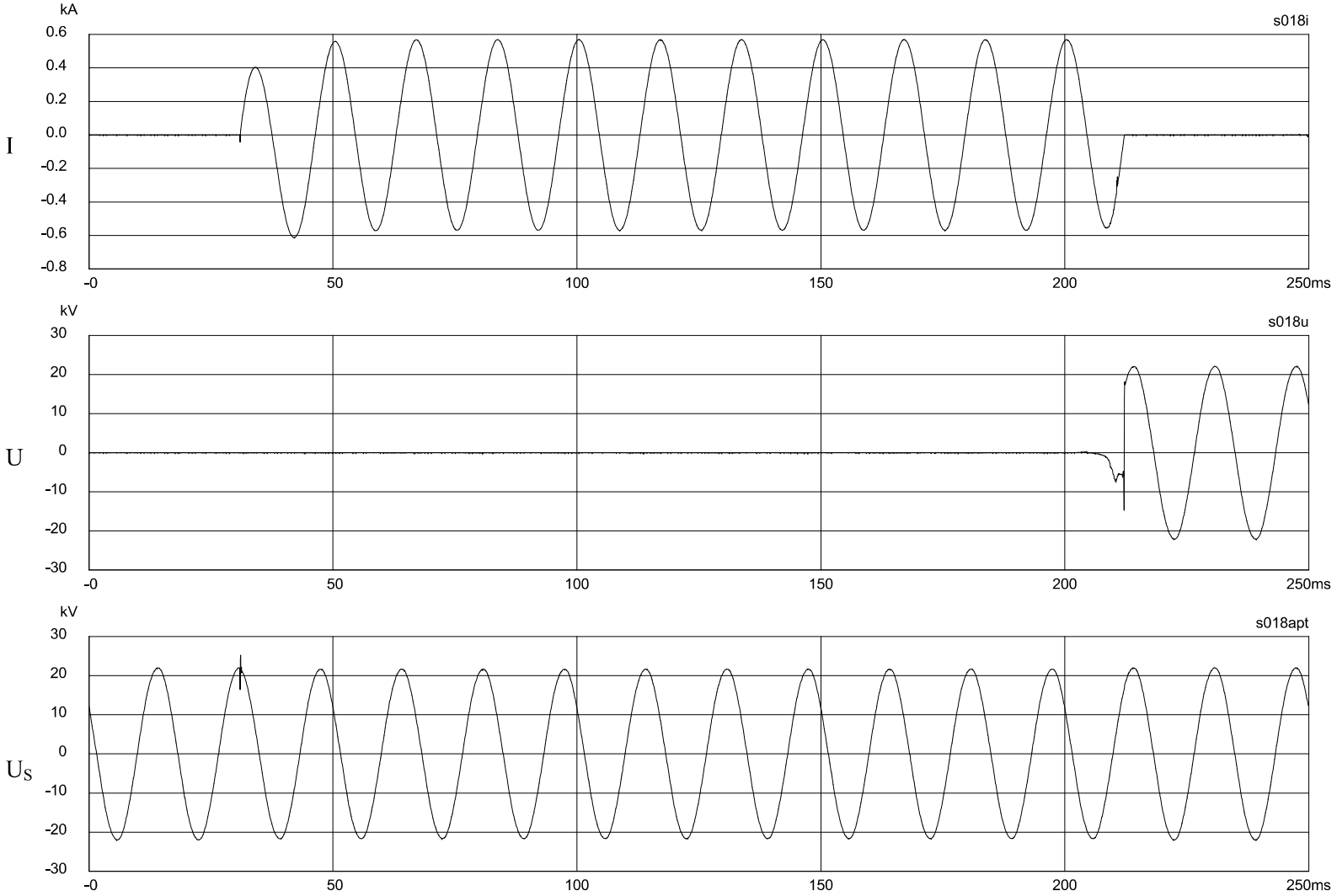


Figure 23. Test #18 waveforms.

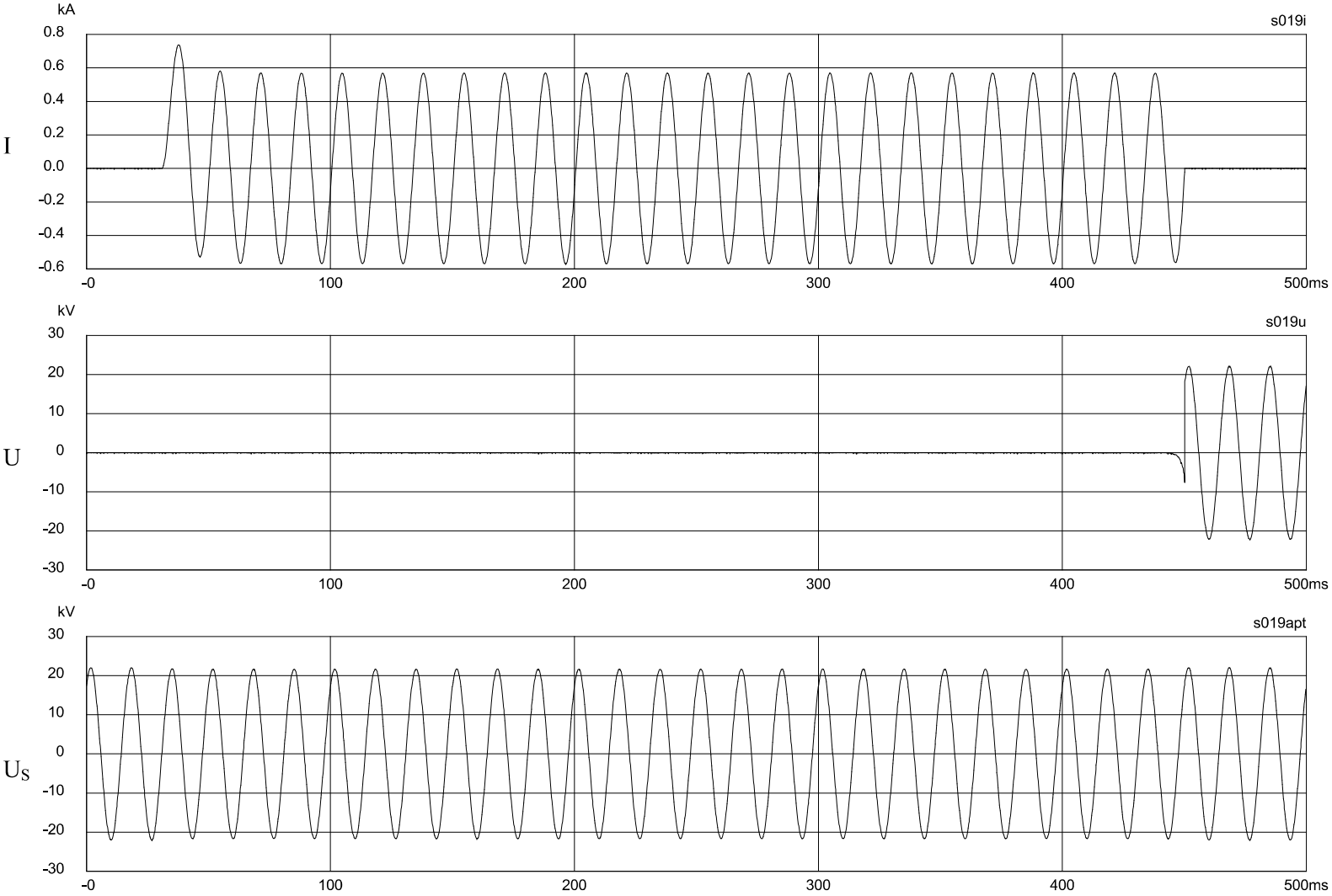


Figure 24. Test #19 waveforms.

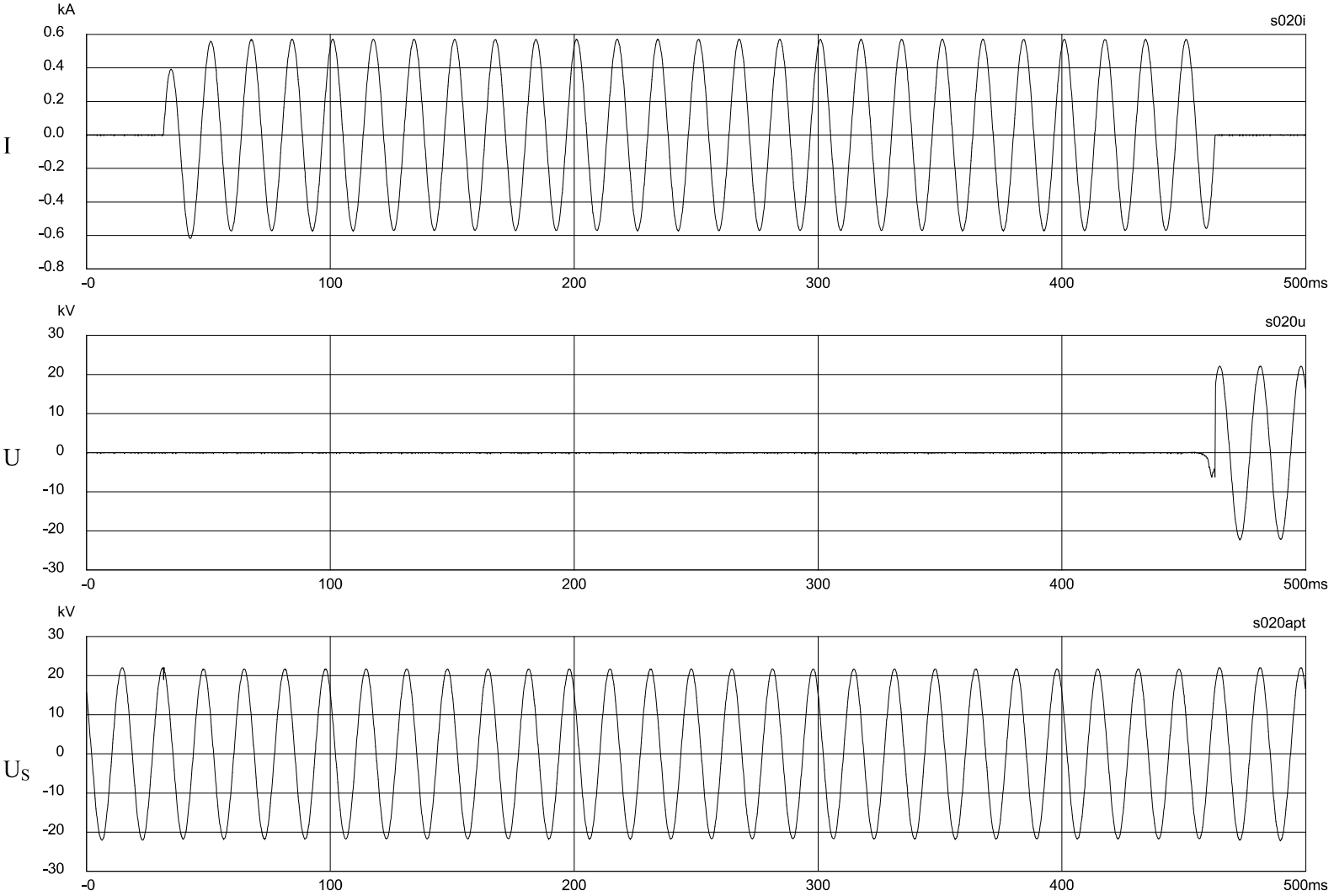


Figure 25. Test #20 waveforms.

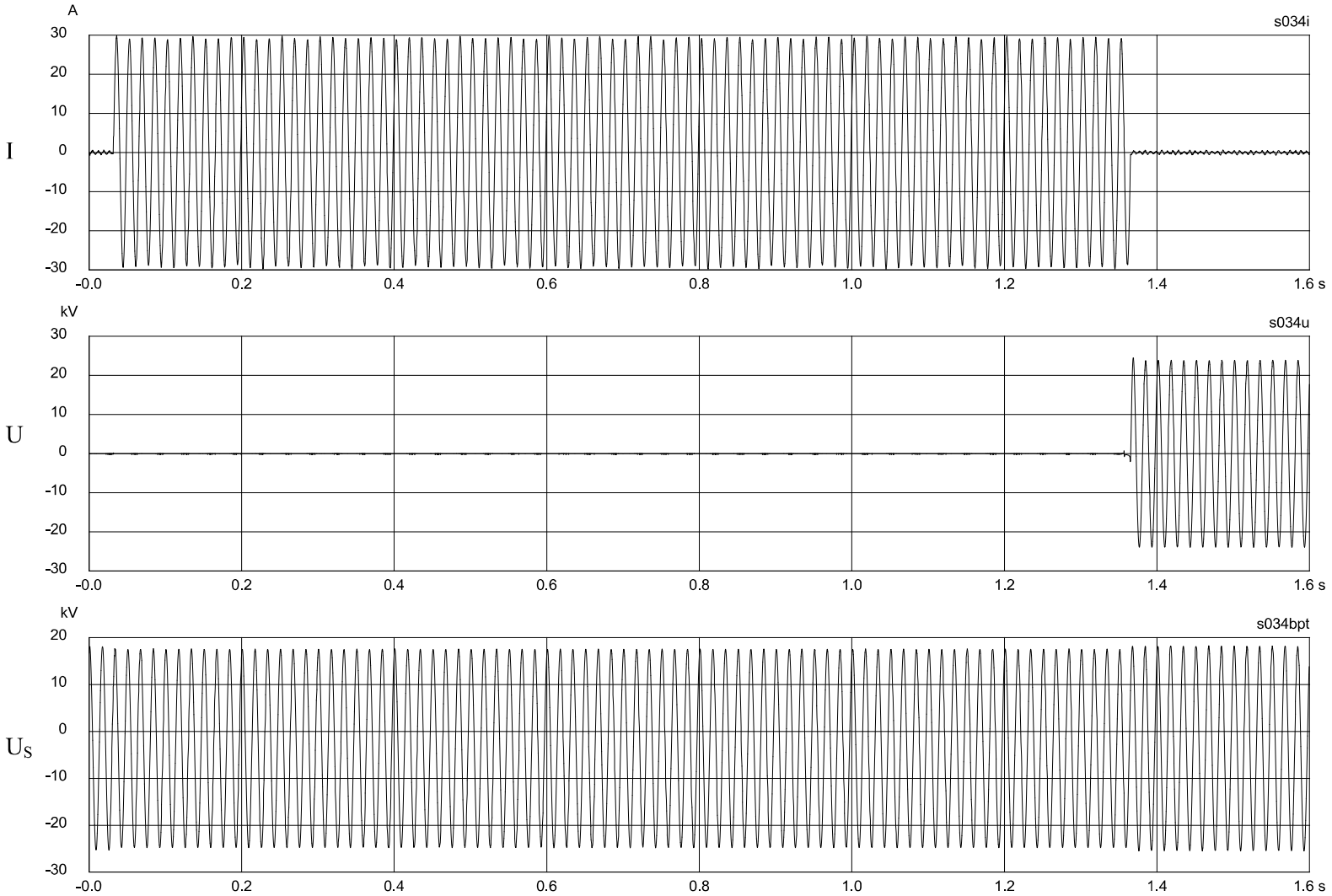


Figure 26. Test #21 waveforms.

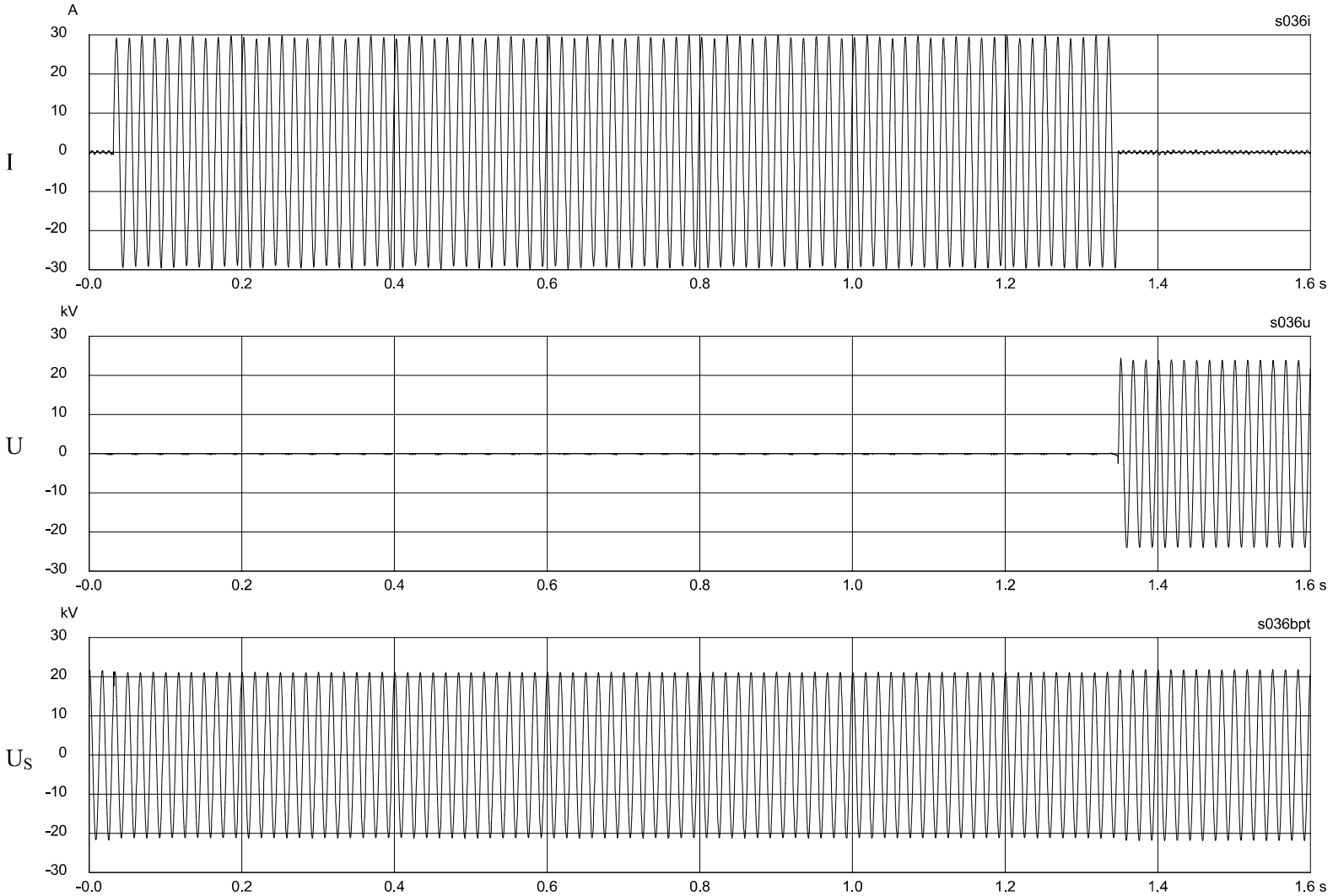


Figure 27. Test #22 waveforms.

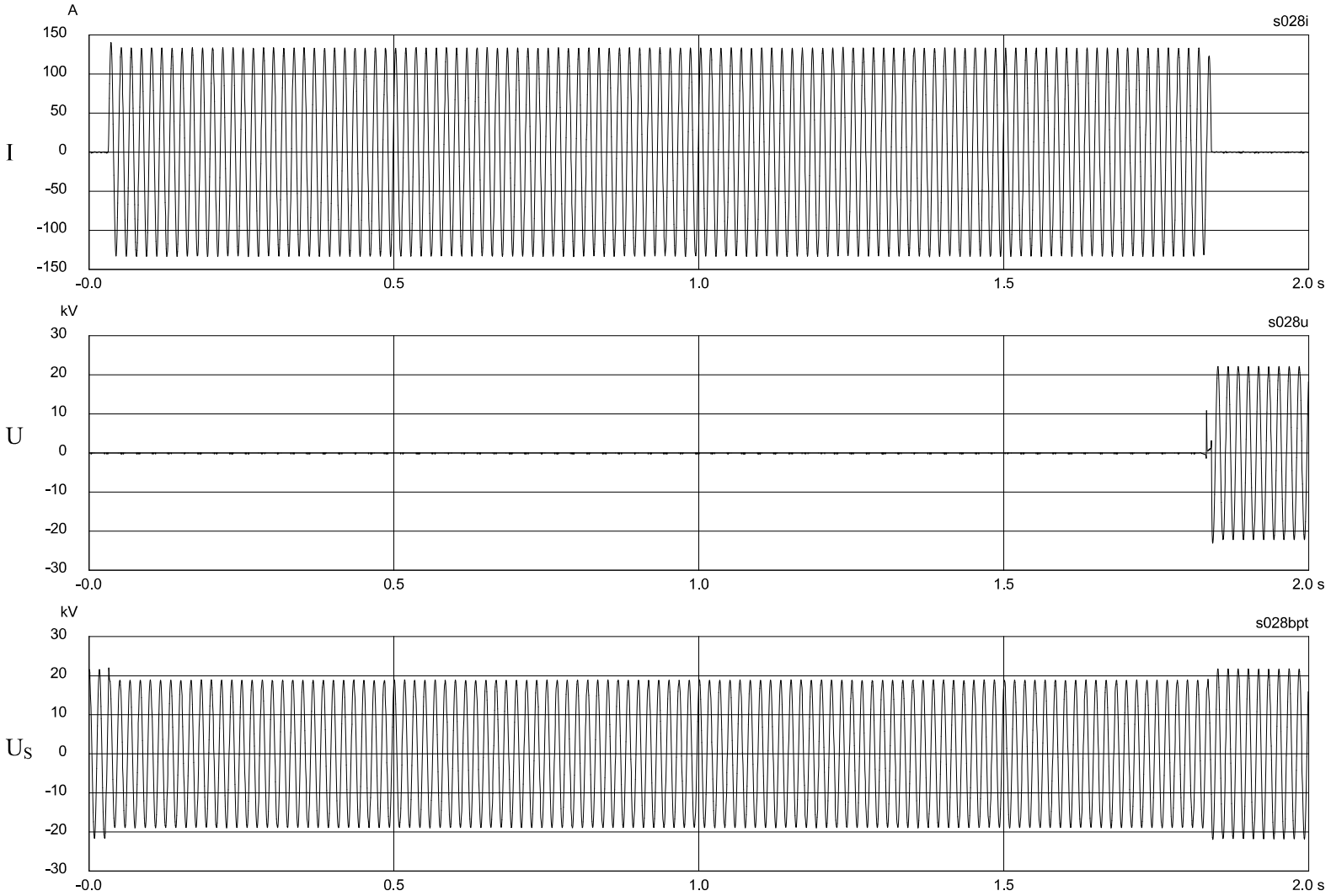


Figure 28. Test #23 waveforms.

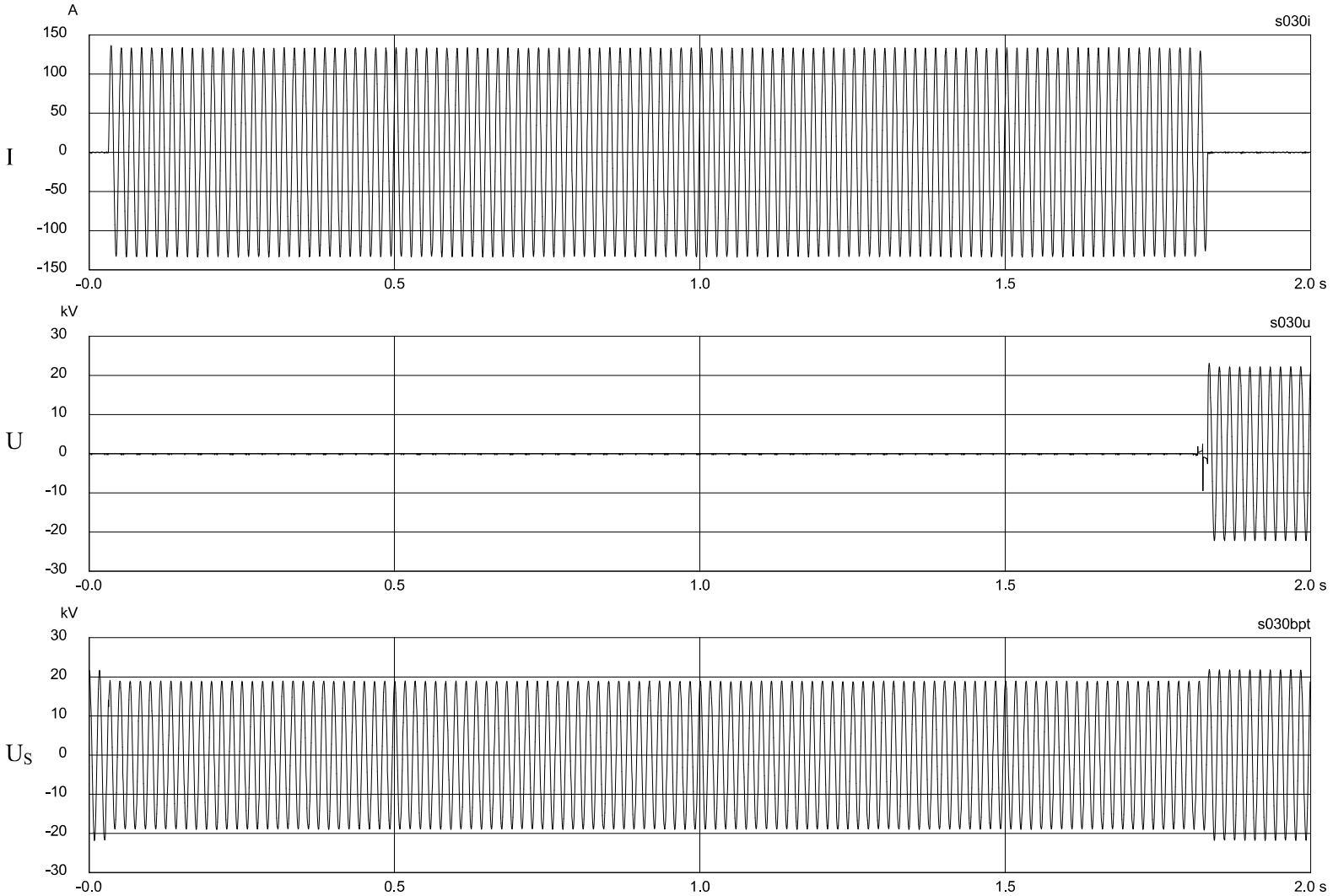


Figure 29. Test #24 waveforms.

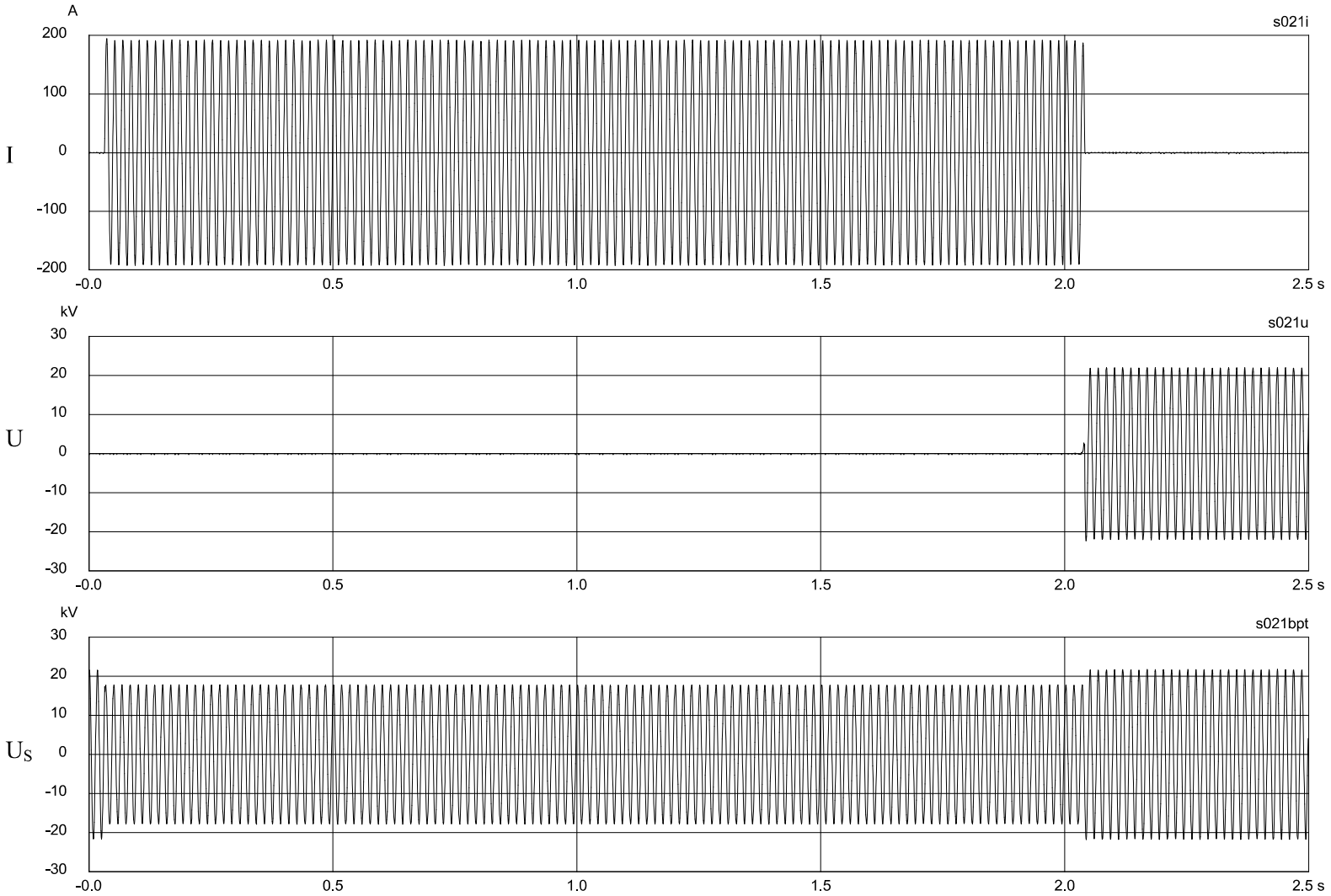


Figure 30. Test #25 waveforms.

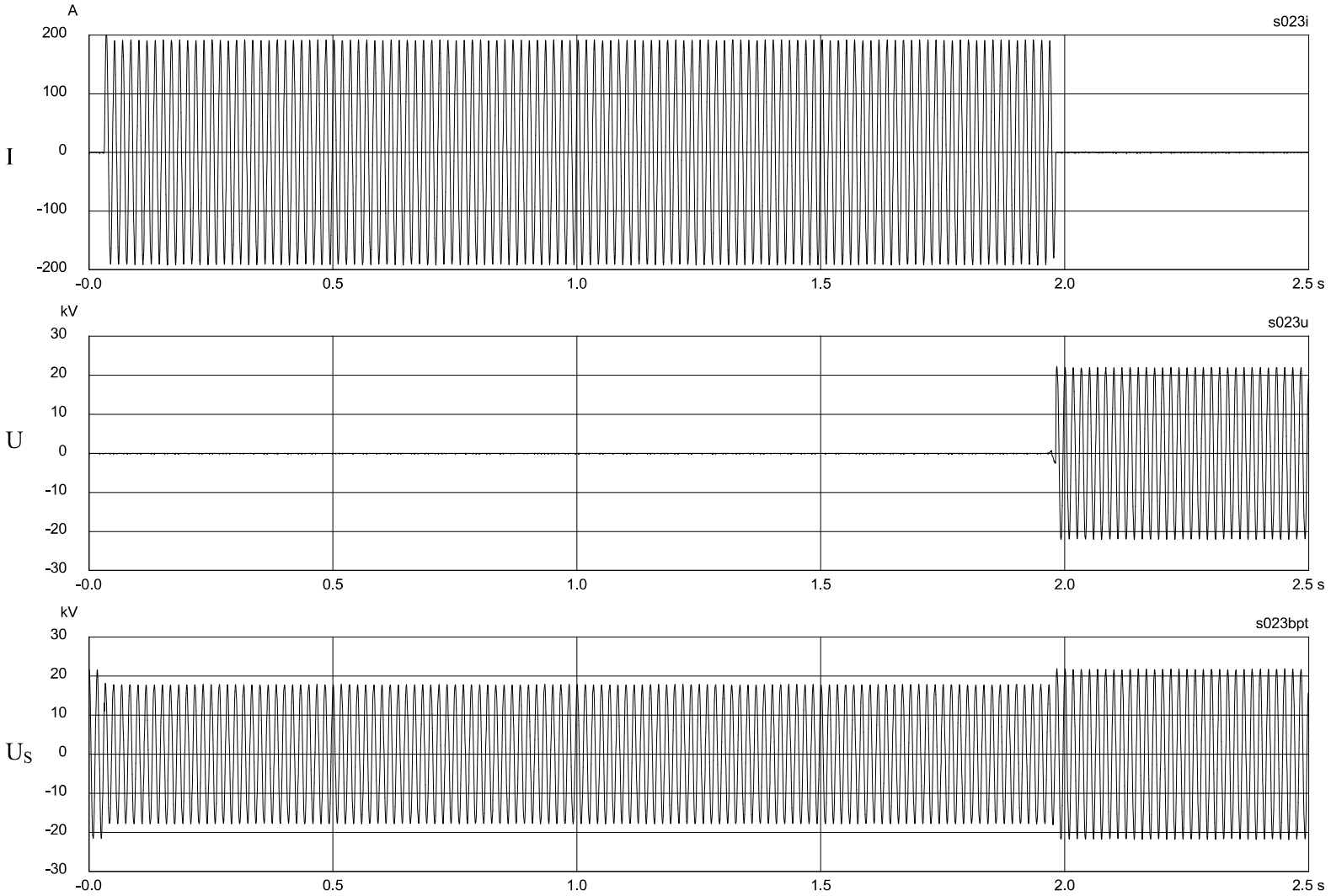


Figure 31. Test #26 waveforms.

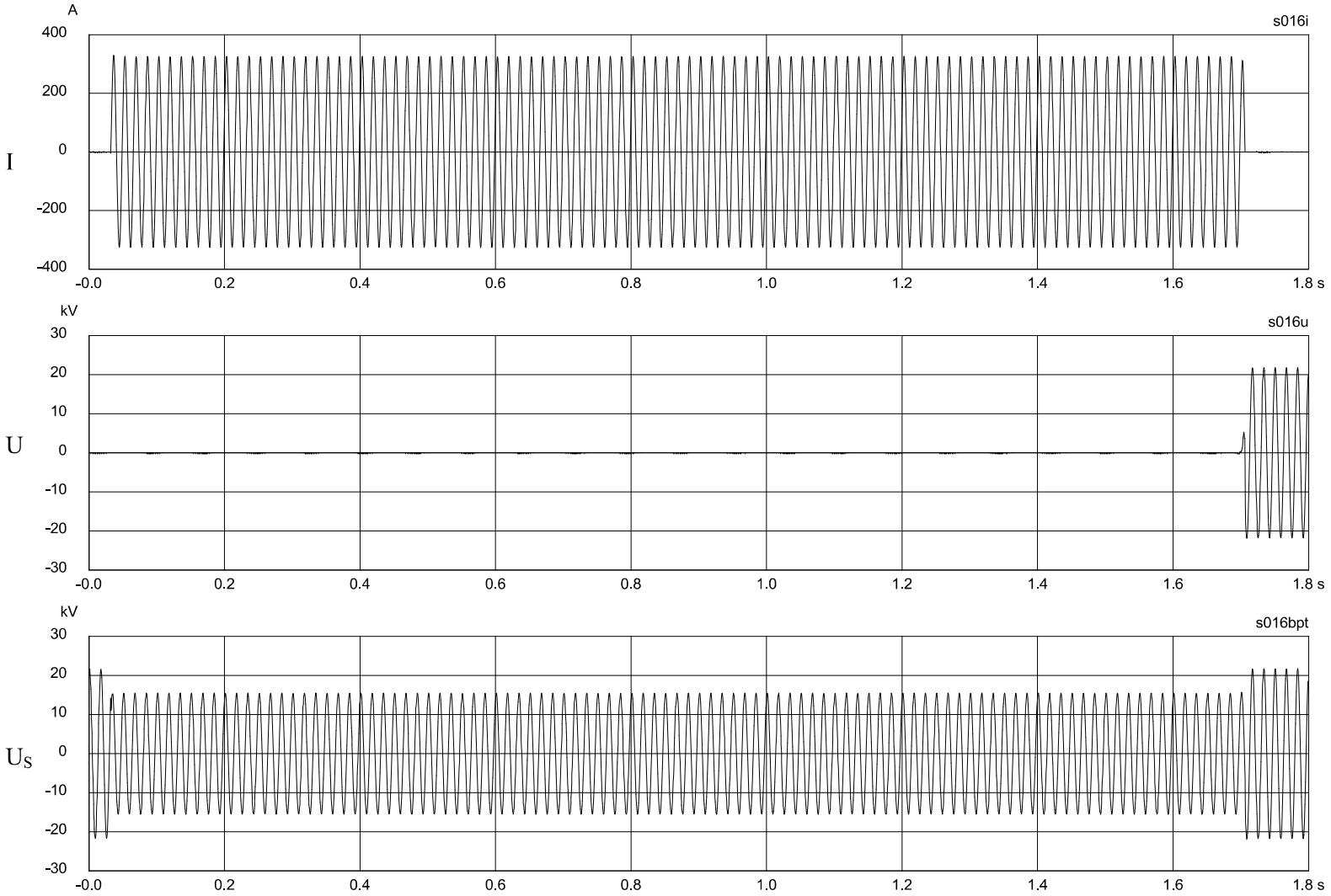


Figure 32. Test #27 waveforms.

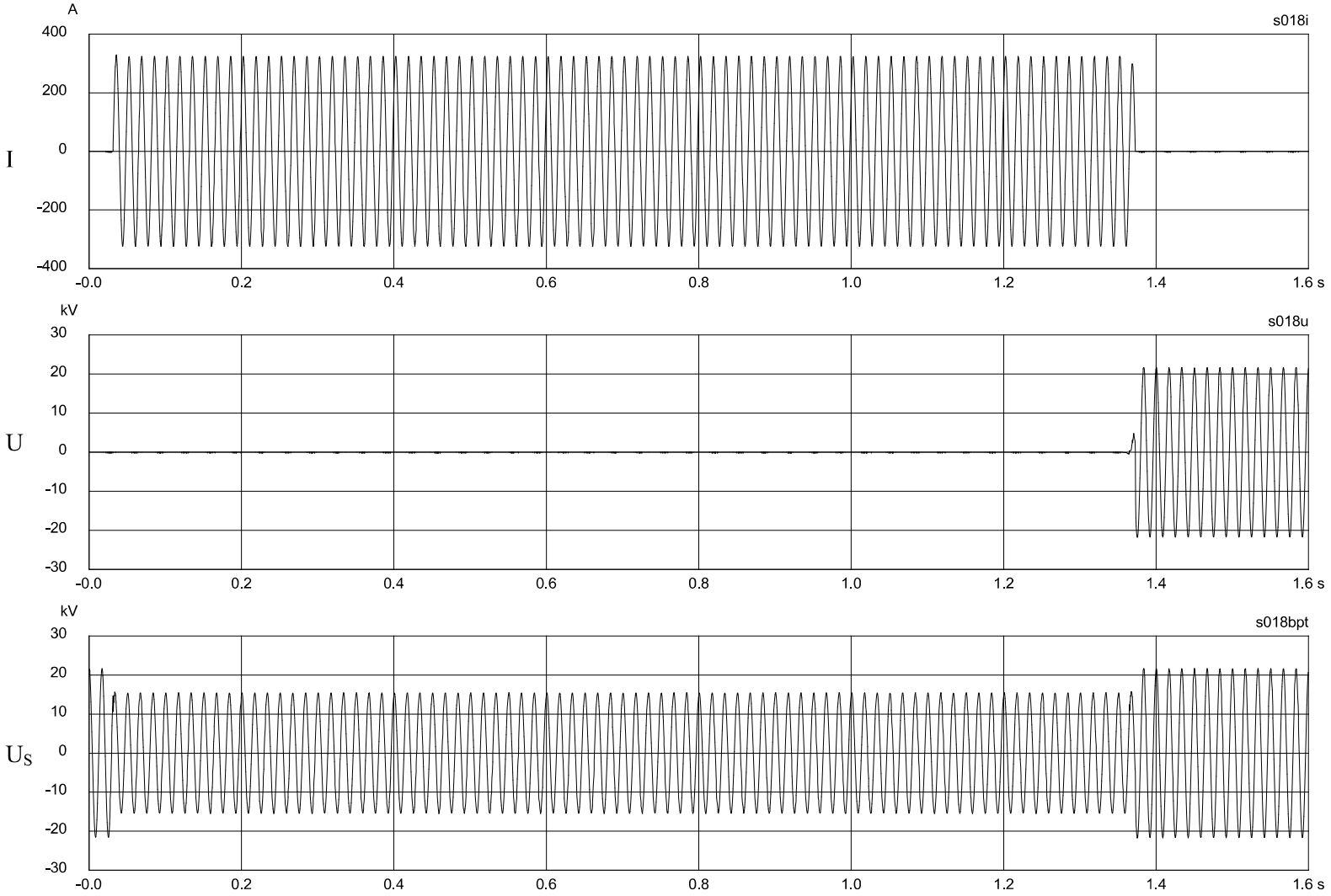


Figure 33. Test #28 waveforms.

Figure 34. 6K fuse link.

Figure 35. 25K fuse link.

Figure 36. 30K fuse link.

Figure 37. 50K fuse link.

Figure 38. Typical fuse holder used for testing.

Figure 39. Markings on the fuse holder.

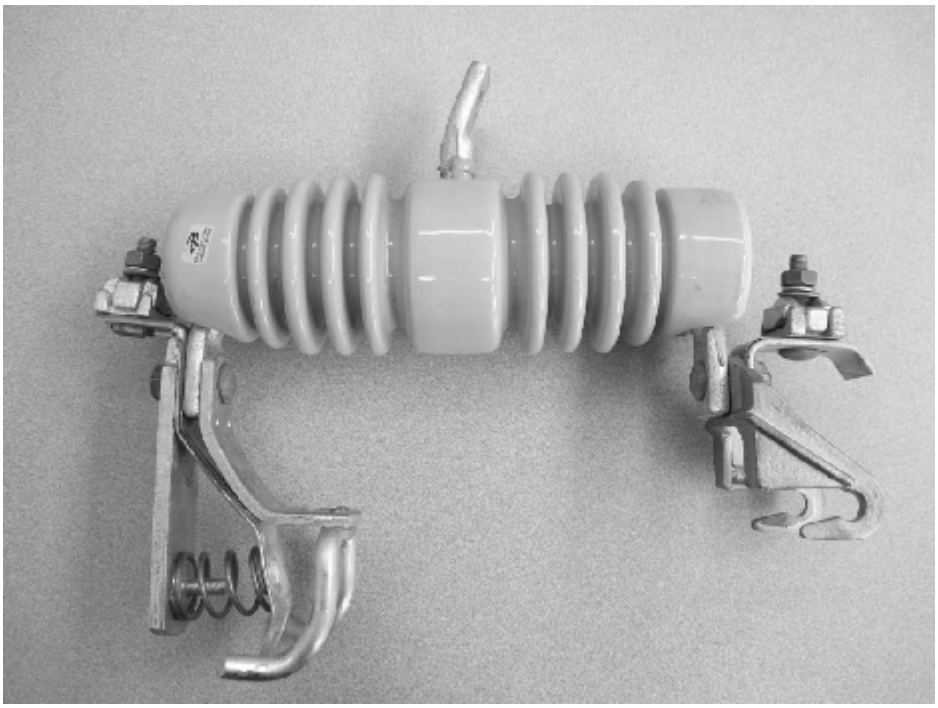


Figure 40. Typical insulating support used for testing.

Figure 41. Markings on the insulating support.