TS-SSC 91-011

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1-21-91

Failure of DC0303 During Impulse Test

The dipole magnet DC0303 (a 40mm aperture, long SSC magnet) failed an impulse test on 1-17-91. This magnet was about to enter the cryostating stage of its fabrication. It had previously undergone impulse testing twice: The individual coils had been pulsed to 1000 V in their free state, and the upper, lower and total coils of the collared coil assembly had each been pulsed to a maximum of 2000 V prior to yoking. The results of the latter tests are shown in figures 1-3. This note summarizes the sequence of events which occurred immediately prior to the determination that an upper inner coil to lower inner coil short exists in DC0303.

The completed cold mass of DC0303 was moved to the cryostating area of the ICB and a full set of electrical checks, including coil to ground hipots, were made. The magnet was then readied for the impulse test which involves switching the equivalent of a charged 60 μf capacitor in series with the magnet and measuring the frequency characteristics of this RLC circuit. The capacitor is charged to 500, 1000, 1500 and 2000 volts and the resonant frequency is measured for each of these voltages. If a turn to turn short develops, the inductance, L , of the circuit will change and therefore so will the measured frequency. This was the first long magnet for which an impulse test was being done after the yoking stage of its assembly. It is important to determine if any shorts exist prior to cryostating to insure that this work will not be wasted.

The capacitors of the impulse test apparatus were charged to 500 volts for the initial pulse and discharged. Two individuals standing at the lead end of the magnet reported hearing a pop when this occurred which they believed had come from the instrumentation wiring extending from the magnet. The scope display showed that the voltage drop across the magnet had reached 500 volts and had begun to decrease following the expected sinusoidal curve for a few tens of μs, and then had dropped rapidly to zero. Upon examination of the instrumentation wiring, it was found that the voltage taps had not been double insulated where they were soldered to their connectors and it was thought that a short to ground had occurred through one of these wires. They were insulated with Kapton tape and the test was repeated, with the voltage set to

100V. The magnet behaved as expected at this voltage; the circuit oscillating with a frequency of about 90 Hz. The test voltage was increased to 500 volts and the capacitors were discharged. The digital scope indicated that the magnet again had shorted, this time nearly instantaneously with the beginning of the discharge, as seen in figure 4. All cabling was rechecked for shorts to ground and some double insulating was done. The assembly was DC hipotted to 3000 V to check that there were no internal coil shorts to the beam pipe or collars, or shorts through the instrumentation wire to ground. The scope probe was also replaced. The magnet was then pulsed at 100 volts and was seen to be completely shorted. A resistance measurement across the magnet now showed that the total coil resistance was about 6.2 to 6.4 Ω, as opposed to 6.59 Ω before the impulse tests, and was dependent on the current used (0.1 or 1 amp) to make the measurement. Resistance measurements done at this time indicated that a short existed between the upper and lower inner coils. A short of this nature across the mid-plane of the magnet explains the results of the impulse test. (It should be pointed out that the maximum voltage differential between the upper and lower inner coils at the mid-plane during an impulse test is approximately the full voltage to which the capacitors are charged.) The following morning another series of resistance measurements were made to try to determine the position of the short. During the course of these measurements the total coil resistance dropped to approximately 2 Ω and then to 0.89 Ω and stabilized (at least when measurements were made using 0.1 amps). Evidently the 1 amp used to make resistance measurements was sufficient to "burn in" the short. Further measurements were made by Jim Strait and are summarized in TS-SSC-91-010.

To summarize, an electrical breakdown occurred in DC0303 between the upper and lower inner coils across the mid-plane during impulse testing at 500 V. The magnet had successfully withstood D.C. hipotting across the mid-plane to 3000 V before the upper to lower splice had been made, and impulse testing, to a maximum of 2000 V, of the collared coil assembly.

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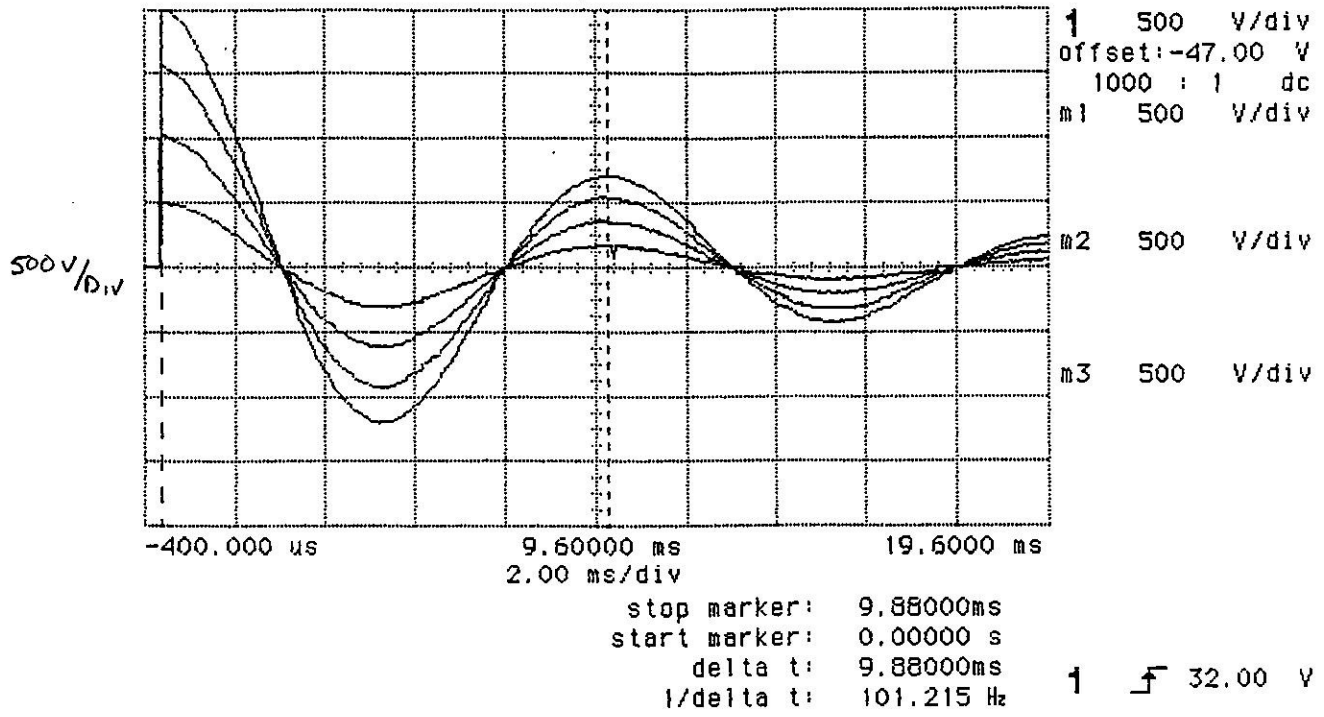
303 WHOLE MAGNET

Whole Magnet
DCφ3φ3



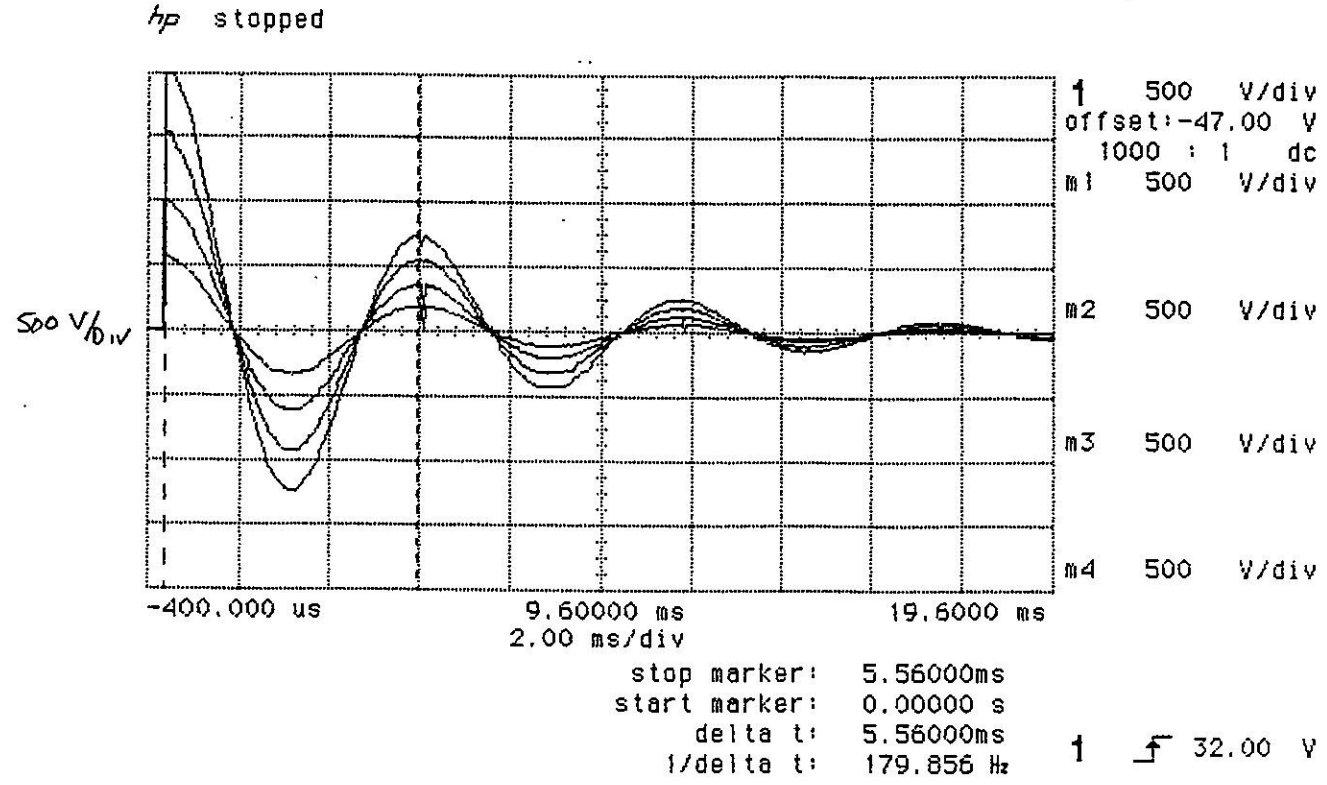
Collared Coil Assembly

Figure 1

Upper Coils

DC ϕ 3 ϕ 3

Collared Coil Assembly



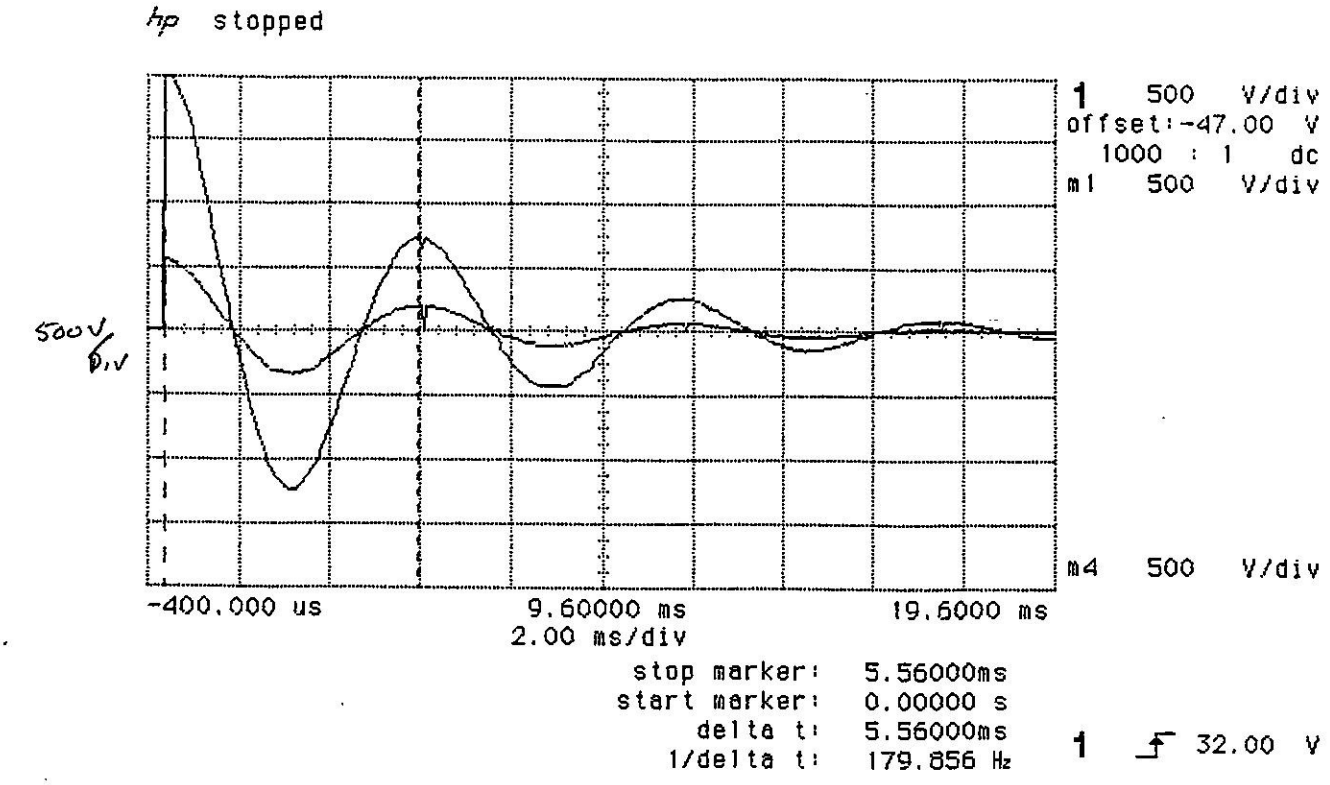


Figure 2

LOWER 503

Collared Coil Assemby

Lower coils

DCφ3φ3

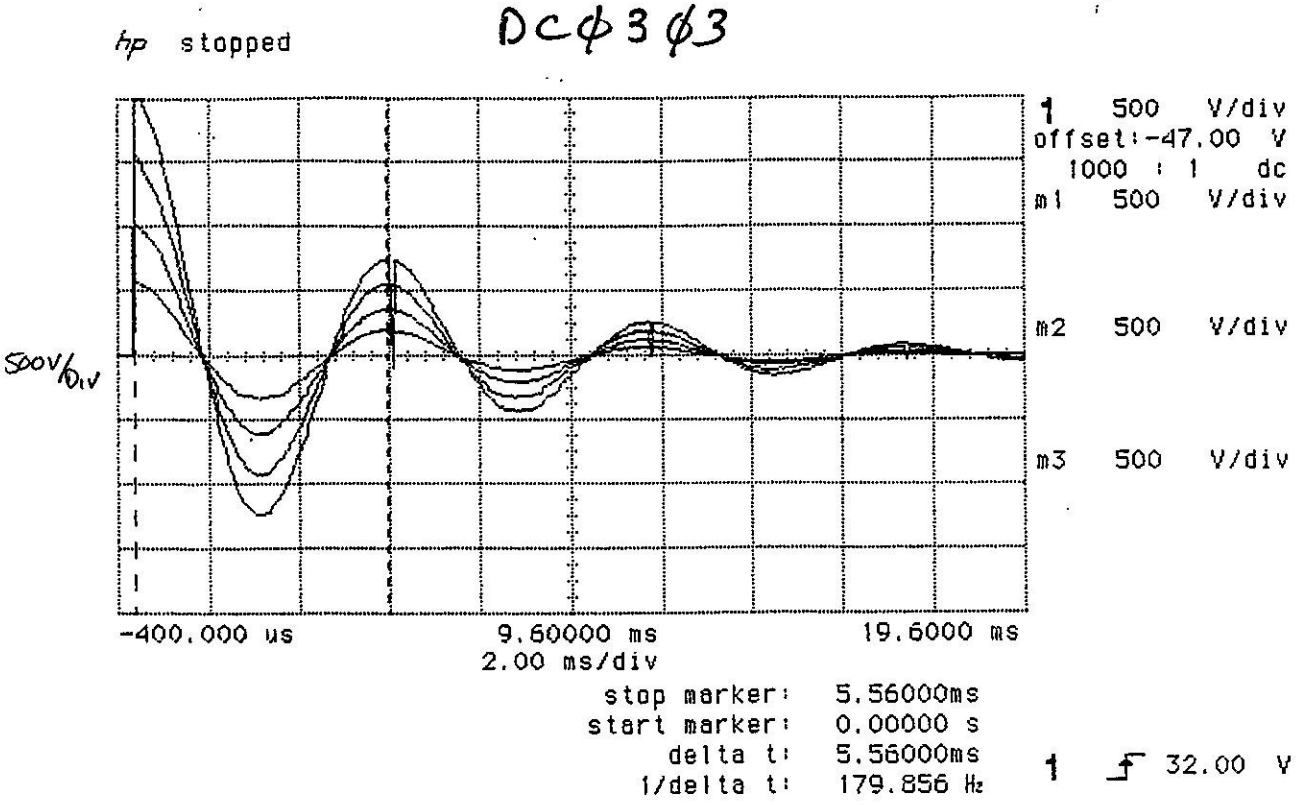
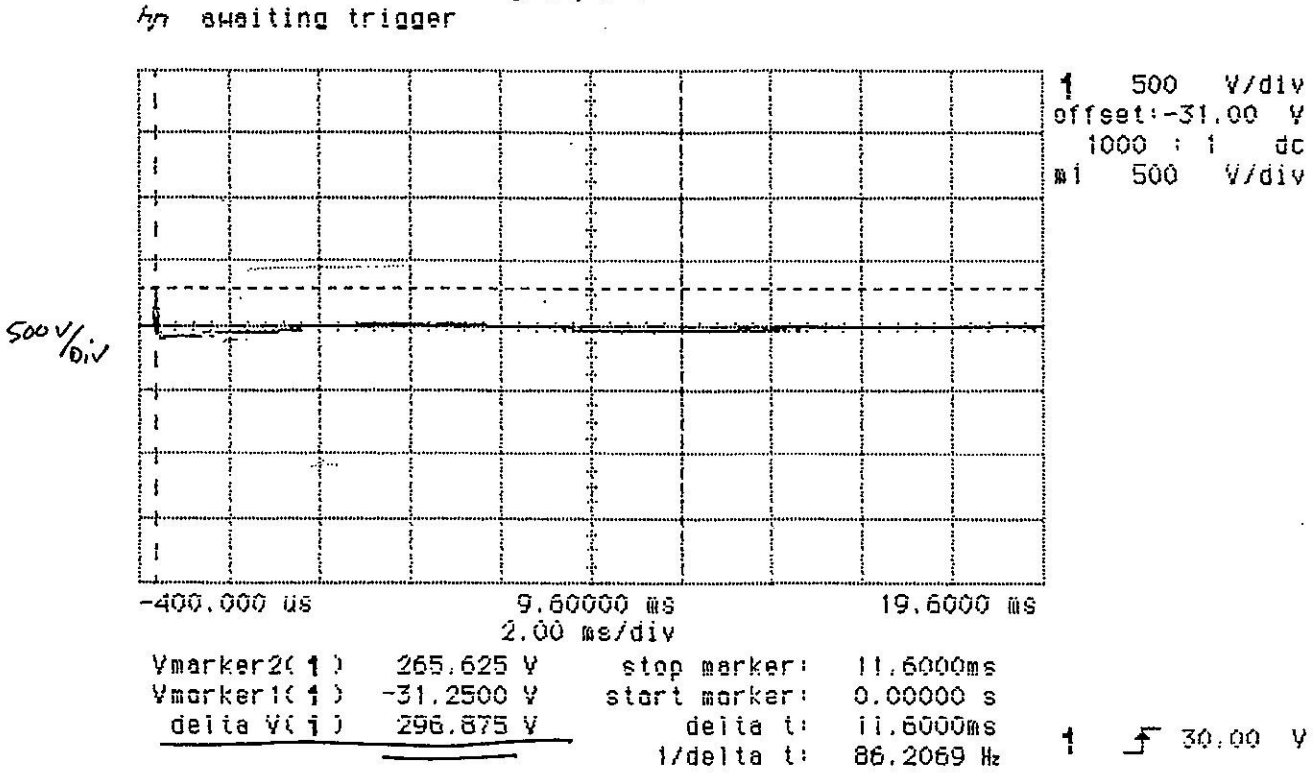


Figure 3

Whole Magnet

DCØ3Ø3



Yoked Coil Assembly

Capacitor Voltage = 500 V

Figure 4