LT-09-3206

TEST REPORT:

LIGHTNING QUALIFICATION TESTS

ON FOUR GLENAIR 470HS013M091G AND 470HS013Z1091G

BACKSHELL TERMINATIONS WITH TSP WIRES

Report by:

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For

Glenair, Inc.
1211 Air Way
Glendale, CA 91201

Purchase Order No. H95430

Tests by:

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J. DiNicola

Test dates:

7, 9-13 October 2009

References:

LTI-4142
DB 339, pp 48-53, 55

5 January 2010

Lightning Technologies, Inc
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1.0 INTRODUCTION

Indirect effects lightning tests were performed on two Glenair 470HS013M091G and two Glenair 470HS013Z1091G Backshell Terminations with Twisted Shielded Pair (TSP) wires in order to verify their ability to tolerate lightning induced transients without system damage or upset. The test results contained in this report relate only to the test item drawings and processes as the test items/part numbers tested or to items manufactured using the same design drawings and processes as the test items.

Tests were performed by K. Crouch, and J. DiNicola of Lightning Technologies, Inc. (LTI) at our facility in Pittsfield, Massachusetts during the period of 7 through 13 October 2009. Testing was performed in accordance with Glenair's Test Plan (Ref. 1) and RTCA DO-160E, Section 22 (Ref. 2).

2.0 SUMMARY

The samples underwent testing with applied Waveform 5B (50 x 500 μs) at 4.5 kA and 10 kA levels. Bonding measurements were taken prior to and at the completion of each set of transients, resulting in resistances remaining about the same. No arcing was observed while the test was being performed. Upon visual inspection of the samples, no damage was observed.

3.0 TEST ARTICLES

Glenair provided four backshell terminations with twisted shielded pairs approximately 30 inches long. The samples are described on Table 1.

Table 1 – Test Article Description

Sample No.	Shell Size	TSP No.	TSP Type	Wire Gauge	Part Number
1	A	2	55PC2131-24	24	470HS013M091G
2	A	2	M27500	22	470HS013M091G
3	A	2	M27500	22	470HS013Z1091G
4	A	*	B08 01 238-20	20	470HS013Z1091G

*This test article was a twisted shielded quad.

Ref. 1 Glenair, Inc., *Qualification Testing Plan For Glenair 470HS013 Series Backshells Lightning Strike Survivability*, 6 August 2009

Ref. 2 RTCA, Inc., Document DO-160, *Environmental Conditions and Test Procedures for Airborne Equipment*, Revision E, 9 December 2004

4.0 TEST EQUIPMENT

Table 2 provides a list of calibrated equipment used during these tests. All measurement equipment furnished by Lightning Technologies, Inc. is calibrated by a commercial calibration agency in accordance with the requirements of the second edition of ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories,* and/or ANSI/NCSL Z540-1-1994*, Calibration Laboratories and Measuring and Test Equipment-General Requirements*, using standards traceable to the National Institute of Standards and Technology.

Table 2 – Calibrated Equipment List

Manufacturer	Nomenclature	Model No.	Serial No.	Calibration	
				Date	Due Date
LeCroy	Digital Oscilloscope	LT342	02109	25 Nov 08	25 Nov 09
Pearson	Current Probe	4160	080862	13 Jul 09	13 Jul 10
	Attenuator	A10	099669	05 May 09	05 May 10
BCD	Milliohm Meter	M1	DC001158	04 Feb 09	04 Feb 10

5.0 WAVEFORM 5B TEST REQUIREMENTS

Tests were performed in accordance with Glenair's Test Plan and Section 22 of RTCA DO-160E. Test requirements are shown in Table 3.

Table 3 – Test Requirements

Test Article Part Number	Waveform 5B Test Level (kA)
470HS013M091G	4.5
470HS013M091G	4.5
470HS013Z1091G	10
470HS013Z1091G	10

Waveform 5B is a unipolar current waveform which is characterized by a time-to-peak of 50 µs and a time-to-50% decay of 500 µs, as shown in Figure 1.

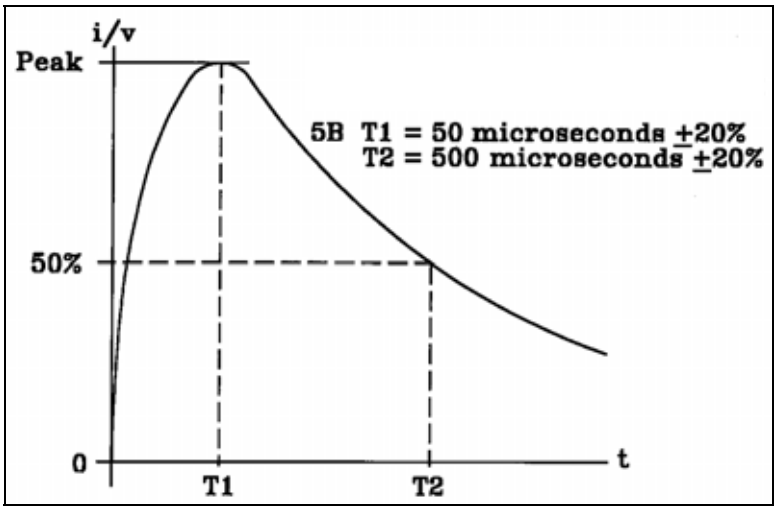


Figure 1 – Waveform 5B

Ten Waveform 5B single stroke transients were applied by direct connection to the aluminum tube. The unit was tested by applying ten pulses in the positive and ten pulses in the negative polarity.

6.0 TEST SETUP AND PROCEDURES

The wires were terminated at one end to the Glenair backshell and the appropriate solder sleeves were used to terminate the shields to the backshell. The braid straps were terminated within the backshell. The connector was fastened to a metal plate and the internal conductors were terminated at the connector end. At the opposite end the internal wire conductors were isolated from the aluminum tube.

Prior to test, the Waveform 5B generator was calibrated to produce a 4.5 kA or 10 kA, 50 x 500 µs (±20%). Pertinent waveform parameters were plotted off the screen of a digital oscilloscope and logged in the data book. Waveform calibration was performed on a low impedance loop placed through the injection transformer to record the open circuit voltage and short circuit current.

The output of the generator was bolted to the braid which was attached to the aluminum tube. The connector was mounted metal plate, as supplied by Glenair, Inc and attached to a copper ground plane. A current probe was clamped around the twisted shielded pairs to measure the shield current. Bonding measurements were taken from the aluminum tube to the backshell, connector and metal plate pre- and post-test. Figure 2 shows the laboratory setup.

Ten negative transients were applied to the aluminum tube which carried the current into the wire shields, down the shields, into the backshell, to the connector and ultimately to the metal plate. The generator polarity was reversed and the same procedure was followed as described above. Each transient was monitored on a digital

oscilloscope. Pertinent waveform parameters were plotted off the screen and logged in a data book.

The lightning test generators consisted of a dc power supply that charged a capacitor through a charging resistor. Once the capacitor was charged, a switch closed which allowed the capacitor to discharge through a waveshaping circuit and series impedance to the TSP wires.

7.0 TEST RESULTS

A complete listing of data collected from testing is provided in Tables 4 and 5. Short circuit current calibration oscillograms are provided in Figures 3 and 4. Appendix A provides all test waveform oscillograms.

No arcing was observed on Sample No. 1 and Sample No. 2 as a result of applying Waveform 5B at 4.5 kA. A visual inspection was performed and no damage was observed.

Initially Sample No. 3 and Sample No. 4 were tested to 4.5 kA. The test was repeated at 10 kA per the test plan. No arcing was observed at either test level. A visual inspection was performed and no damage was observed.

In all cases, bonding resistances remained the about same after transients had been applied to the samples. The samples were returned to Glenair, Inc. for final inspection and evaluation.

Table 4 – Waveform 5B Test Results for Test Article 470HS013M091G

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
7 October 2009				
4.5 kA Level				
1	Calibration	5,150	-	Short Circuit Current: t_{peak} = 50 µs, $t_{50\%\ decay}$ = 535 µs
11	Calibration	4.55	+	Short Circuit Current: t_{peak} = 50 µs, $t_{50\%\ decay}$ = 530 µs
13 October 2009				
Pre-Test (Negative Polarity) Resistance Measurements, Sample 1: Metal Tube to Backshell: 13.3 mΩ Metal Tube to Connector: 13.4 mΩ Metal Tube to Metal Plate: 13.5 mΩ				
176	1	4.5	-	No Arcing Observed
177	1	4.5	-	No Arcing Observed
178	1	4.5	-	No Arcing Observed
179	1	4.5	-	No Arcing Observed
180	1	4.55	-	No Arcing Observed
181	1	4.55	-	No Arcing Observed
182	1	4.55	-	No Arcing Observed
183	1	4.55	-	No Arcing Observed
184	1	4.55	-	No Arcing Observed
185	1	4.55	-	No Arcing Observed
Post-Test (Negative Polarity) and Pre-Test (Positive Polarity) Resistance Measurements, Sample 1: Metal Tube to Backshell: 13.2 mΩ Metal Tube to Connector: 13.2 mΩ Metal Tube to Metal Plate: 13.2 mΩ				
186	1	4.5	+	No Arcing Observed
187	1	4.5	+	No Arcing Observed
188	1	4.55	+	No Arcing Observed
189	1	4.55	+	No Arcing Observed

Table 4 – Waveform 5B Test Results for Test Article 470HS013M091G (*Continued*)

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
13 October 2009				
4.5 kA Level				
190	1	4.55	+	No Arcing Observed
191	1	4.55	+	No Arcing Observed
192	1	4.55	+	No Arcing Observed
193	1	4.55	+	No Arcing Observed
194	1	4.55	+	No Arcing Observed
195	1	4.55	+	No Arcing Observed
Post-Test (Positive Polarity) Resistance Measurements, Sample 1: Metal Tube to Backshell: 13.2 mΩ Metal Tube to Connector: 13.2 mΩ Metal Tube to Metal Plate: 13.3 mΩ				
Pre-Test (Negative Polarity) Resistance Measurements, Sample 2: Metal Tube to Backshell: 27.6 mΩ Metal Tube to Connector: 27.7 mΩ Metal Tube to Metal Plate: 27.8 mΩ				
196	2	4.5	+	No Arcing Observed
197	2	4.5	+	No Arcing Observed
198	2	4.5	+	No Arcing Observed
199	2	4.5	+	No Arcing Observed
200	2	4.5	+	No Arcing Observed
201	2	4.5	+	No Arcing Observed
202	2	4.5	+	No Arcing Observed
203	2	4.5	+	No Arcing Observed
204	2	4.5	+	No Arcing Observed
205	2	4.5	+	No Arcing Observed
Post-Test (Positive Polarity) and Pre-Test (Negative Polarity) Resistance Measurements, Sample 2: Metal Tube to Backshell: 27.7 mΩ Metal Tube to Connector: 27.5 mΩ Metal Tube to Metal Plate: 27.4 mΩ				

Table 4 – Waveform 5B Test Results for Test Article 470HS013M091G (*Continued*)

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
13 October 2009				
4.5 kA Level				
206	2	4.5	-	No Arcing Observed
207	2	4.5	-	No Arcing Observed
208	2	4.5	-	No Arcing Observed
209	2	4.5	-	No Arcing Observed
210	2	4.5	-	No Arcing Observed
211	2	4.5	-	No Arcing Observed
212	2	4.5	-	No Arcing Observed
213	2	4.5	-	No Arcing Observed
214	2	4.5	-	No Arcing Observed
215	2	4.5	-	No Arcing Observed
Post-Test (Negative Polarity) Resistance Measurements, Sample 2: Metal Tube to Backshell: 27.9 mΩ Metal Tube to Connector: 27.6 mΩ Metal Tube to Metal Plate: 27.5 mΩ				

Table 5 - Waveform 5B Test Results for Test Article 470HS013Z1091G

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
7 October 2009				
4.5 kA Level				
1	Calibration	5,150	-	Short Circuit Current: t_{peak} = 50 µs, $t_{50\% \ decay}$ = 535 µs
11	Calibration	4.55	+	Short Circuit Current: t_{peak} = 50 µs, $t_{50\% \ decay}$ = 530 µs
9 October 2009				
Pre-Test (Positive Polarity) Resistance Measurements, Sample 3: Metal Tube to Backshell: 20.6 mΩ Metal Tube to Connector: 21.0 mΩ Metal Tube to Metal Plate: 21.3 mΩ				
67	3	4.6	+	No Arcing Observed
68	3	4.6	+	No Arcing Observed
69	3	4.6	+	No Arcing Observed
70	3	4.55	+	No Arcing Observed
71	3	4.55	+	No Arcing Observed
72	3	4.55	+	No Arcing Observed
73	3	4.55	+	No Arcing Observed
74	3	4.55	+	No Arcing Observed
75	3	4.55	+	No Arcing Observed
76	3	4.55	+	No Arcing Observed
Post-Test (Positive Polarity) and Pre-Test (Negative Polarity) Resistance Measurements, Sample 3: Metal Tube to Backshell: 14.4 mΩ Metal Tube to Connector: 14.8 mΩ Metal Tube to Metal Plate: 14.7 mΩ				
77	3	4.55	-	No Arcing Observed
78	3	4.55	-	No Arcing Observed
79	3	4.55	-	No Arcing Observed
80	3	4.55	-	No Arcing Observed

Table 5 - Waveform 5B Test Results for Test Article 470HS013Z1091G (*Continued*)

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
9 October 2009				
4.5 kA Level				
81	3	4.55	-	No Arcing Observed
82	3	4.55	-	No Arcing Observed
83	3	4.55	-	No Arcing Observed
84	3	4.55	-	No Arcing Observed
85	3	4.55	-	No Arcing Observed
86	3	4.55	-	No Arcing Observed
Post-Test (Negative Polarity) Resistance Measurements, Sample 3: Metal Tube to Backshell: 14.4 mΩ Metal Tube to Connector: 14.8 mΩ Metal Tube to Metal Plate: 14.6 mΩ				
Pre-Test (Negative Polarity) Resistance Measurements, Sample 4: Metal Tube to Backshell: 13.6 mΩ Metal Tube to Connector: 14.0 mΩ Metal Tube to Metal Plate: 14.1 mΩ				
87	4	4.55	-	No Arcing Observed
88	4	4.55	-	No Arcing Observed
89	4	4.55	-	No Arcing Observed
90	4	4.55	-	No Arcing Observed
91	4	4.55	-	No Arcing Observed
92	4	4.55	-	No Arcing Observed
93	4	4.55	-	No Arcing Observed
94	4	4.55	-	No Arcing Observed
95	4	4.55	-	No Arcing Observed
96	4	4.55	-	No Arcing Observed
Post-Test (Negative Polarity) and Pre-Test (Positive Polarity) Resistance Measurements, Sample 4: Metal Tube to Backshell: 13.3 mΩ Metal Tube to Connector: 13.7 mΩ Metal Tube to Metal Plate: 13.5 mΩ				

Table 5 - Waveform 5B Test Results for Test Article 470HS013Z1091G (*Continued*)

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
9 October 2009				
4.5 kA Level				
97	4	4.55	+	No Arcing Observed
98	4	4.55	+	No Arcing Observed
99	4	4.55	+	No Arcing Observed
100	4	4.55	+	No Arcing Observed
101	4	4.55	+	No Arcing Observed
102	4	4.55	+	No Arcing Observed
103	4	4.55	+	No Arcing Observed
104	4	4.55	+	No Arcing Observed
105	4	4.55	+	No Arcing Observed
106	4	4.55	+	No Arcing Observed
Post-Test (Positive Polarity) Resistance Measurements, Sample 4: Metal Tube to Backshell: 13.4 mΩ Metal Tube to Connector: 13.7 mΩ Metal Tube to Metal Plate: 13.6 mΩ				
133	Calibration	10.5	-	Short Circuit Current: t_{peak} = 47 µs, $t_{50\% \ decay}$ = 505 µs
Samples 3 and 4 were Supposed to be Tested to 10 kA only, not 4.5 kA				
Pre-Test (Negative Polarity) Resistance Measurements, Sample 3: Metal Tube to Backshell: 13.3 mΩ Metal Tube to Connector: 13.5 mΩ Metal Tube to Metal Plate: 13.6 mΩ				
10 October 2009				
10 kA Level				
136	3	9.9	-	No Arcing Observed
137	3	10.0	-	No Arcing Observed
138	3	10.0	-	No Arcing Observed
139	3	10.5	-	No Arcing Observed

Table 5 - Waveform 5B Test Results for Test Article 470HS013Z1091G (*Continued*)

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
10 October 2009				
10 kA Level				
140	3	10.5	-	No Arcing Observed
141	3	10	-	No Arcing Observed
142	3	10	-	No Arcing Observed
143	3	10.5	-	No Arcing Observed
144	3	10.5	-	No Arcing Observed
145	3	10	-	No Arcing Observed
Post-Test (Negative Polarity) and Pre-Test (Positive Polarity) Resistance Measurements, Sample 3: Metal Tube to Backshell: 14.0 mΩ Metal Tube to Connector: 13.9 mΩ Metal Tube to Metal Plate: 13.9 mΩ				
146	3	10	+	No Arcing Observed
147	3	10	+	No Arcing Observed
148	3	10	+	No Arcing Observed
149	3	10	+	No Arcing Observed
150	3	10	+	No Arcing Observed
151	3	10.5	+	No Arcing Observed
152	3	10	+	No Arcing Observed
153	3	10	+	No Arcing Observed
154	3	10	+	No Arcing Observed
155	3	10	+	No Arcing Observed
Post-Test (Positive Polarity) Resistance Measurements, Sample 3: Metal Tube to Backshell: 13.9 mΩ Metal Tube to Connector: 13.9 mΩ Metal Tube to Metal Plate: 14.0 mΩ				
Pre-Test (Positive Polarity) Resistance Measurements, Sample 4: Metal Tube to Backshell: 14.7 mΩ Metal Tube to Connector: 15.0 mΩ Metal Tube to Metal Plate: 15.0 mΩ				

Table 5 - Waveform 5B Test Results for Test Article 470HS013Z1091G (*Continued*)

Test No.	Sample No.	Peak Current (kA)	Polarity (+/-)	Comments
10 October 2009				
10 kA Level				
156	4	10.5	+	No Arcing Observed
157	4	10	+	No Arcing Observed
158	4	10	+	No Arcing Observed
159	4	10	+	No Arcing Observed
160	4	10	+	No Arcing Observed
161	4	10	+	No Arcing Observed
162	4	10	+	No Arcing Observed
163	4	10	+	No Arcing Observed
164	4	10	+	No Arcing Observed
165	4	10	+	No Arcing Observed
Post-Test (Positive Polarity) and Pre-Test (Negative Polarity) Resistance Measurements, Sample 4: Metal Tube to Backshell: 15.5 mΩ Metal Tube to Connector: 15.5 mΩ Metal Tube to Metal Plate: 15.8 mΩ				
166	4	9.9	-	No Arcing Observed
167	4	10	-	No Arcing Observed
168	4	10	-	No Arcing Observed
169	4	10.5	-	No Arcing Observed
170	4	10.5	-	No Arcing Observed
171	4	10.5	-	No Arcing Observed
172	4	10	-	No Arcing Observed
173	4	10	-	No Arcing Observed
174	4	10	-	No Arcing Observed
175	4	10	-	No Arcing Observed

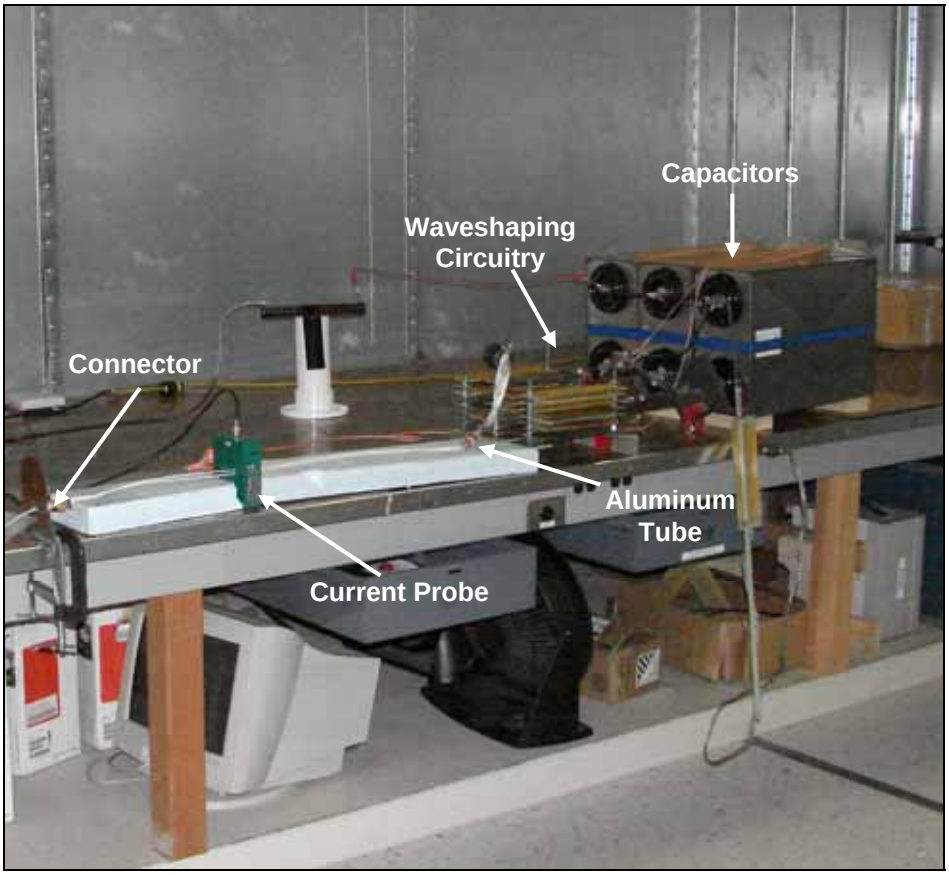
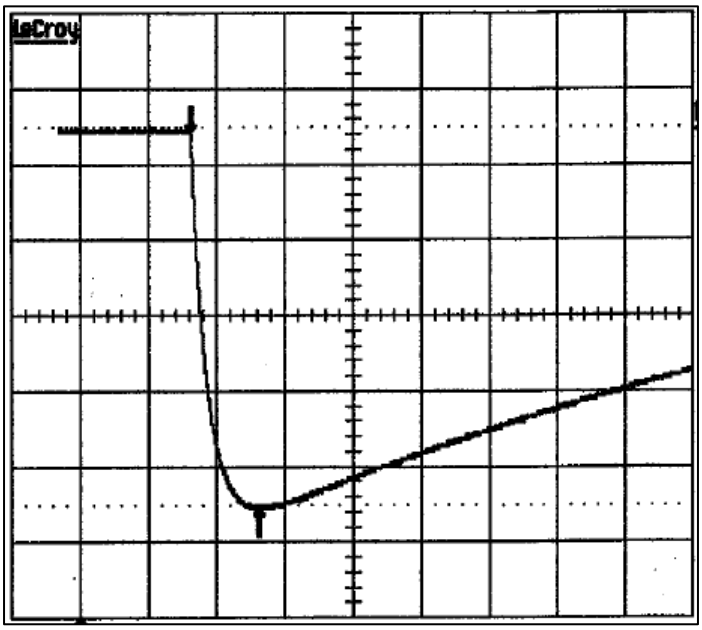


Figure 2 – Laboratory Test Setup

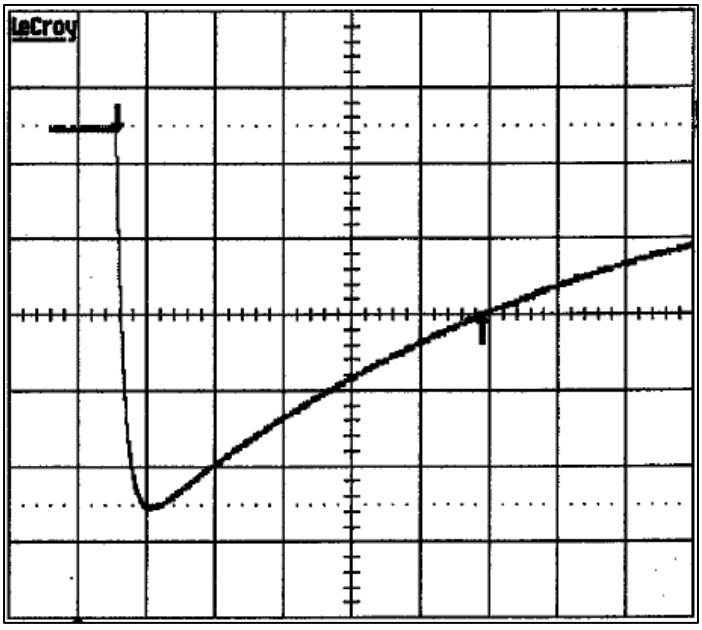


1,040 A/div. 50 µs/div.

Test No. 1

Short Circuit Current
Negative Polarity

I_{peak} = 5,150 A
t_{peak} = 50 µs



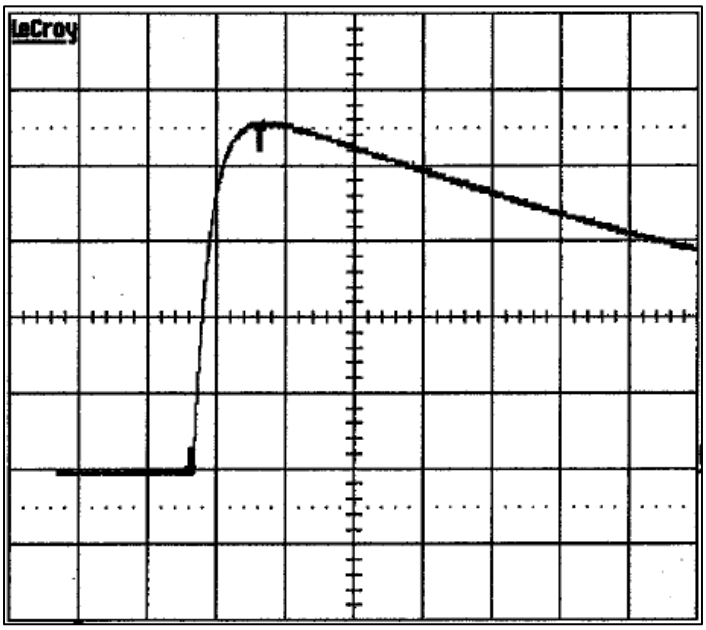
1,040 A/div. 100 µs/div.

Test No. 1

Short Circuit Current
Negative Polarity

I_{peak} = 5,150 A
$t_{50\% \text{ decay}}$ = 535 µs

Figure 3A – Waveform 5B Generator Verification Oscillograms
(4.5 kA Level)

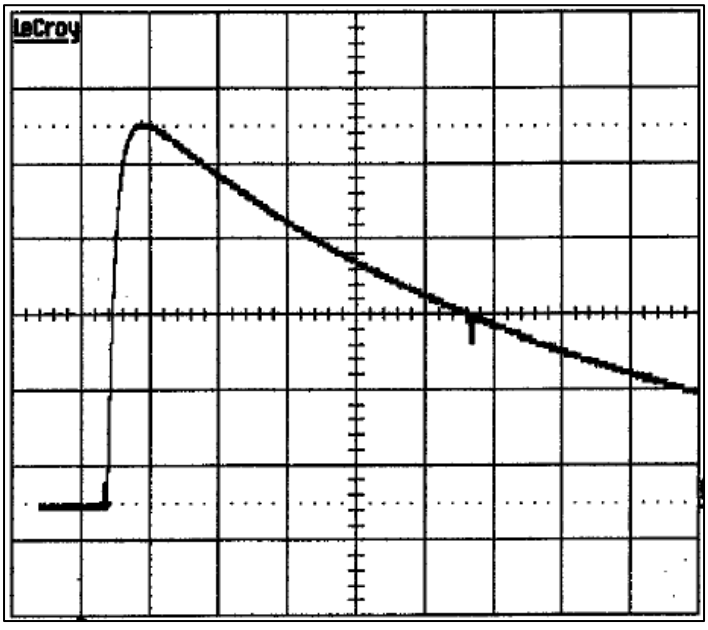


1,000 A/div. 50 µs/div.

Test No. 11

Short Circuit Current
Positive Polarity

I_{peak} = 4,550 A
t_{peak} = 50 µs



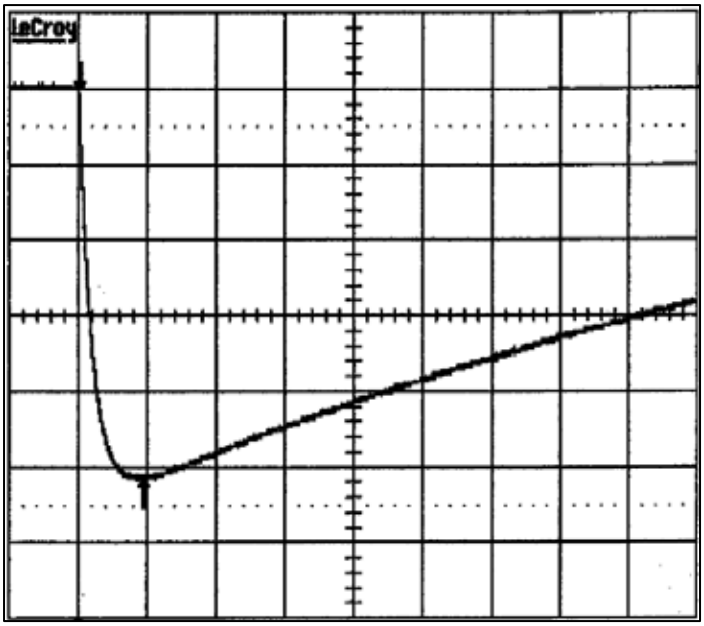
910 A/div. 100 µs/div.

Test No. 11

Short Circuit Current
Positive Polarity

I_{peak} = 4,550 A
$t_{50\% \text{ decay}}$ = 530 µs

Figure 3B – Waveform 5B Generator Verification Oscillograms
(4.5 kA Level)

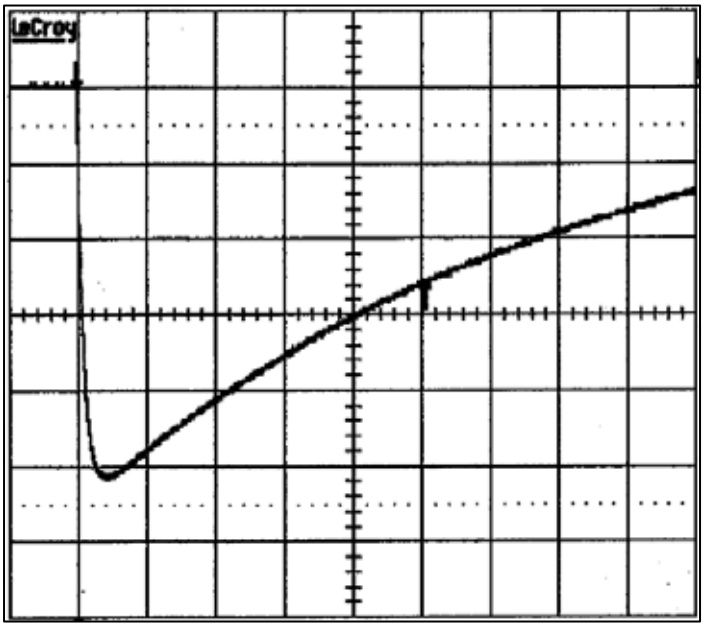


Test No. 133

Short Circuit Current
Negative Polarity

I_{peak} = 10,500 A
t_{peak} = 47 µs

2,000 A/div. 50 µs/div.



Test No. 133

Short Circuit Current

I_{peak} = 10,500 A
$t_{50\% \text{ decay}}$ = 505 µs

2,000 A/div. 100 µs/div.

Figure 4 – Waveform 5B Generator Verification Oscillograms
(10 kA Level)