

Interruption Capacity Tests for 0.5H and 100K Tefuse Expulsion Fuse Links

ABNT NBR 7282:2011, Clause B.7.14



REPORT OF PERFORMANCE

CLIENT/MANUFACTURER Tecfuse Industria Electrica Ltda
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TEST OBJECTS Expulsion Fuse Links
Manufacturer: Tecfuse Industria Electrica Ltda
Models: 0.5H, 500 mm, T-EP
100K, 500 mm, T-EP

Porcelain Cutout Support
Manufacturer: Maurizio & Cia Ltda
Type: MZ-89021
Rated Voltage: 15 kV, 110 kV BIL
Rated Continuous Current: 300 A

Cutout Fuseholder
Manufacturer: Maurizio & Cia Ltda
Type: MZ-9021
Rated Voltage: 15 kV
Rated Continuous Current: 100 A
Rated Interrupting Current: 7,100 A (sym.), 10,000 A (asym.)

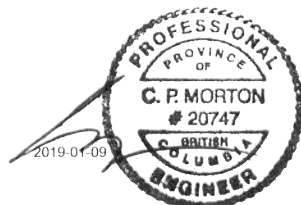
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TEST DATES 2013-03-08, 2013-06-27 and 2013-09-18

TEST SPECIFICATION ABNT NBR 7282:2011, Clause B.7.14

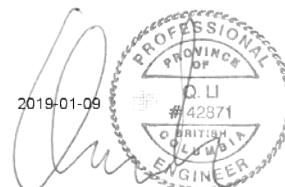
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1 INTRODUCTION

At the request of Tecfuse Industria Electrica Ltda, expulsion fuse links, models 0.5H and 100K, were subjected to Series 1, 4 and 5 interruption capacity tests in accordance with ABNT NBR 7282:2011, Clause B.7.14. The fuse links were tested with porcelain fuse cutouts manufactured by Maurizio & Cia Ltda and supplied by the client.

The tests were performed at the High Power Laboratory of Powertech Labs Inc., which is a member of the Short-Circuit Testing Liaison North America (STLNA), which is the North American Member of STL. The High Power Lab is accredited by the Standards Council of Canada to ISO 17025.

2 TEST OBJECT INFORMATION

The test objects were identified based on nameplate information, as follows:

Expulsion Fuse Links

Manufacturer: Tecfuse Industria Electrica Ltda
Models: 0.5H, 500 mm, T-EP
100K, 500 mm, T-EP
Condition: New

Porcelain Cutout Support

Manufacturer: Maurizio & Cia Ltda
Type: MZ-89021
Rated Voltage: 15 kV, 110 kV BIL
Rated Continuous Current: 300 A
Condition: New

Cutout Fuseholder

Manufacturer: Maurizio & Cia Ltda
Type: MZ-9021
Rated Voltage: 15 kV
Rated Continuous Current: 100 A
Rated Interrupting Current: 7,100 A (sym.), 10,000 A (asym.)
Condition: New

Photographs of the tested fuse links and cutouts are shown in Figures 24 through 27.

3 GENERAL INFORMATION

3.1 Purpose

The purpose of the testing was to verify that the test objects comply with the requirements of the Standard.

3.2 Witnesses

Manoel Esteves	Tecfuse	
Gary Haynes	ABB	(Series 4 tests only)
Antonio Flavio	Tecfuse	(Series 4 tests only)

3.3 Tests Performed

Test Standards/Specifications:

ABNT NBR 7282:2011
Clause B.7.14 – Verifying the total interruption time for distribution Class A

4 INTERRUPTION CAPACITY TESTS

General Information:

Standards	ABNT NBR 7282:2011, Clause B.7.14 and Clause 8.6
Test Dates	2013-03-08, 2013-06-27 and 2013-09-18
Test Leaders	Kamran Tabarraee, Tom Stefanski

Test Conditions:

Interruption Rating:	7,100 A (symmetrical), 10,000 A (asymmetrical)
Test Voltage:	15 kV _{rms} phase-to-ground
Test Frequency:	60 Hz
Phases:	1

Interruption capacity tests for series 1, 4 and 5 were carried out in accordance with Clause 8.6, Table 6 and Table 9 of the Standard. Before testing for each test series 1 and 4, the Transient Recovery Voltage (TRV) was measured using a current injection method and adjusted to meet the requirements of the Standard. For series 5, critical damping was confirmed by observing minimal overshoot on the TRV during testing.

Series 1 Tests:

Test current (symmetrical):	7.17 kA _{rms}	(≥ 7.1 kA _{rms} is required)
Test current (asymmetrical):	11.3 kA _{rms}	(≥ 10 kA _{rms} is required)
Circuit Power Factor:	0.105	(< 0.15 is required)
TRV peak:	AF = 1.35	(≥ 1.3 is required)
TRV rate of rise:	t ₃ = 186 μs	(≤ 187 μs is required)

The test circuit is provided in Figure 1, the prospective current is shown in Figure 4 and the prospective TRV waveform is shown in Figure 5.

Series 4 Tests:

Test current (symmetrical):	405 A _{rms}	(400-500 A _{rms} is required)
Circuit Power Factor:	0.37	(0.35-0.45 is required)
TRV peak:	AF = 1.60	(≥ 1.5 is required)
TRV rate of rise:	t ₃ = 18 μs	(≤ 18 μs is required)

The test circuit is provided in Figure 2, the prospective current is shown in Figure 6 and the prospective TRV waveform is shown in Figure 7.

Series 5 Tests (0.5H fuse links):

Test current (symmetrical):	16.7 A _{rms}	(≥ 15 A _{rms} , or a current level to produce an interruption time of 1.6 to 2.4 ms, is required))
Circuit Power Factor:	0.74	(0.6-0.8 is required)
TRV:	critically damped	

The test circuit is provided in Figure 3 and the prospective current is shown in Figure 8.

Series 5 Tests (100K fuse links):

Test current (symmetrical):	462 A _{rms}	(400-500 A _{rms} , or a current level to produce an interruption time of 1.6 to 2.4 ms, is required)
Circuit Power Factor:	0.73	(0.6-0.8 is required)
TRV:	critically damped	

The test circuit is provided in Figure 3 and the prospective current is shown in Figure 9.

Requirements:

The fuse links shall be subjected to the interruption capacity test in accordance with following conditions:

- a) The sample to be tested shall consist of fusible links randomly taken from the lot on delivery by the buyer.
- b) The fuse links shall be subjected to test sequences 1, 4 and 5 using fuse cutouts that have already been approved in all tests of the Standard.
- c) Test series 5 shall be tested with an interruption time of (2 ± 0.4) s.
- d) For each family, K and T, by agreement between manufacturer and buyer, three types of links may be used (links of lower, intermediate and higher current values), provided that they are of the same manufacturing lot. For type H, two types of links may be used (links of lower and higher currents).

The fuses shall meet the following conditions during the tests, in accordance with Clause 7.2:

- e) No ground faults or flashovers shall occur during any operation.
- f) After the fuse has operated, the components of the fuse, apart from those intended to be replaced after each operation, shall be in substantially the same condition as before operation except for internal erosion of the fuseholder. The fuse device, after renewal of the components intended to be replaced after each operation, shall be capable of carrying its rated current at rated voltage. Any mechanical damage after the operation shall not be such as to impair drop-out action, nor the ability to easily remove and replace the fuse-carrier. However, it is permissible for the components designed to secure the fuse-link in renewable fuses to be slightly damaged, provided that such damage is not likely to prevent the replacement of the melted fuse-element, to decrease the breaking capacity of the fuse, to modify its operating characteristics or to increase its temperature rise in normal service. Such damage is normally verified by visual inspection of the fuse.
- g) After operation, the dielectric withstand of the fuse across its terminals may be limited to the power-frequency recovery voltage.
- h) During operation of a drop-out fuse, small points of arc erosion at the upper contact may occur, mainly at low levels of interruption current and are acceptable.
- i) The pre-arcing time (melting time) shall be inside the limits of the time-current characteristic provided by the manufacturer.
- j) The times to the interruption, in each series, shall be measured to determine the arcing time. The maximum arcing times for 15 kV devices shall be 60 ms for test series 4 and 100 ms for test series 5.

Evaluation:

Data for each fuse link tested are provided in Table 1.

The tested fuse link samples completed the interruption tests in accordance with the Standard, with the following exceptions to the procedure:

- 1) The grounding point on the test circuit was not in accordance with Figure 3 of the Standard. Due to laboratory limitations in achieving the required TRV, the grounding point was applied at the lower terminal of the fuse cutout support. This was in conformance with IEC 60262-2:2008, Clause 8.6.1.3.
- 2) The arrangement of the test conductors did not exactly match Figure 4 of the Standard. The test leads used were extra flexible conductors which provided no additional support to the fuse cutout terminals, which is a more severe condition compared to the arrangement presented in the Standard.
- 3) Series 4 tests on 100K fuse links were not required by the Standard. These tests were performed at the request of the client.
- 4) For series 5, a current of 15 A was used for the 0.5H fuse links and 462 A for the 100K fuse links, which produced interruption times less than the specified time in the Standard (2 ± 0.4) s.

- 5) The pre-arcing times (melting times) were not evaluated, as reference values from the fuse link manufacturer were not available.

Results:

The fuse links completed the interruption tests in accordance with above requirements (e), (f), (g), (h) and (j).

Items (a), (b), (d) and (i) could not be confirmed by the laboratory.

Item (c) was not met.

APPENDIX A – TEST CIRCUITS

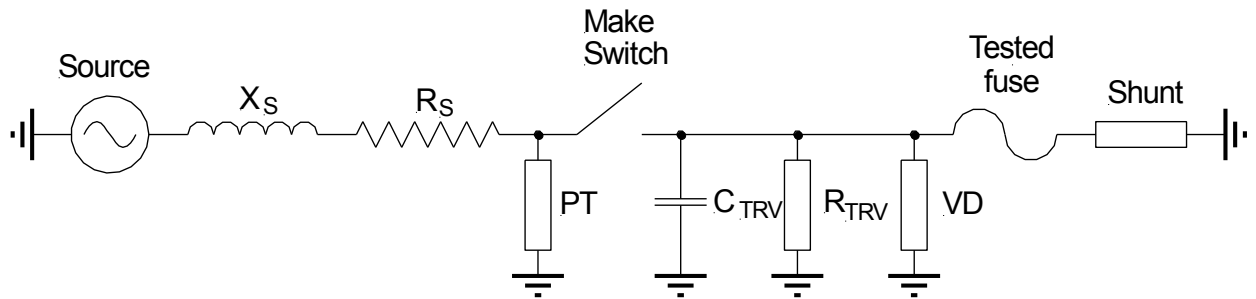


Figure 1: Test circuit schematic for series 1 interruption capacity tests.

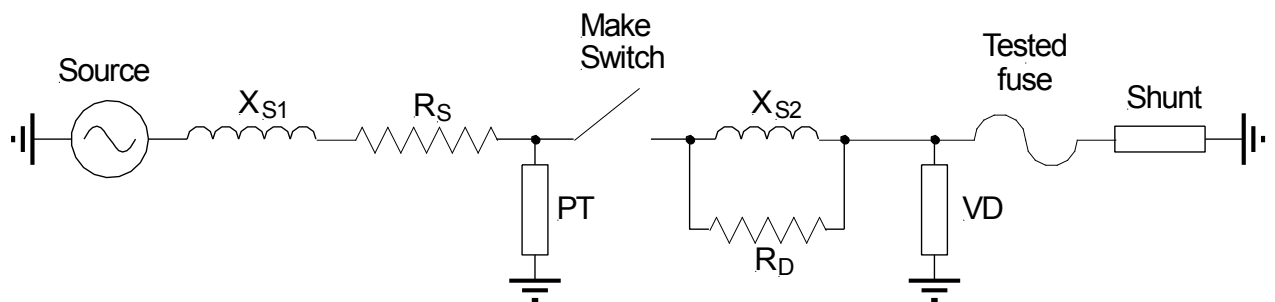


Figure 2: Test circuit schematic for series 4 interruption capacity tests.

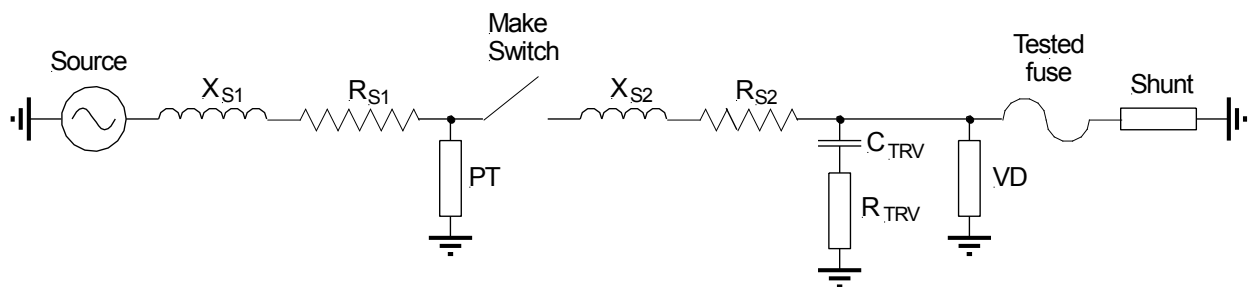


Figure 3: Test circuit schematic for series 5 interruption capacity tests.

Notes:

- | | |
|---|--|
| 1. X_s, X_{S1}, X_{S2} - Source reactances | 5. C_{TRV}, R_{TRV} - TRV control components |
| 2. R_s, R_{S1}, R_{S2} - Source resistances | 6. VD - DUT voltage measurement |
| 3. R_D - Damping resistance | 7. Shunt - Current measurement |
| 4. PT - Source voltage measurement | |

APPENDIX B – TEST DATA

Table 1: Test data for interruption capacity tests for 0.5H and 100K fuses

Test Series	Sample №		Fuse Link	Test No.	Current				Rms Current at Melting [A _{rms}]	I ² t at Melting [A ² s x10 ³]	Melting Time [ms]	Arcing Time [ms]	Peak Voltage [kV _{peak}]	Figure №	Test Result ³⁾ [Pass/Fail]
	Support	Holder			Closing Angle	Pro-spective [A _{rms}]	Peak [A _{peak}]	Duration [ms]							
1	A	1	0.5H	1	-1	7170	13900	19.36	549	0.367	1.22	18.1	32.7	10	Pass
				2	91	7170	6540	6.5	930	0.376	0.44	6.1	27.9	11	Pass
				3	140	7170	1930	2.93	783	0.405	0.66	2.3	21.7	12	Pass
	H	10	100K	4	0	7170	17100	13	6360	202	4.99	8.0	32.1	13	Pass
				5	92	7170	9530	15.9	6870	206	4.37	11.5	31.6	14	Pass
				6	137	7170	15500	14.66	5180	199	7.42	7.2	32.7	15	Pass
4	5-A	5-1	0.5H	7	1	405	702	10.5	259	0.279	4.16	6.3	25.4	16	Pass
				8	86	405	478	14.1	293	0.285	3.32	10.8	22	17	Pass
4 ¹⁾	4-C	4-6	100K	9	3	405	735	2151	399	343	2135	16.0	22.1	18	Pass
				10	96	405	613	2314	398	367	2298	15.9	22.0	19	Pass
5	5-A	5-1	0.5H	11	45	16.7	24.5	567 ²⁾	16.8	0.158	559	8.5	24.4	20	Pass
				12	46	16.7	24.3	566 ²⁾	16.8	0.156	556	9.8	24.3	21	Pass
5	4-Cr	4-6	100K	13	45	462	668	1483 ²⁾	464	315	1467	16.1	21.8	22	Pass
				14	46	462	669	1483 ²⁾	463	314	1462	21.1	21.8	23	Pass

Notes: ¹⁾ Series 4 tests on 100K fuse links were not required by the Standard.

²⁾ Interruption time values were outside the range (2 ± 0.4) s.

³⁾ 'Pass' indicates that the fuse successfully interrupted the test current in accordance with Clause 7.2, items (a) through (d), of the Standard.

APPENDIX C – TEST WAVEFORMS

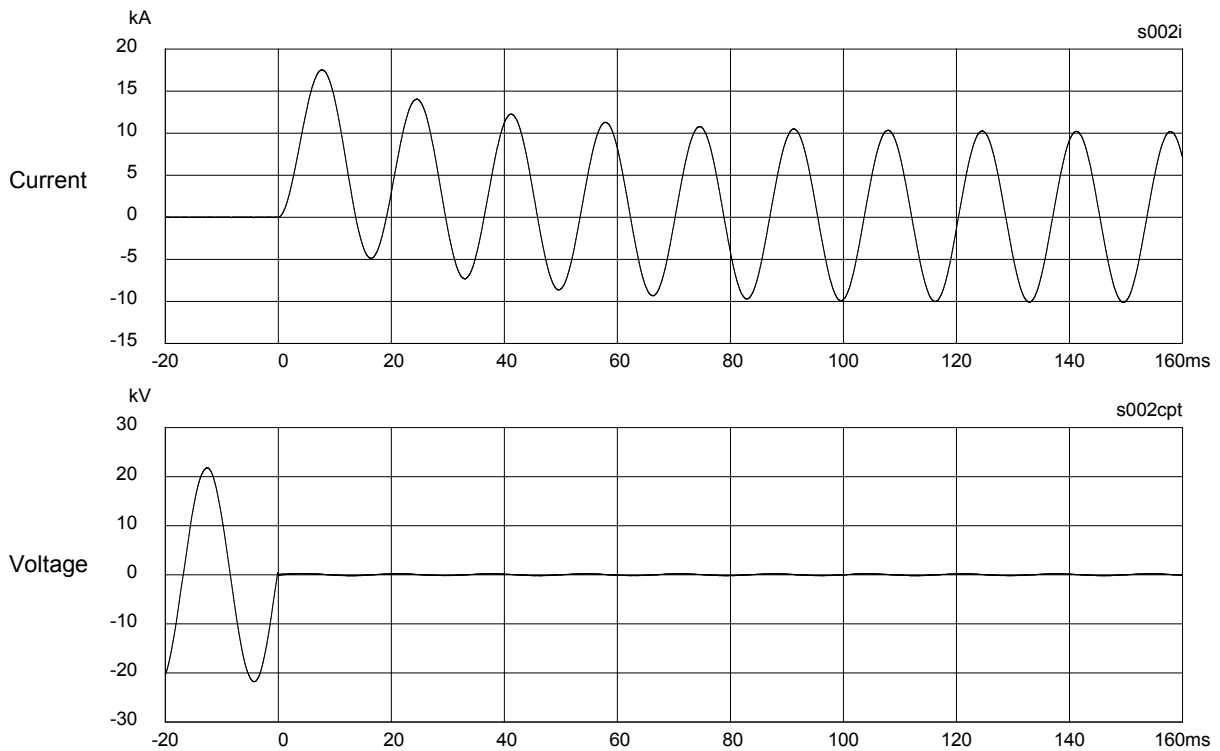


Figure 4: Prospective current waveform for series 1 interruption capacity tests.

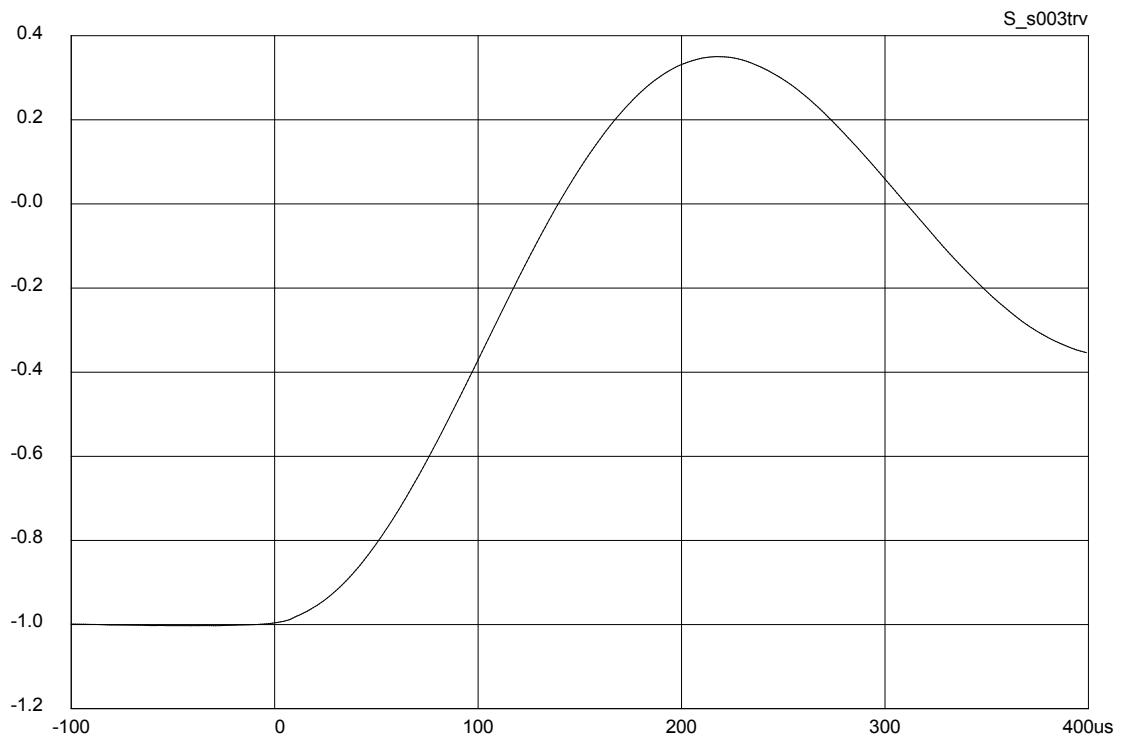


Figure 5: Prospective TRV waveform for series 1 interruption capacity tests.

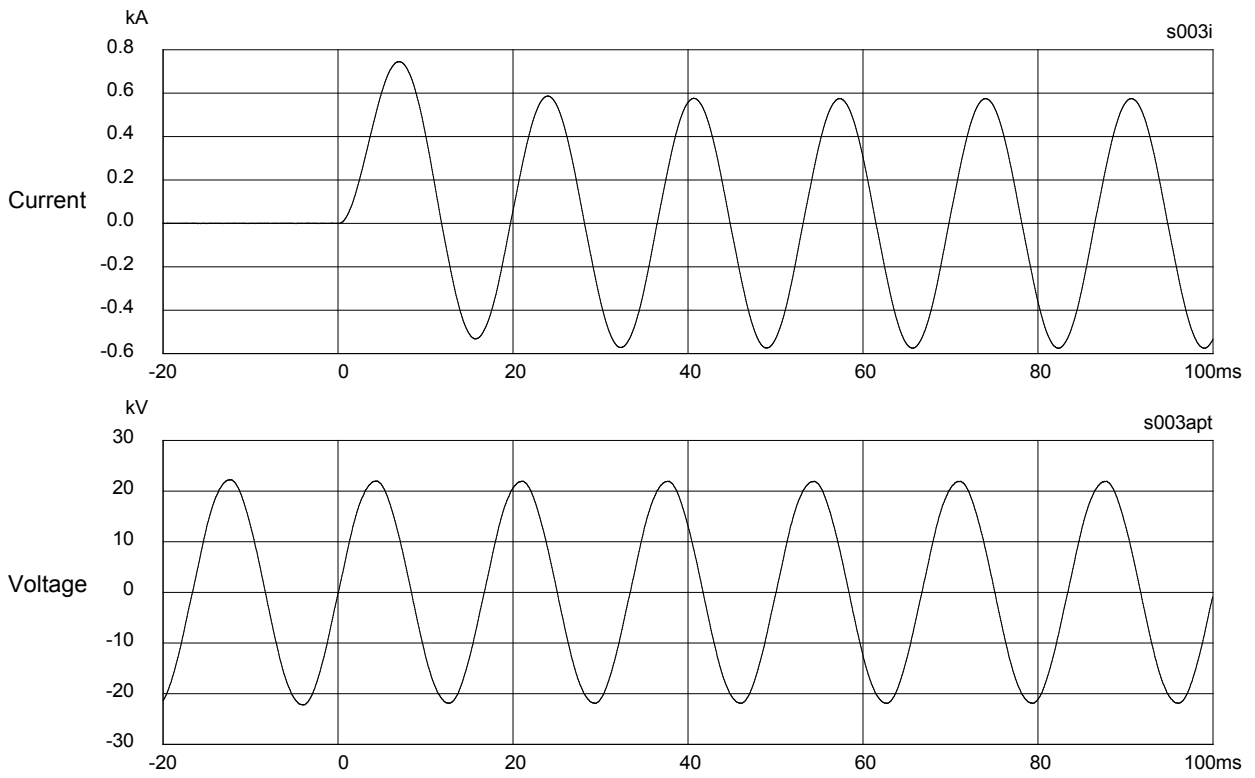


Figure 6: Prospective current waveform for series 4 interruption capacity tests.

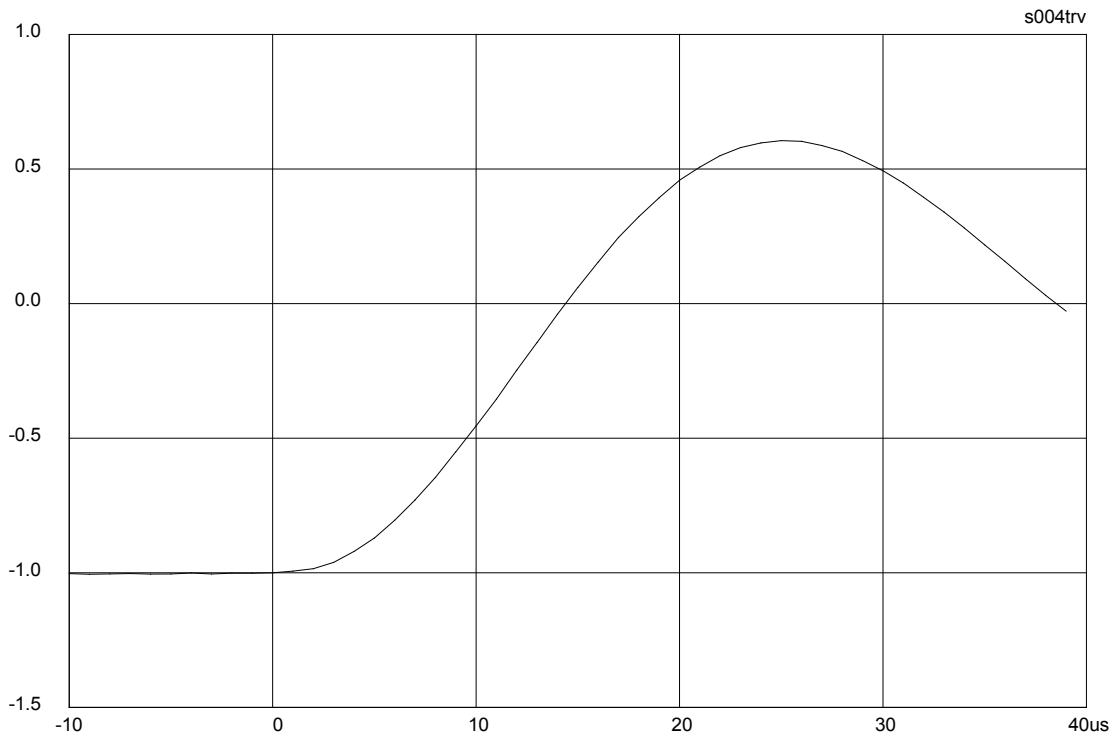


Figure 7: Prospective TRV waveform for series 4 interruption capacity tests.

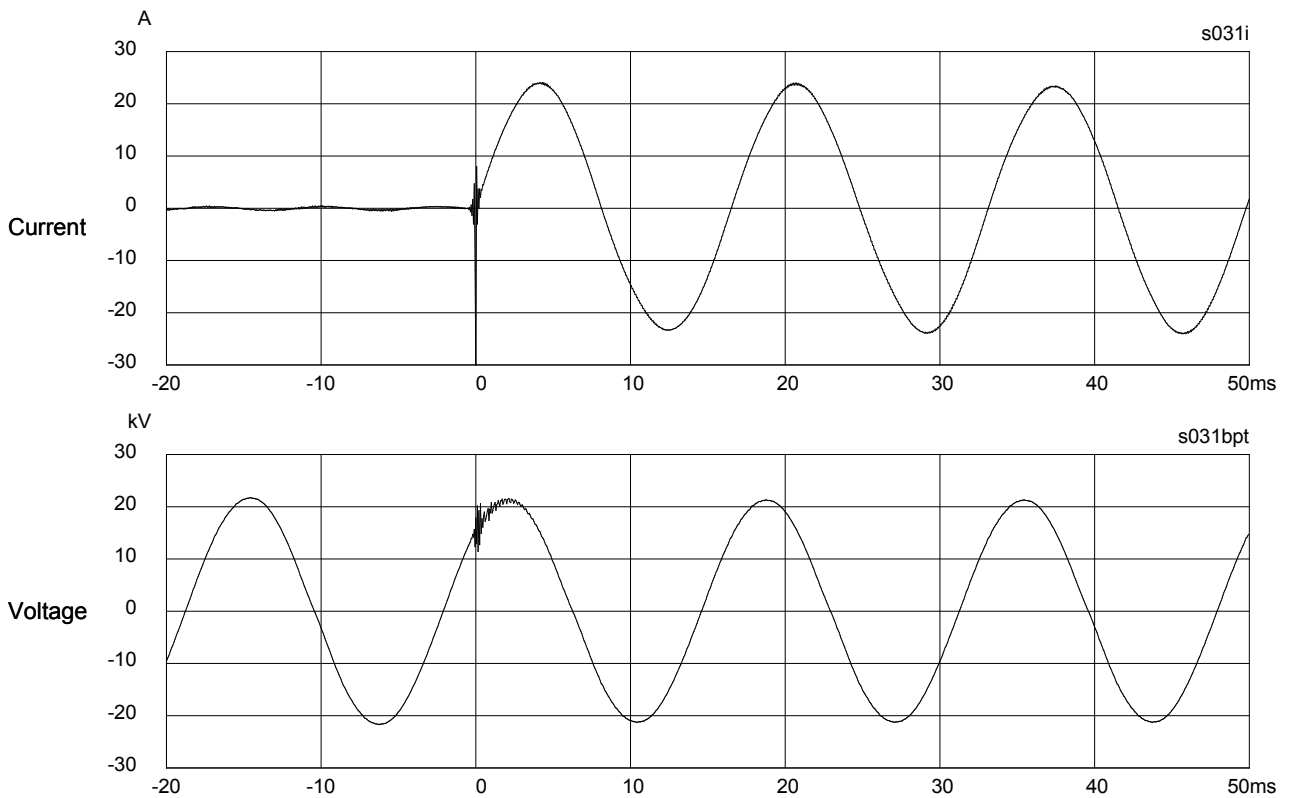


Figure 8: Prospective current waveform for series 5 interruption capacity tests (0.5H fuse links).

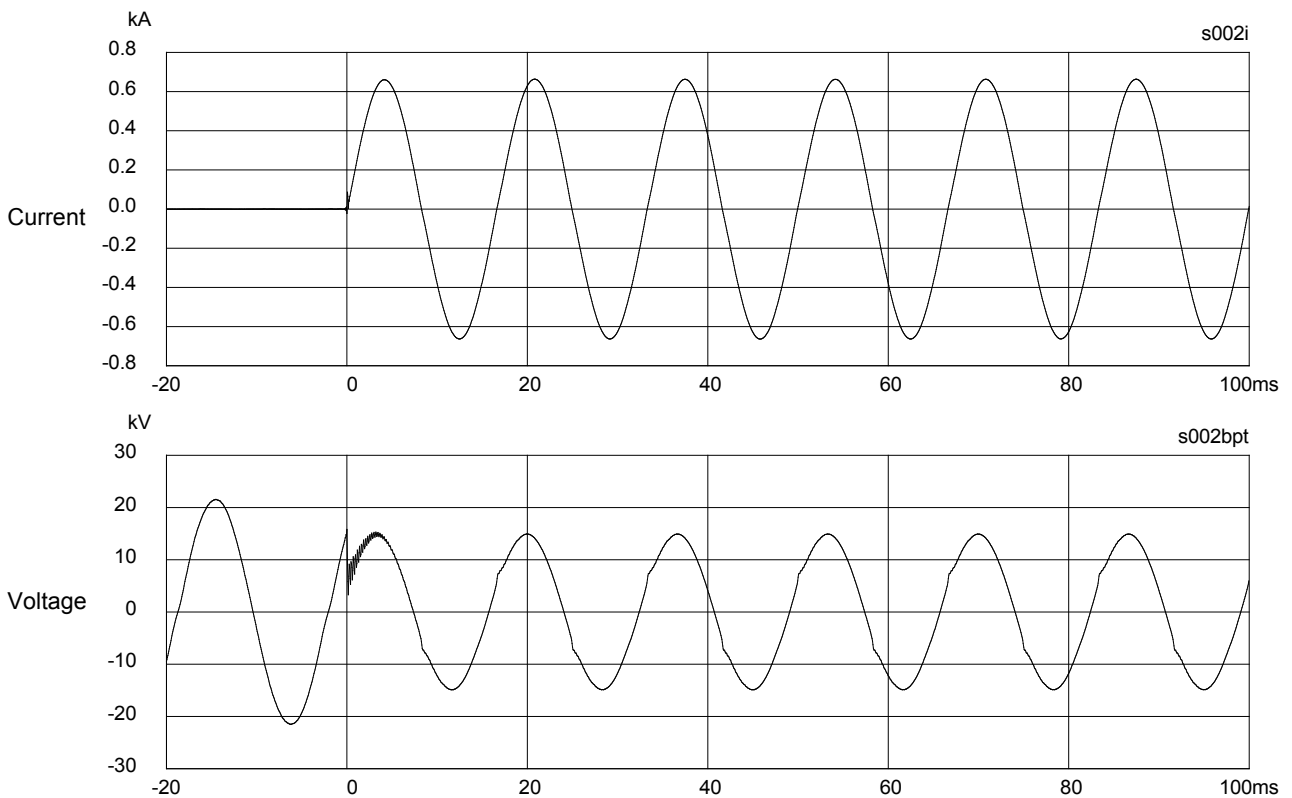


Figure 9: Prospective current waveform for series 5 interruption capacity tests (100K fuse links).

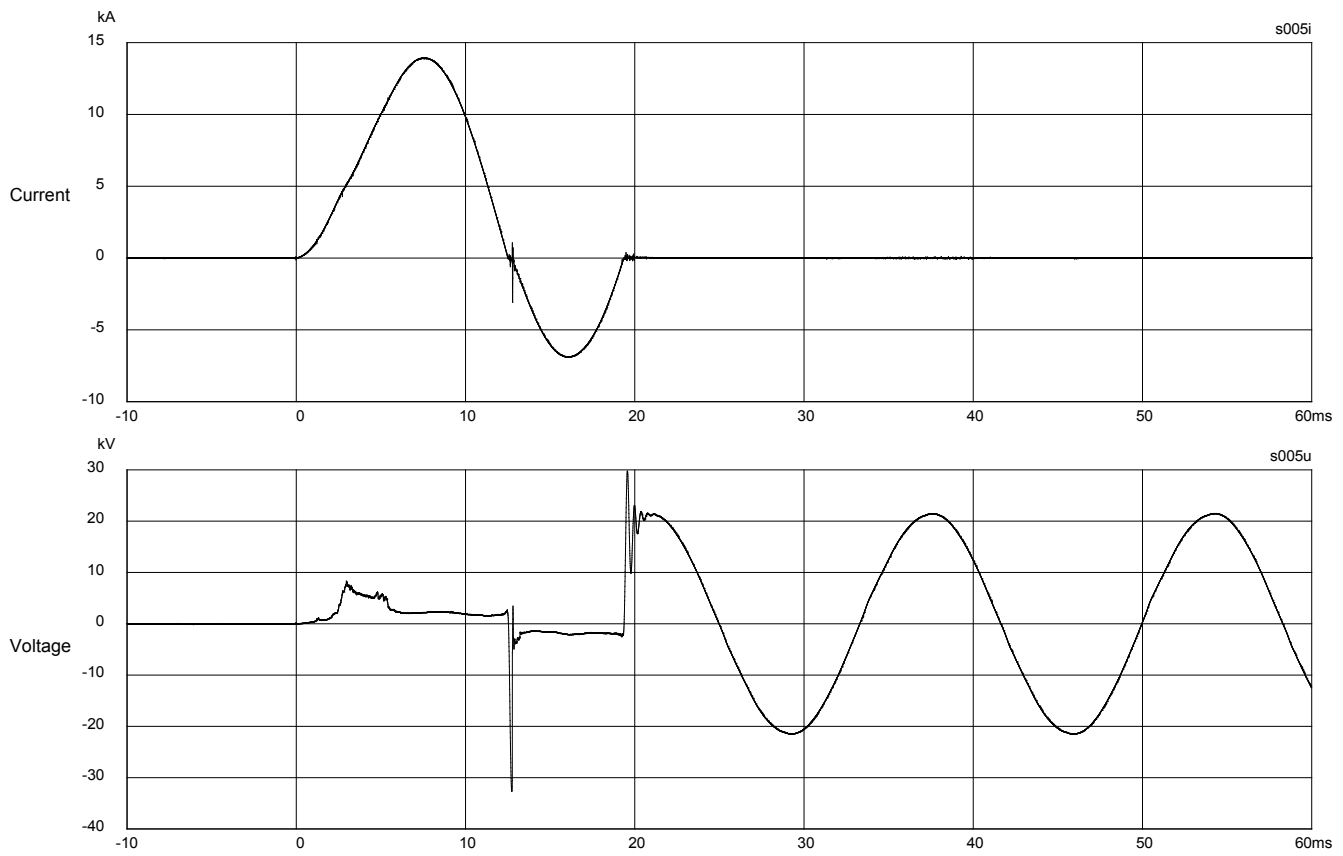


Figure 10: Test waveforms for series 1, test 1, 0.5H.

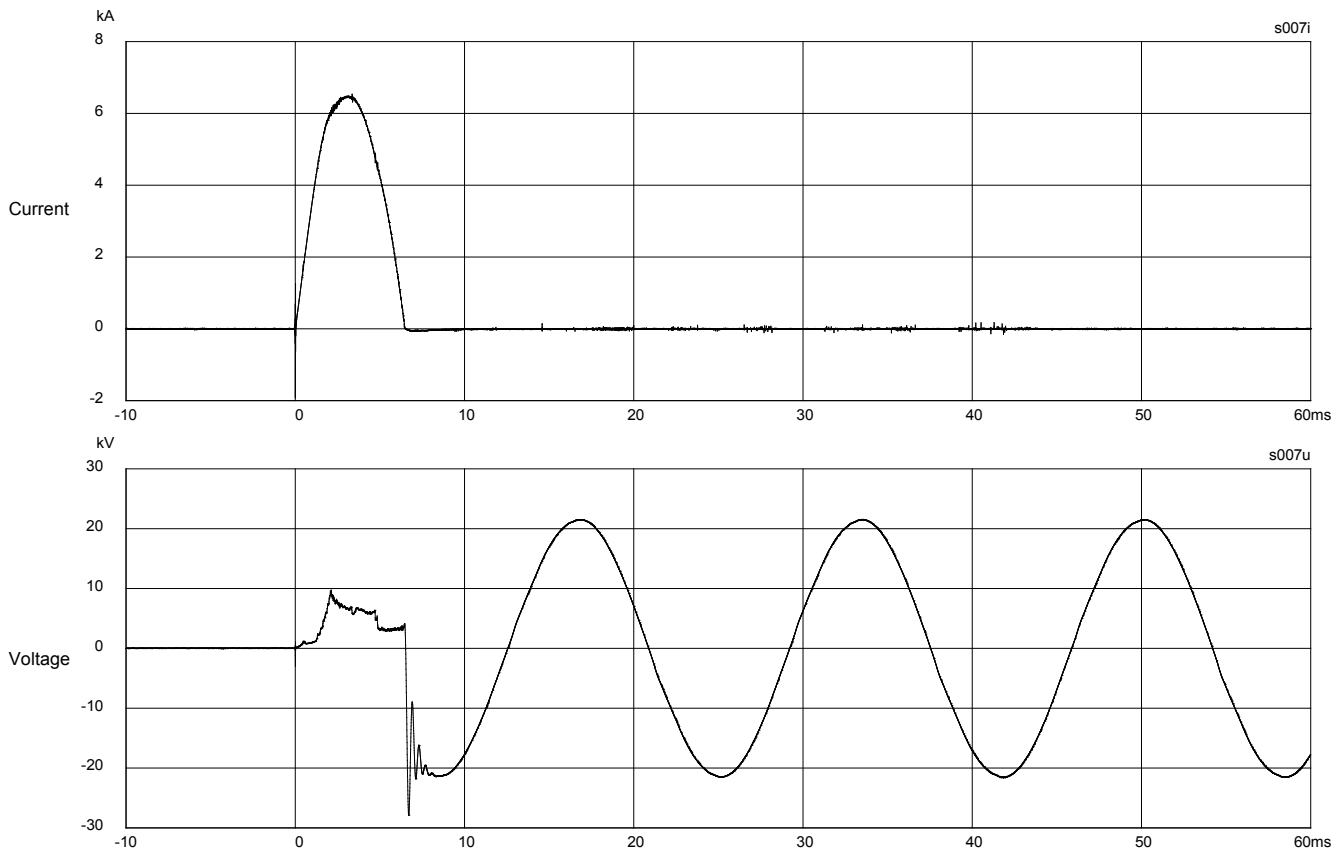


Figure 11: Test waveforms for series 1, test 2, 0.5H.

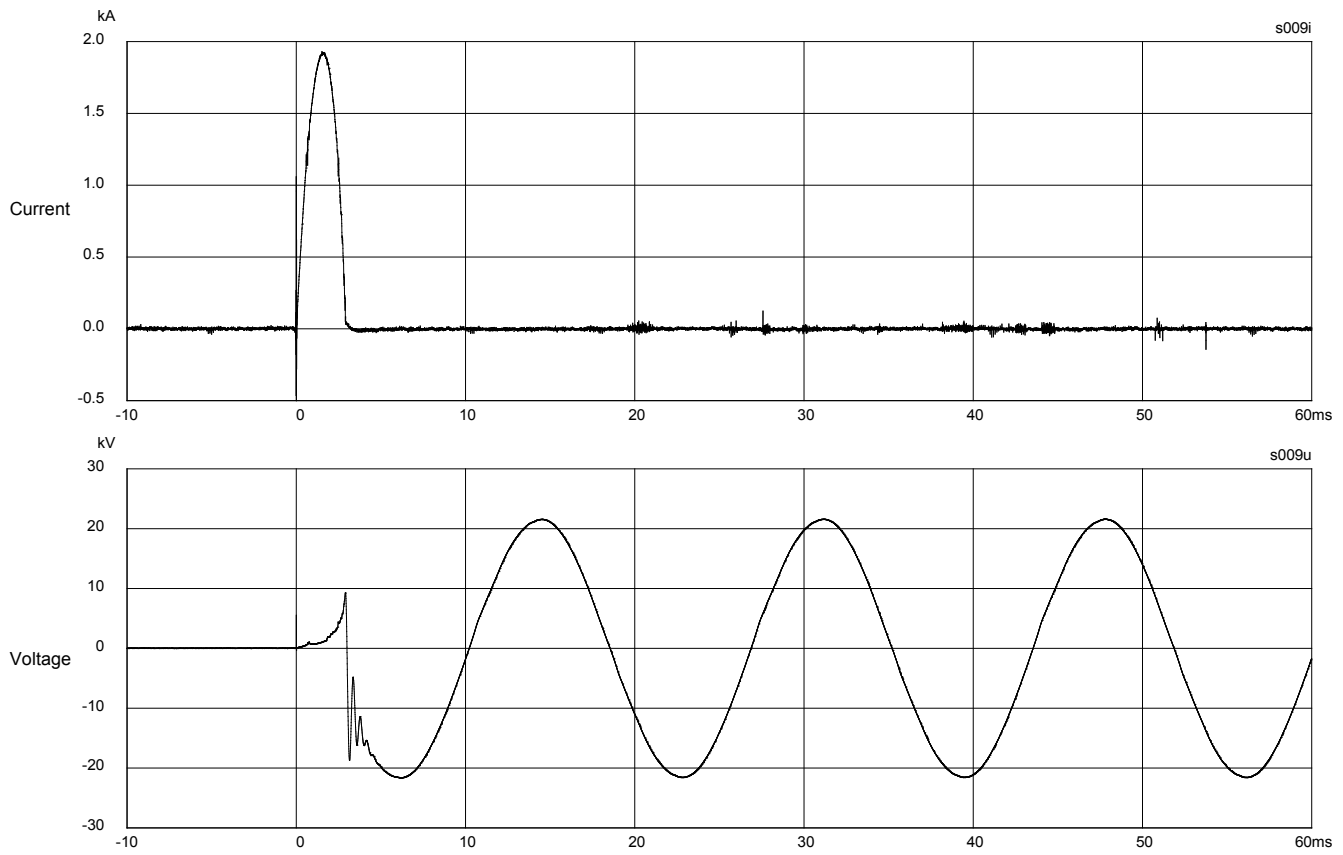


Figure 12: Test waveforms for series 1, test 3, 0.5H.

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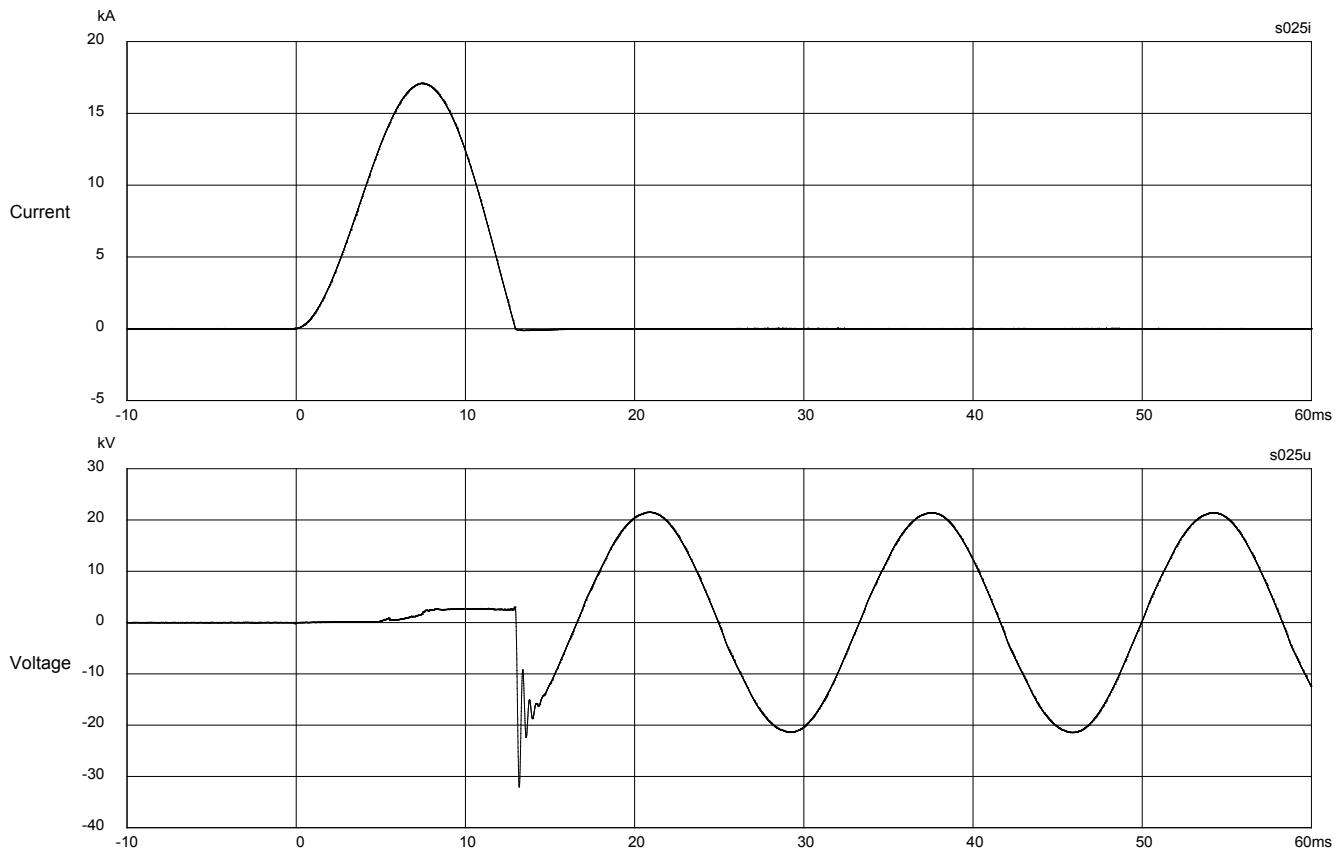


Figure 13: Test waveforms for series 1, test 4, 100K.

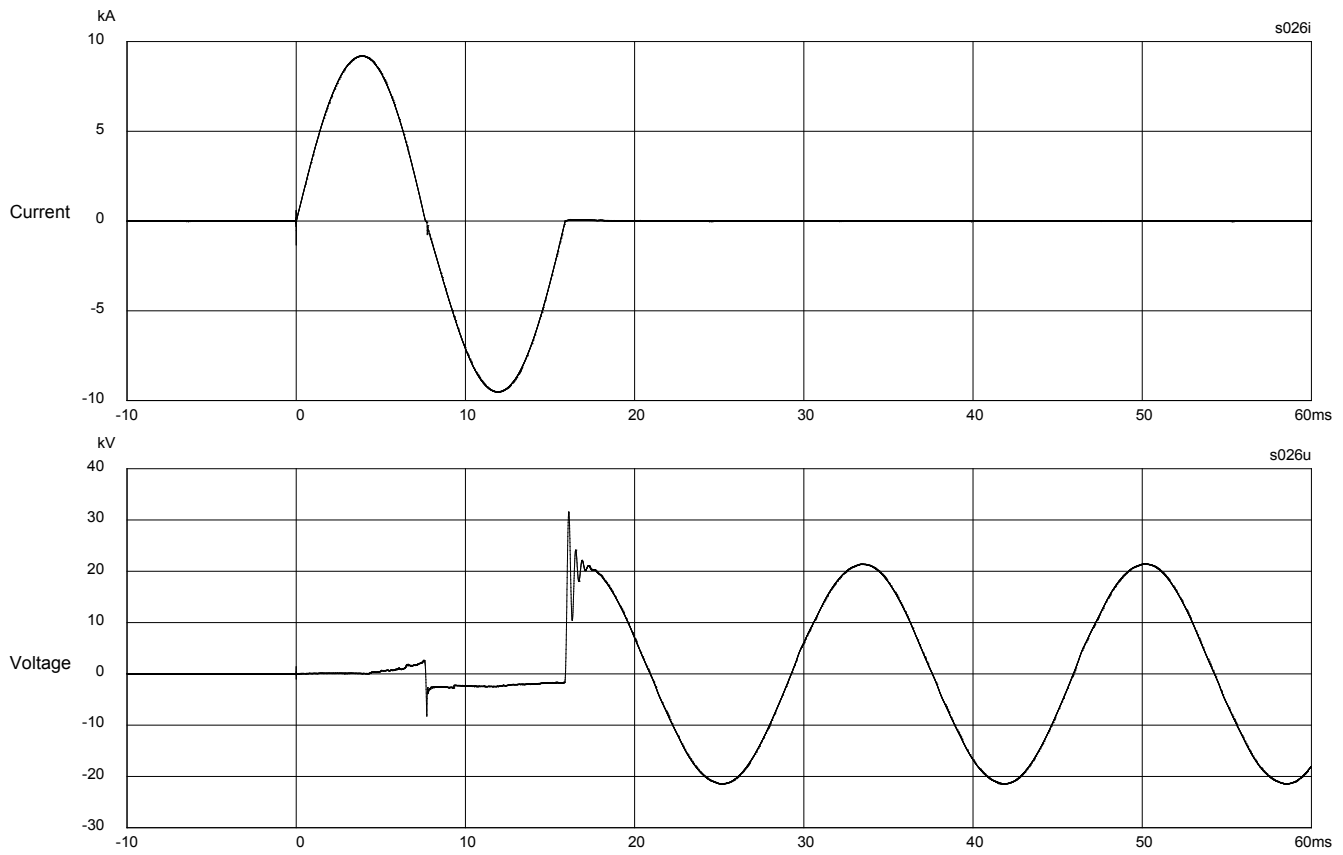


Figure 14: Test waveforms for series 1, test 5, 100K.

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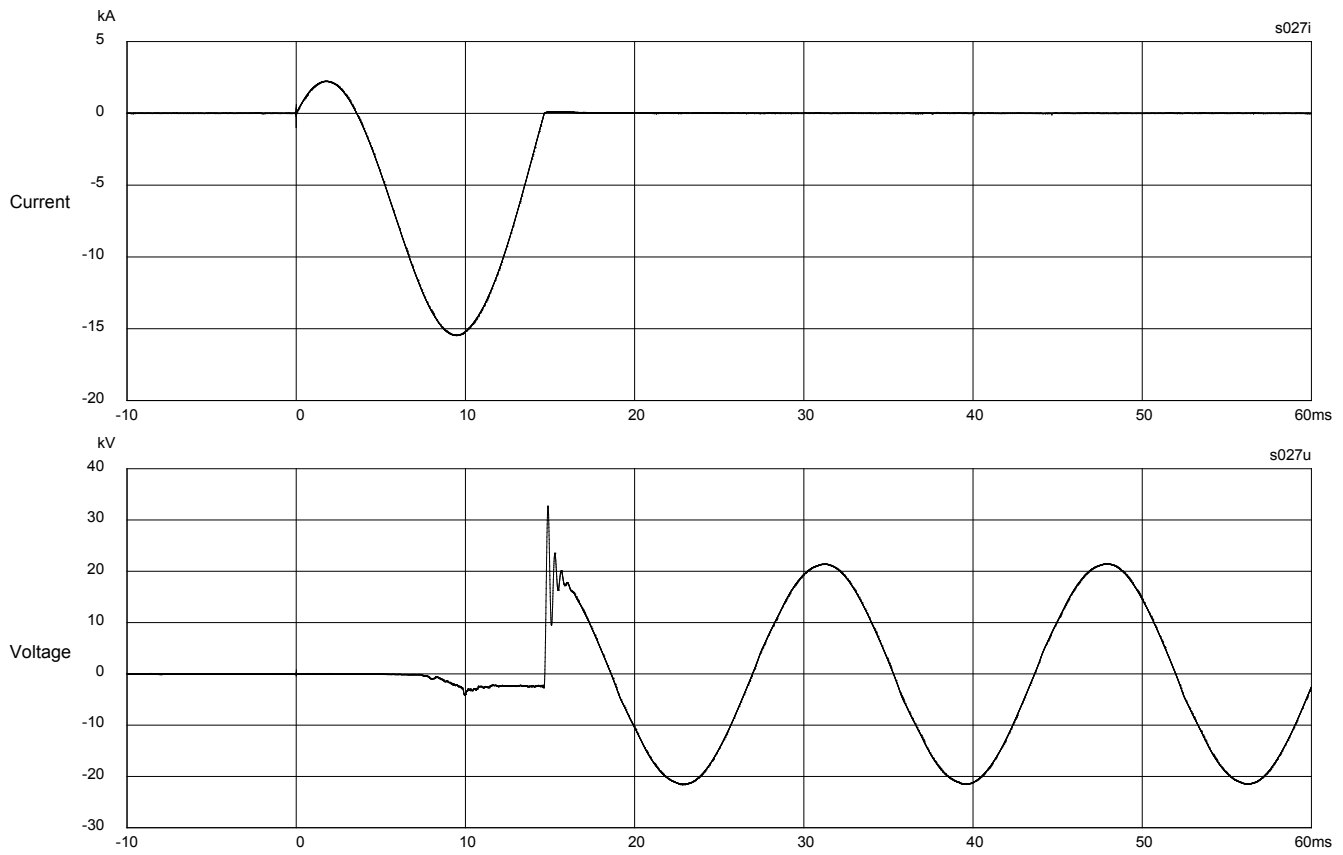


Figure 15: Test waveforms for series 1, test 6, 100K.

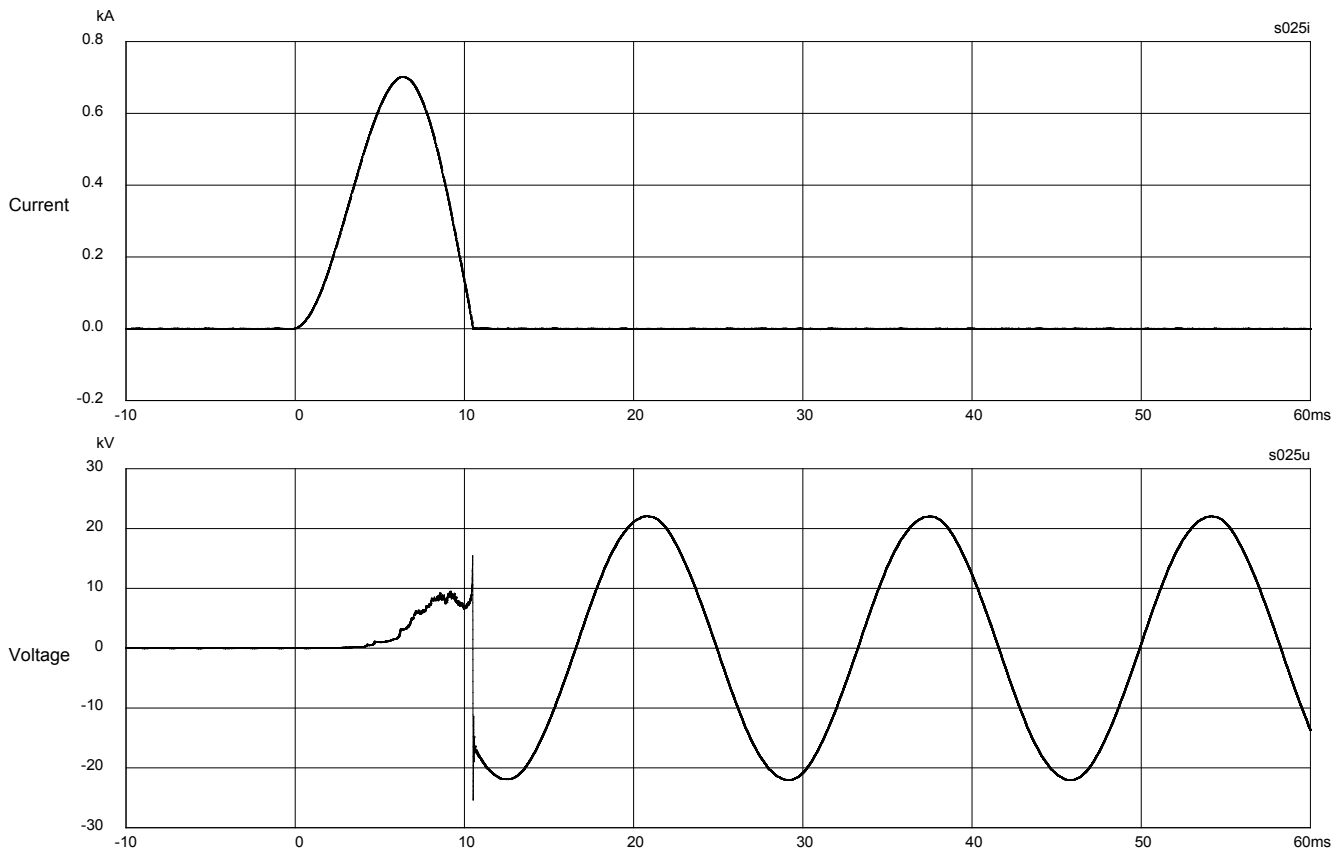


Figure 16: Test waveforms for series 4, test 7, 0.5H.

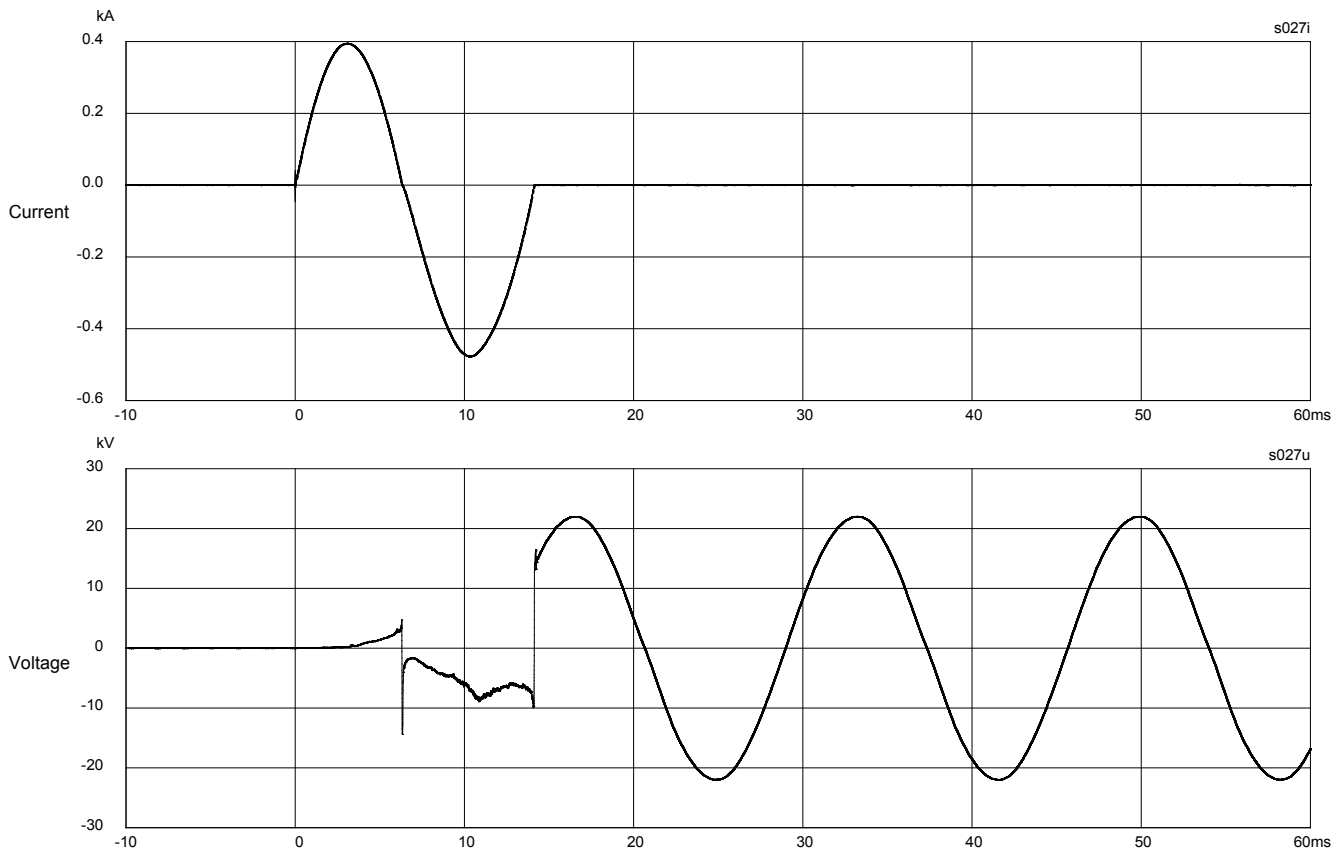


Figure 17: Test waveforms for series 4, test 8, 0.5H.

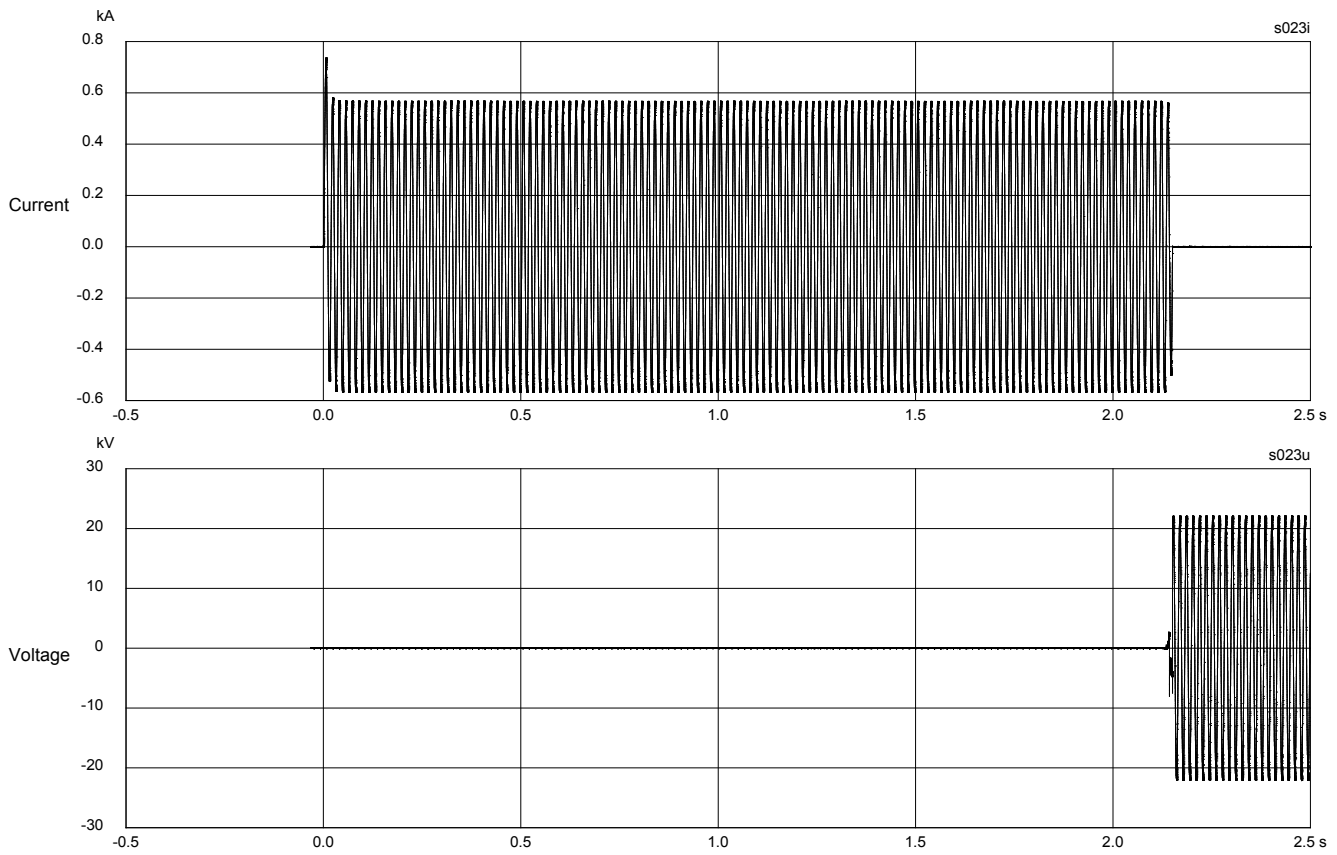


Figure 18: Test waveforms for series 4, test 9, 100K.

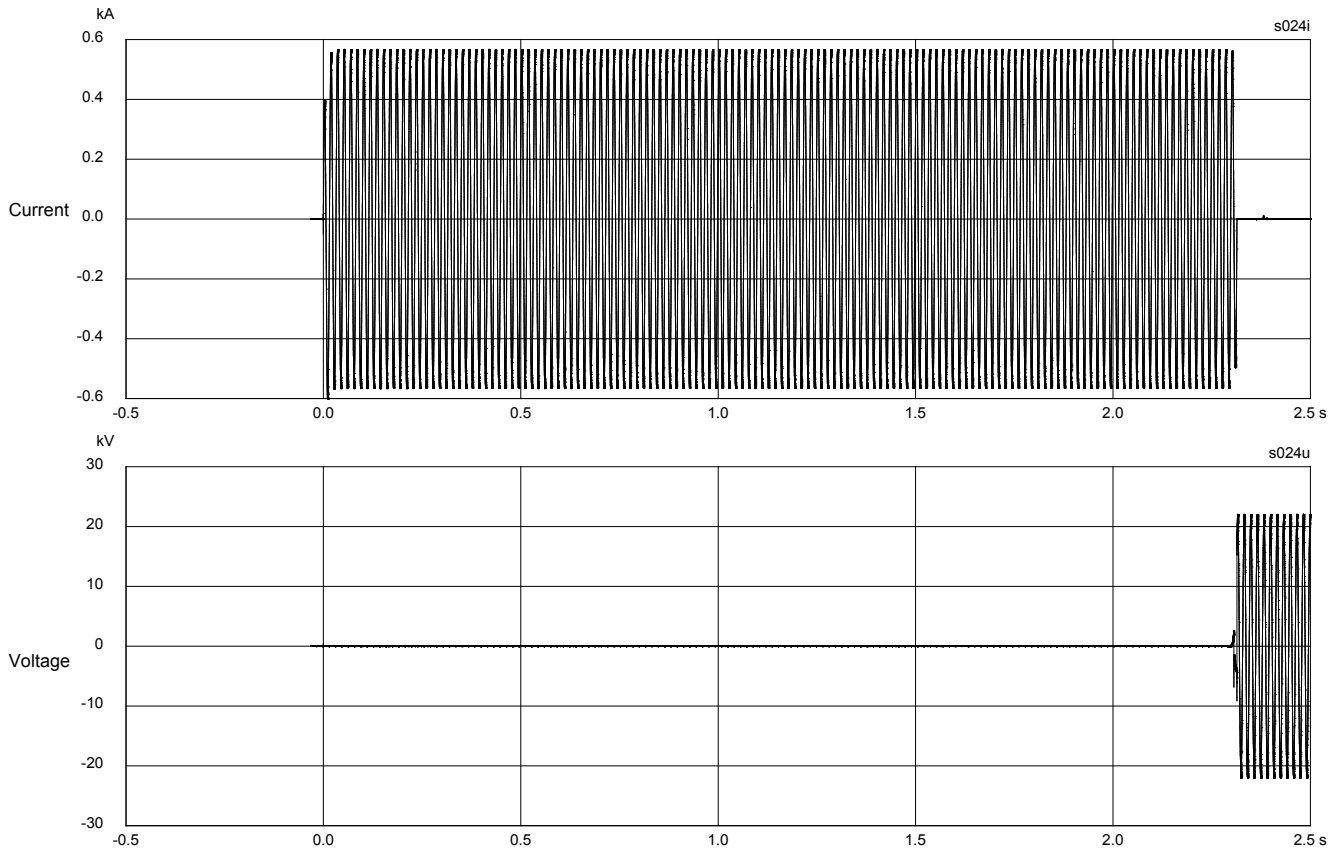


Figure 19: Test waveforms for series 4, test 10, 100K.

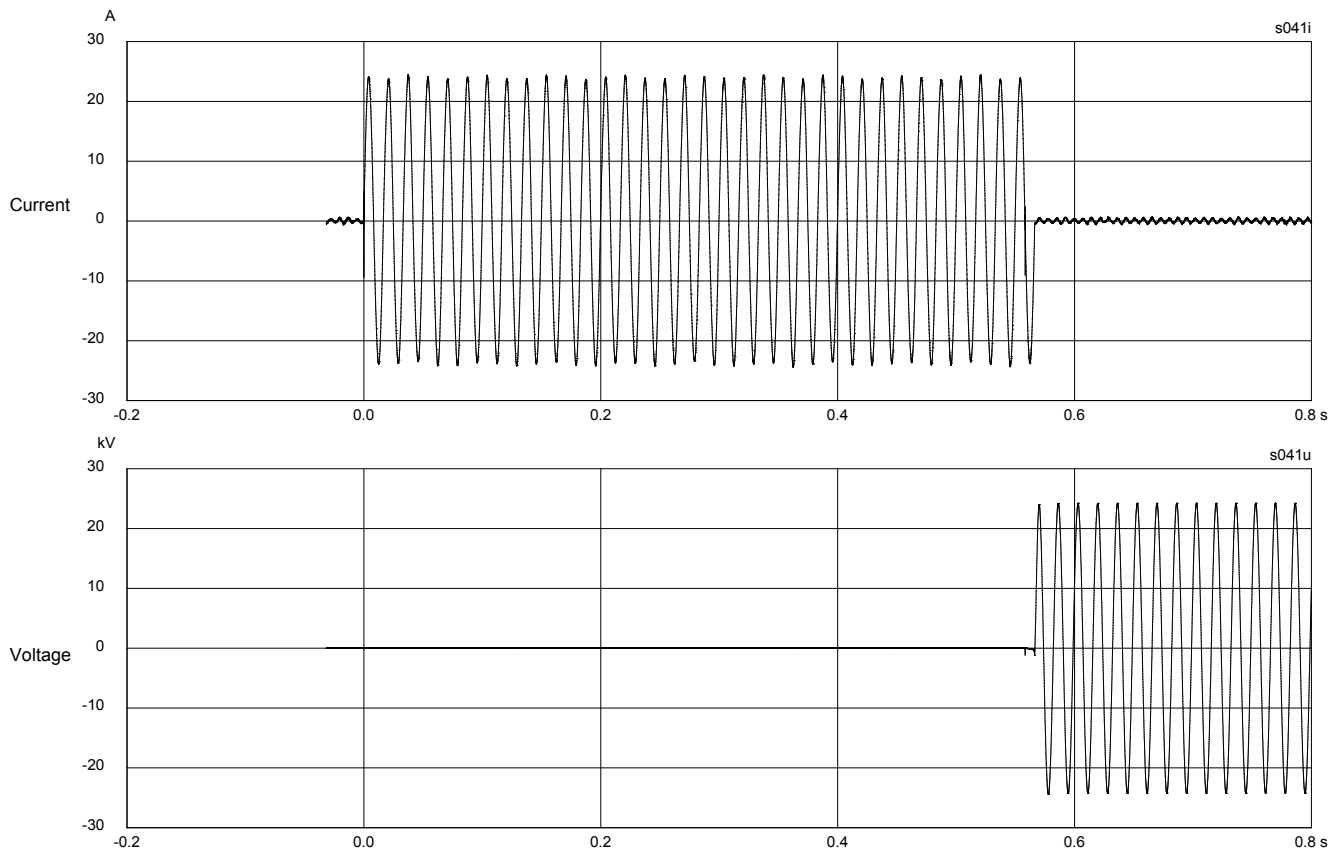


Figure 20: Test waveforms for series 5, test 11, 0.5H.

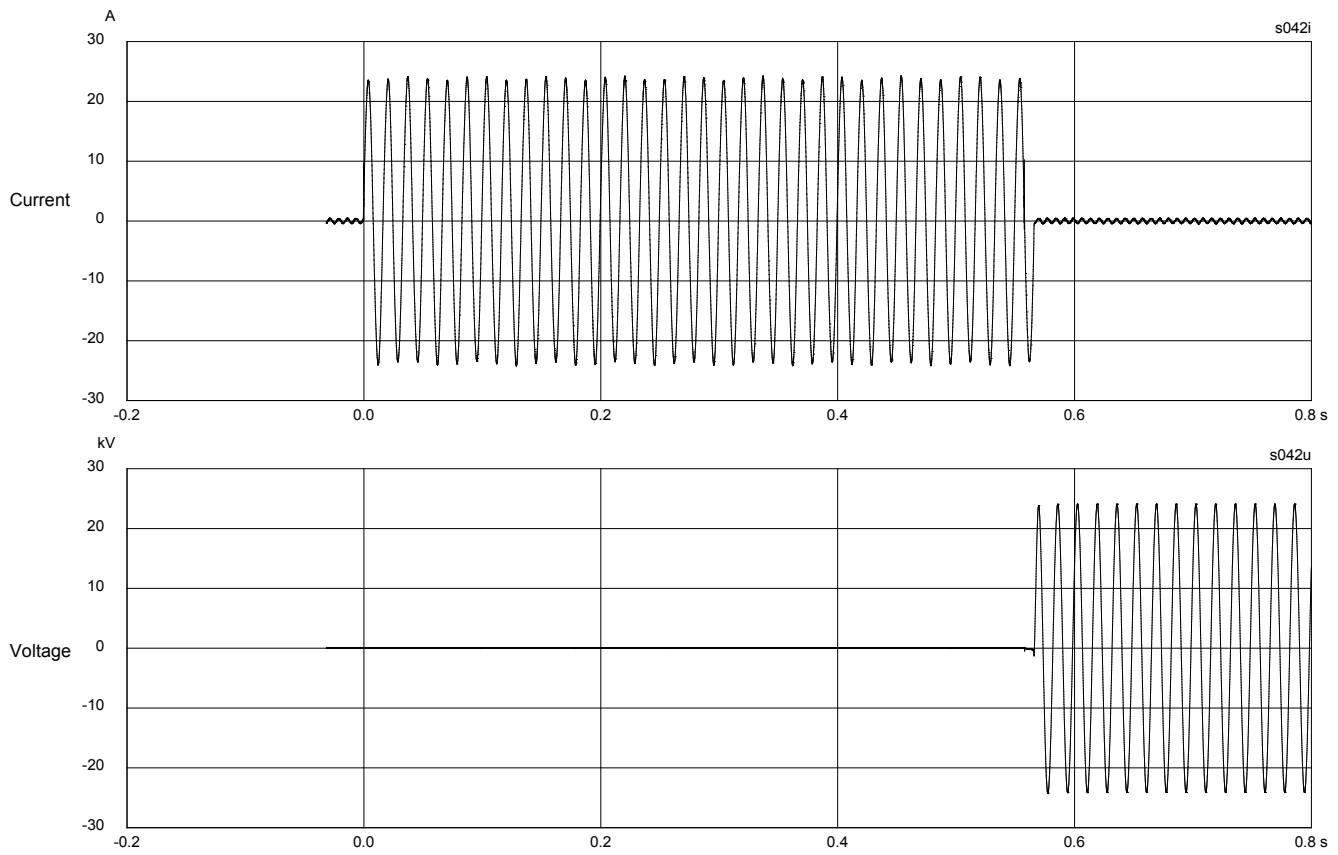


Figure 21: Test waveforms for series 5, test 12, 0.5H.

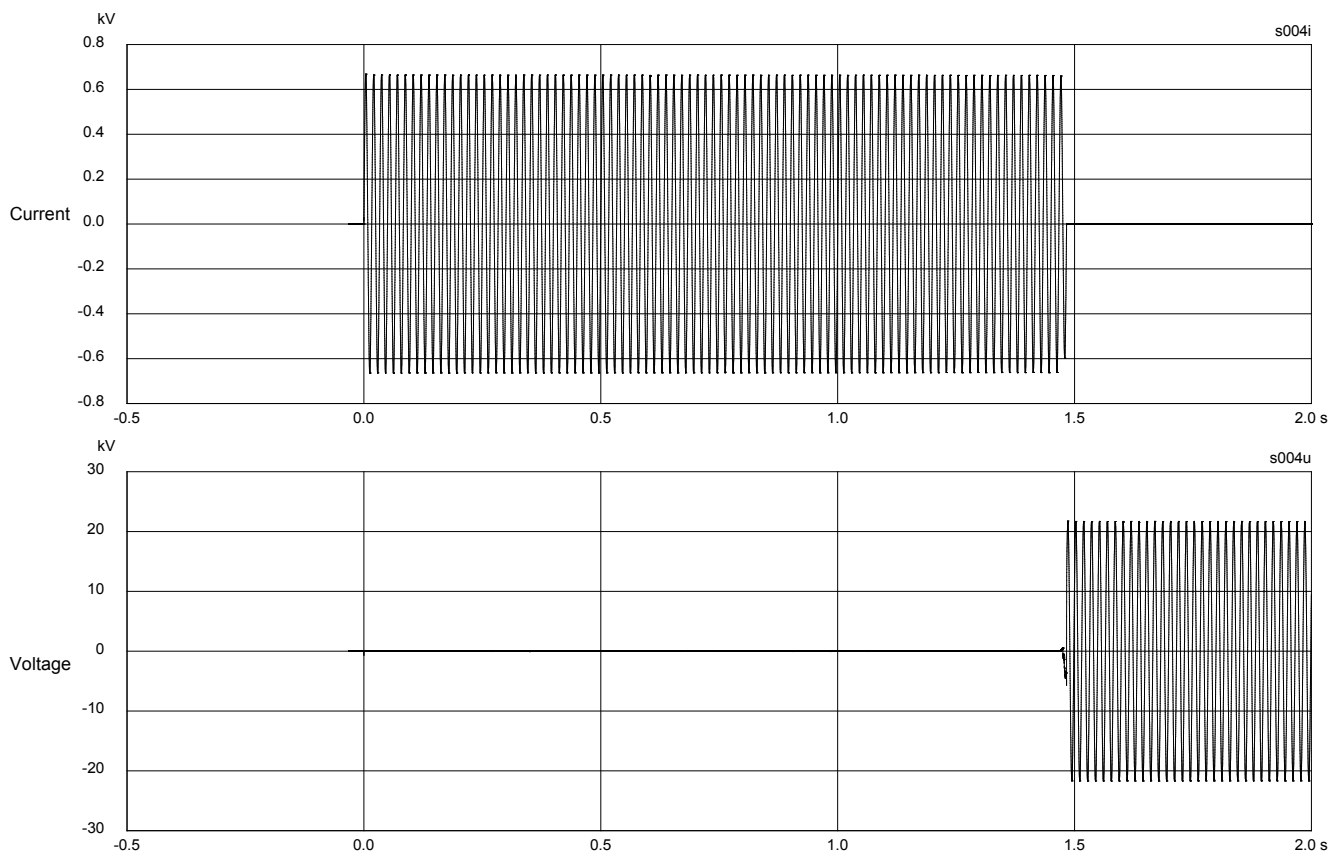


Figure 22: Test waveforms for series 5, test 13, 100K.

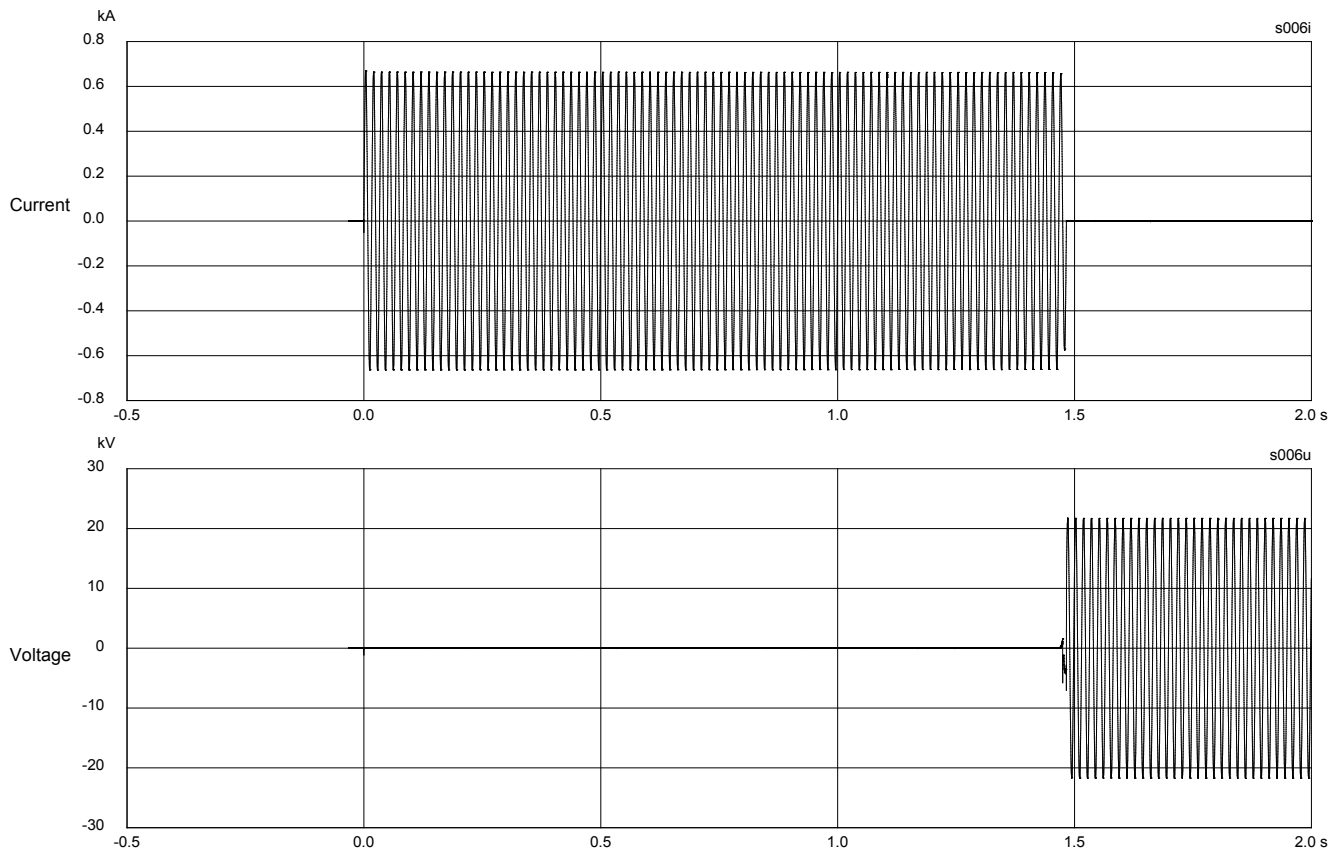


Figure 23: Test waveforms for series 5, test 14, 100K.

APPENDIX D – PHOTOGRAPHS OF THE TEST OBJECTS



Figure 24: Tested 0.5H fuse link design.



Figure 25: Tested 100K fuse link design.

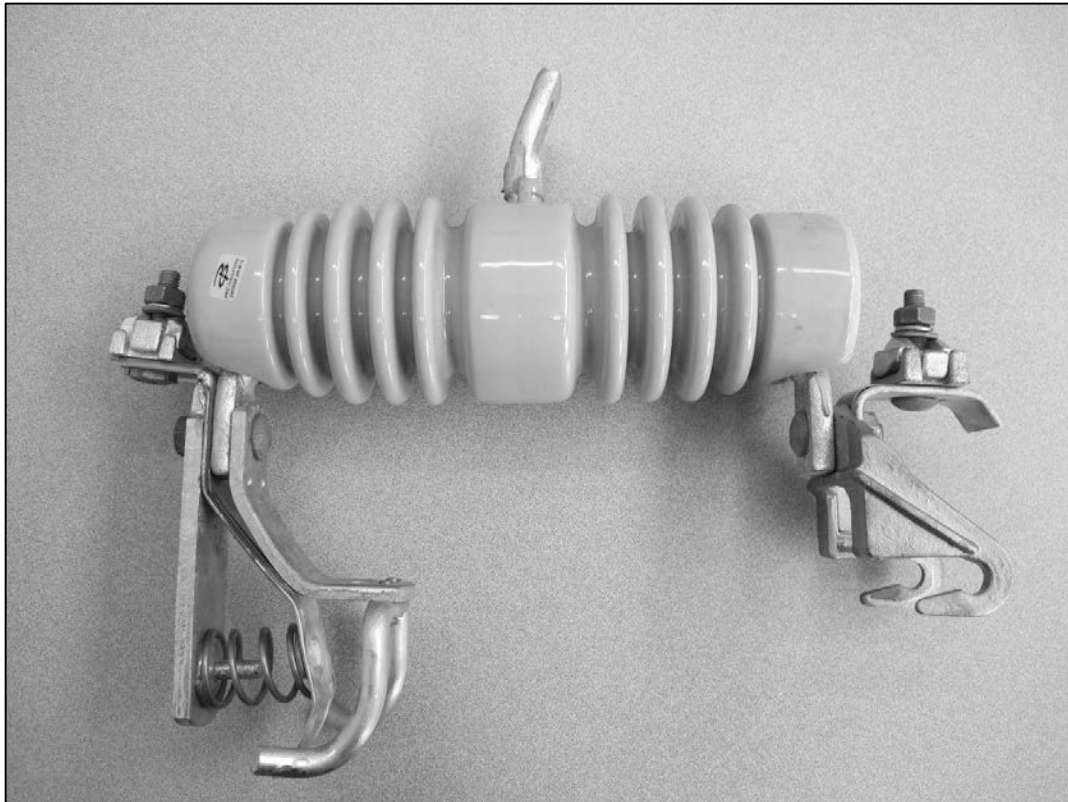


Figure 26: Cutout support used for the tests.



Figure 27: Cutout fuseholder used for the tests.