

References

- Akhmetov, A.A., and T. Ogitsu, "Periodicity of eddy currents in flat Rutherford-type cables", *SSCL test and analysis note MD-TA-245* (1993a).
- Akhmetov, A.A., et al., "Current loop decay in Rutherford cables", *SSCL-Preprint-485* (1993b).
- Akhmetov, A.A., A. Devred, and T. Ogitsu, "Periodicity of crossover currents in a Rutherford-type cable subjected to a time-dependent magnetic field". *J. Appl. Phys.* **75**(6), pp. 3176-3183 (1994).
- Akhmetov, A.A., K. Kuroda, and M. Takeo, "Influence of sample geometry on amplitude of eddy current oscillation in Rutherford-type cables", *IEEE Trans. Appl. SC* **5**, pp. 725-728 (1995).
- Akita, S., et al., "AC loss and quenching characteristics of 500 kVA AC superconducting coil", *KEK proc. 92-14*, K. Tsuchiya, Ed., pp.40-43 (1992).
- Amemiya, N., et al., "Influence of current re-distribution and thermal diffusion among strands on stability of superconducting cables against local disturbances", *IEEE Trans. Magn.* **30**, pp. 2281-2284 (1994b).
- Anderson, P.W., Theory of flux creep in hard superconductors", *Phys. Rev. Lett.* **9**, pp. 309-311 (1962).
- Andreyev, N.I. et al., "Study of AC losses in the models of SC magnets for UNK", *Proc. MT-9*, pp. 524-527 (1985).
- Asner, A., et al., "First Nb₃Sn 1 m long superconducting dipole model magnet for the LHC break the 10 T field threshold", *Proc. MT-11*, pp. 36-41 (1990).
- AT-MA '93: Summary of the CERN AT-MA meeting of 11-11-1993 (1993).
- Avest, D. ter, and L.J.M. van de Klundert, "On the interstrand resistances in superconducting cables", *Cryogenics* **30**, p. 694 (1990).
- Avest, D. ter, *Properties of the superconductor in accelerator dipole magnets*, PhD thesis, University of Twente, The Netherlands, 1991.
- Balbekov, V.I., et al., "The IHEP accelerating and storage complex (UNK)", *Proc. IHEP XII* (1983).
- Bona, M. et al., "Design, fabrication variants and results of LHC twin aperture models", *IEEE Trans. Magn.* **28**, pp. 338-341 (1992).
- Brück, H. et al., "Time dependence of persistent current effects in the superconducting HERA magnets", *Proc. MT-11*, pp. 141-146 (1990).
- Brück, H. et al., "Observation of a periodic pattern in the persistent-current fields of the superconducting HERA dipole magnets", *DESY 91-01* (1991a).
- Brück, H. et al., "Observation of a periodic pattern in the persistent-current fields of the superconducting HERA dipole magnets", *Proc. '91 IEEE Part. Acc. Conf.*, pp. 2149-2151 (1991b).

- Burnod, L., and J.B. Jeanneret, "Beam losses in the SPS and the LHC due to beam-gas and beam-beam collisions", *CERN LHC note 91* (1989).
- Burnod, L., and J.B. Jeanneret, "Beam losses and collimation in the LHC: a quantitative approach", *CERN LHC note 167* (1991).
- Campbell, A.M., "A general treatment of losses in multifilamentary superconductors", *Cryogenics* **22**, pp. 3-16 (1982).
- Carr, W.J. Jr., "AC loss in a twisted filamentary superconducting wire", *J. Appl. Phys.* **45**(2), pp. 929-934 (1974).
- Carr, W.J. Jr., et al., "Alternating field losses in a multifilamentary superconducting wire for weak ac fields superposed on a constant bias", *J. Appl. Phys.* **46**, pp. 4048-4052 (1975).
- Caspi, S., et al., "Ramp rate sensitivities of several superconducting dipole magnets operated in He I and superfluid He II", *IEEE Trans. Magn.* **MAG-19**, pp. 1394-1397 (1983).
- Caspi, S., et al., "The effects of filament magnetization in superconducting magnets as calculated by Poisson", *IEEE Trans. Magn.* **MAG-23**, pp. 510-513 (1987).
- Cole, F.T., et al., "Report on the design of the Fermi National Laboratory superconducting accelerator", *FNAL int. report* (1979).
- Collings, E.W., *Applied superconductivity – metallurgy, and physics of titanium alloys*, Plenum press, New York, 1986.
- Coull, L., et al., "LHC quench protection system", *IEEE Trans. Magn.* **30**, pp. 1742-1745 (1994).
- Courant, E.D., "Eddy currents in superconducting braid", *ISABELLE Technical note 168* (1980).
- Dauguet, P., "Mesure de la conductivite thermique des isolations des aimants du futur accelerateur du CERN: le LHC", *Int. report (in French) CERN* (1992).
- Dell'Orco, D., et al., "Design of the Nb3Sn dipole D20", *IEEE Trans. Appl. SC* **3**, pp. 82-86 (1993).
- Devred, A., and T. Ogitsu, "Ramp-rate sensitivity of SSC dipole magnet prototypes", *KEK preprint 94-156* (1994).
- Druyvesteyn, W.F., "The resistivity of hard superconductors subjected to an increasing field", *Phys. Lett.* **25A**, pp. 31-32 (1967).
- Durand, E., *Magnetostatique*, Masson, Paris, 1968.
- Edwards, H.T., "The Superconducting Super Collider", *Proc. 2nd EPAC conf.*, pp. 356-360 (1990).
- Egorov, S.A., et al., "AC coupling losses in superconducting cables of finite length", *Presented at the ITER Magnet System technical Meeting, MIT, Boston, ITER-RF-MS/ACL-02-09-94* (1994).
- Faivre, D., and B. Turck, "Current sharing in an insulated multistrand cable in transient and steady state current conditions", *IEEE Trans. Magn.* **MAG-17**, pp. 1048-1051 (1981).
- Finley, D.A., et al., "Time dependent chromaticity changes in the Tevatron", *Proc. IEEE Part. Acc. Conf.*, pp. 151-153 (1987).
- Foner, S., and B.B. Schwartz, Eds., *Superconductor materials science – metallurgy, fabrication, and applications*, Plenum press, New York, 1981.

- Genevey, P., et al., "Cryogenic tests of the first two LHC quadrupole prototypes", *IEEE Trans. Appl. SC* **5**, pp. 202-205 (1995).
- Ghosh, A.K., "Ramp rate effects in superconducting cables and dipole magnets", *Int. note BNL* (1992).
- Ghosh, A.K., et al., "Axial variations in the magnetic field of superconducting dipoles and quadrupoles", *Proc. '93 IEEE Part. Acc. Conf.*, pp. 2742-2744 (1993).
- Ghosh, A.K., et al., "The ramp rate dependence of the sextupole field in superconducting dipoles", *IEEE Trans. Magn.* **30**, pp. 1718-1721 (1994).
- Gilbert, W.S., et al., "Magnetic field decay in model SSC dipoles", *IEEE Trans. Magn.* **25**, pp. 1459-1462 (1989).
- Gömöry, F., and L. Cesnak, "Loss and magnetization of superconducting magnets pulsed at very low ramp rates", *Cryogenics* **25**, pp. 375-380 (1985).
- Green, M.A., LBL report 23823 (1987).
- Groover, F.W., *Inductance calculations – working formulas and tables*, Dover Publications, New York, p. 55, 1946.
- Hague, B., *The principles of electromagnetism*, Dover publications, New York (1962).
- Haken, B. ten, *Strain effects on the critical properties of high-field superconductors*, PhD thesis, University of Twente, The Netherlands, 1994.
- Hartmann, R.A., A contribution to the understanding of AC losses in composite superconductors, PhD thesis, University of Twente, The Netherlands, 1989.
- Hosono, F., et al., "AC loss of the toroidal model pancake (TMP)", *IEEE Trans. Appl. SC* **3**, pp. 531-534 (1993).
- Kate, H.H.J. ten, "AC losses and magnet research", *Adv. Cryog. Eng.* **40**, pp. 559-568 (1994).
- Kim, Y.B., et al., "Critical persistent currents in hard superconductors", *Phys. Rev. Lett.* **9**, pp. 306-309 (1962).
- Kimura, A., et al., "Stabilities of the Rutherford cables with Cu matrix and CuMn barrier", *IEEE Trans. Appl. SC* **5**, pp. 385-388 (1995).
- Klundert, L.J.M. van de, et al., "Degradation of the maximum transport current in wires and cables caused by coupling currents", *Proc. MT-11*, pp. 1021-1026 (1990).
- Knoopers, H.G., et al., "Distribution of currents in a 6-strand superconducting cable", *Proc. MT-9*, pp. 539-542 (1985).
- Kovachev, V.T., et al., "Interstrand resistance of DSA328 inner coil", SSCL-637 (1993a).
- Kovachev, V.T., et al., "Interstrand resistance of selected sections of DCA312", SSCL-651 (1993b).
- Kovachev, V.T., et al., "Interstrand resistance of SSC magnets", *Cryogenics* **34**, pp. 813-820 (1994).
- Krempasky, L., "AC losses in flat twisted superconducting cables", *CERN int. note SPS/EA/78-2* (1978).
- Krempasky, L., C. Schmidt, "Influence of a longitudinal variation in dB/dt on the magnetic field distribution of accelerator magnets", *Appl. Phys. Lett.* **66**(12), pp. 1545-1547 (1995a).

- Krempasky, L., and C. Schmidt, "A possible explanation of the problem of ramp rate limitation in large superconducting magnets", *Presented at MT-14*, Tampere (1995b).
- Kwasnitza, K., and B. Bruzzone, "Large AC losses in superconducting multistage Nb₃Sn cables due to low transverse resistance", *Proc. ICEC-11*, pp. 741-745 (1986).
- Lei, Y.Z., et al., "AC loss measurements of Rutherford type superconducting cables under mechanical stresses", *IEEE Trans. Appl. SC* **3**, p. 747 (1993).
- Leroy, D., et al., "Test results on 10 T LHC superconducting one metre long dipole models", *IEEE Trans. Appl. SC* **3**, p. 614 (1993a).
- Leroy, D., et al., "Quench observation in LHC superconducting one meter long dipole models by field perturbation measurements", *IEEE Trans. Appl. SC* **3**, pp. 781-784 (1993b).
- LHC, '88, From: Specifications *CERN SPS/EMA 88-1* (1998).
- LHC, '91, The LHC Study Group, "Design Study of the Large Hadron Collider", *CERN 91-03* (1991).
- LHC, '93, The LHC Study Group, "LHC, The Large Hadron Collider Accelerator project", *CERN/AC/93-03/LHC* (1993).
- London, H., "Alternating current losses in superconductors of the second kind", *Phys. Lett.* **6**, pp. 162-165 (1963).
- Lubell, M.S., "Emperical scaling formulas for critical current and critical field for commercial NbTi", *IEEE Trans. Magn.* **19**, pp. 754-757 (1983).
- Lvovsky, Y.M., "Stability against transient disturbances in cable-in-conduit conductors cooled by supercritical helium", *IEEE Trans. Appl. SC* **5**, pp. 584-587 (1995).
- Mallick, G.T., et al., "Results of AC loss measurements on heat treated SSC cables", *IEEE Trans. Appl. SC* **3**, p. 744 (1993).
- Marken, K.R., et al., "Magnetization decay of SSC-type strands in various short sample configurations", *Adv. Cryog. Eng.* **38**, pp. 715-722 (1992).
- Meuris, C., "Heat transport in insulation of cables cooled by superfluid helium", *Cryogenics* **31**, pp. 624-628 (1991).
- Meuris, C., "Comparaison de differentes isolations", *Workshop on LHC technology, Chamonix* (1993).
- Morgan, G.H., "Theoretical behavior of twisted multicore superconducting wire in a time varying uniform magnetic field", *J. Appl. Phys.* **41**, pp. 3673-3679 (1970).
- Morgan, G.H., "Eddy currents in flat metal-filled superconducting braids", *J. Appl. Phys.* **44**, pp. 3319-3322 (1973).
- Mower, T.M. and Y. Iwasa, "AC losses in multifilamentary composite superconducting strands and cables", *Adv. Cryog. Eng.* **32**, pp. 771-778 (1986).
- Niessen, E.M.J., et al., "Application of the network method to superconducting cables", *Proc. LTEC 90*, p. 5.4 (1990a).
- Niessen, E.M.J., and L.J.M. van de Klundert, "Loss calculations for the 29-strand NET braid", *University of Twente, Int. note UTNET90.2* (1990b).

- Niessen, E.M.J., *Continuum electromagnetics of composite superconductors*, PhD thesis, University of Twente, The Netherlands, 1993.
- Nijhuis, A., et al., "Parametric study on coupling loss in subscale ITER Nb₃Sn cables specimen", *Presented at MT-14, Tampere* (1995).
- Oberli, L.R., CERN Div. AT-MA, CH1211 Geneva 23, unpublished measurements (1995).
- Ogitsu, T., et al., "Influence of cable eddy currents on magnetic field harmonics", *KEK proc. 92-14*, K. Tsuchiya, Ed., pp. 23-27 (1992a).
- Ogitsu, T., et al., "Influence of cable eddy currents on magnetic field harmonics", *SSCL-preprint-134 Rev A* (1992b).
- Ogitsu, T., "Dependence of AC loss and multipole coefficients on cable eddy currents", *SSCL test & analysis note MD-TA-240* (1993).
- Ogitsu, T., "Influence of cable eddy currents on the magnetic field of superconducting particle accelerator magnets", *SSCL-N-848* (1994).
- Ono, M., et al., "Estimation method of stability for the multi-strand superconducting cables under partial current distribution", *IEEE Trans. Appl. SC* **5**, pp. 564-567 (1995).
- Ouden, A. den, et al., "An experimental 11.5 T Nb₃Sn LHC type of dipole magnet", *IEEE Trans. Magn.* **30**, pp. 2320-2323 (1994).
- Ozaki, S., "Relativistic Heavy Ion Collider RHIC at Brookhaven", *Proc. 2nd EPAC conf.*, P. Marin, P. Mandrillon, Eds, pp. 70-73 (1990).
- Ozelis, J.P., et al., "AC loss measurement of model and full size 50 mm SSC collider dipole magnets at Fermilab", *IEEE Trans. Appl. SC* **3**, pp. 678-681 (1993).
- Pang, C.Y., *Losses in type-II superconducting wire due to alternating and rotating fields*, PhD thesis, University of Cambridge, 1980.
- Perin, R., "Status of LHC programme and magnet development", *IEEE Trans. Appl. SC* **5**, pp. 189-195 (1995).
- Rem, P.C., et al., "A numerical analysis of saturation in multifilamentary wires, carrying AC transport current in an AC-transverse field", *Proc. MT-9*, C. Marinucci, and P. Weymuth, Eds, pp. 567-570 (1985).
- Rem, P.C., *Numerical models for AC superconductors*, PhD thesis, University of Twente, The Netherlands, 1986.
- Richter, D., CERN Div. AT-MA, CH1211 Geneva 23, unpublished measurements (1995).
- Ries, G., and S. Takacs, "Coupling losses in finite length of superconducting cables and in long cables partially in magnetic field", *IEEE Trans. Magn.* **17**, p. 2281 (1981).
- Roovers, A.J.M., et al., "AC losses in a mixed matrix multifilamentary superconducting wire", *Proc. ICEC-11*, G. and I. Klipping, Eds, pp. 766-775 (1986).
- Russenschuck, S., Calculations performed by S. Russenschuck using ROXIE as described in "ROXIE – The routine for the optimization of magnet X-sections, inverse problem solving and end region design", *CERN LHC note 238* (1993).

- Sampson, W.B., and A.K. Ghosh, "Induced axial oscillations in superconducting dipole windings", *IEEE Trans. Appl. SC* **5**, pp. 1036-1039 (1995).
- Schermer, R.I., and B.P. Turck, "Current sharing between insulated strands in a superconducting cable", *Adv. Cryog. Eng.* **26**, pp. 599-607 (1979).
- Shintomi, T. et al., "AC losses of Rutherford-type superconducting cables", *Adv. Cryog. Eng.* **40**, pp. 501-508 (1994).
- Siemko, A., CERN Div. AT-MA, CH1211 Geneva 23, unpublished results (1994).
- Siemko, A., "Quench localization in the superconducting model magnets for the LHC by means of pick-up coils", *IEEE Trans. Appl. SC* **5**, pp. 1028-1031 (1995).
- Spigo, G.-C., CERN Div. AT-MA, CH1211 Geneva 23, unpublished calculations (1994).
- Sumption, M.D., et al., "Calorimetric measurements of the effect of Ni and staybrite coatings on AC losses in accelerator cables", *Presented at the ICMC'95, Columbus* (1995).
- Sytnikov, V.E., et al., "Coupling losses in superconducting transposed conductors located in changing magnetic fields", *Cryogenics* **29**, pp. 926-930 (1989a).
- Sytnikov, V.E., et al., "Experimental study of transverse resistance and coupling losses in superconducting transposed cables", *Presented (but not published) at MT-11* (1989b).
- Sytnikov, V.E., et al., "Transport and induced currents distribution in superconducting transposed cables", *Adv. Cryog. Eng.* **38**, pp. 553-558 (1992).
- Sytnikov, V.E., and I.B. Peshkov, "Coupling losses for superconducting cables in pulsed fields", *Adv. Cryog. Eng.* **40**, pp. 537-542 (1994).
- Takacs, S., "Coupling losses in cables in spatially changing AC fields", *Cryogenics* **22**, pp. 661-665 (1982).
- Tixador, P., et al., "Coupling losses in a superconducting model magnet for the LHC", *Proc. MT-11*, T. Sekigushi, and S. Shimamoto, Eds, pp. 54-59 (1990).
- Turck, B., "Influence of a transverse conductance on current sharing in a two-layer superconducting cable", *Cryogenics* **14**, pp. 448-454 (1974).
- Verweij, A.P., and R. Wolf, "Field errors due to eddy currents in the cable of the LHC pinkbook dipole", *CERN int. note AT-MA 92-52* (1992).
- Verweij, A.P., and R. Wolf, "Field errors due to inter-strand coupling currents in the LHC dipole and quadrupole", *CERN int. note AT-MA 94-97* (1994).
- Vysotsky, V.S., et al., "On stability of multistrand cables with insulated or highly resistive matrix strands", *IEEE Trans. Appl. SC* **5**, pp. 572-575 (1995a).
- Vysotsky, V.S., et al., "New method of current distribution studies for ramp rate stability of multistrand superconducting cables", *IEEE Trans. Appl. SC* **5**, pp. 580-583 (1995b).
- Walckiers, L., "Behaviour of the LHC models with respect to the conductor limit", *CERN int. note AT-MA 93-82* (1993).
- Walckiers, L., "The harmonic-coil method", *CERN accelerator school on magnetic measurements and alignment*, pp. 138-166, CERN 92-05 (1992).

- Walters, C.R., "Magnetization and design of multistrand superconducting conductors", *IEEE Trans. Magn.* **MAG-11**, pp. 328-331 (1975).
- Wanderer, P., et al., "Magnetic design and field quality measurements for full length 50 mm aperture model dipoles built at BNL", *Int. J. Mod. Phys. A* **2B**, pp. 641-643 (1993).
- Wiik, B.H., "Progress in Hera", *IEEE Trans. Nucl. Sc.* **NS-32**, pp. 1587-1591 (1985).
- Wilson, M.N., "Rate dependent magnetization in flat twisted superconducting cables", *RHEL int. note M-A-26* (1972).
- Wilson, M.N., *Superconducting Magnets*, Clarendon, Oxford, 1983.
- Wolf, R., "Persistent currents in LHC magnets", *IEEE Trans. Magn.* **28**, p. 376 (1992).
- Yamamoto, A., et al., "Development of 10 T dipole magnets for the Large Hadron Collider", *IEEE Trans. Appl. SC* **3**, pp. 769-772 (1993).
- Zhao, Y., et al., "Current dependence of harmonic field coefficients of 5-cm-aperture, 15-m-long SSC dipole magnet prototypes", *IEEE Trans. Appl. SC* **3**, pp. 674-677 (1993).

This thesis is partially based on the following publications:

- Verweij, A.P., "Loss measurements on the MTA1 Jeumont-Schneider prototype dipole", *CERN int. note AT-MA 91-29* (1991).
- Verweij, A.P., "Measurements of the stored energy and energy loss of the MTA1 Elin prototype dipole", *CERN int. note AT-MA 91-33* (1991).
- Verweij, A.P., "Measurements of the stored energy and energy loss of the MTA1 Ansaldo prototype dipole", *CERN int. note AT-MA 91-34* (1991).
- Verweij, A.P., "Electrical measurements on prototype twin aperture NbTi dipoles for the CERN LHC", *CERN int. note AT-MA* (1991).
- Verweij, A.P., and R. Wolf, "Field errors due to eddy currents in the cable of the LHC pinkbook dipole", *CERN int. note AT-MA 92-52* (1992).
- Verweij, A.P., and H.H.J. ten Kate, "Coupling currents in Rutherford cables under time varying conditions", *IEEE Trans. App. SC* **3**, p. 146 (1993).
- Verweij, A.P., and L. Walckiers, "Loss measurements of the LHC models and prototypes: Goals and relevant means", *CERN int. note AT-MA 93-70* (1993).
- Verweij, A.P., "Overview of the results of the AC measurements on the 1 m long CERN dipole models", *CERN int. note AT-MA 93-87* (1993).
- Verweij, A.P., and H.H.J. ten Kate, "Time constants of inter-strand coupling currents in Rutherford cables for different geometries", *Appl. SC* **2**, H.C. Freyhardt, Ed., pp. 1625-1628 (1993).
- Verweij, A.P., et al., "Study on the AC magnetization of LHC type of Rutherford cables", *Supercollider* **5** (1994).
- Verweij, A.P., et al., "The effect of transverse pressure on the inter-strand coupling loss of Rutherford cables", *Adv. Cryog. Eng.* **40**, pp. 521-527 (1994).
- Verweij, A.P., et al., "Analysis of the AC loss measurements on the one-metre dipole model magnets for the CERN LHC", *IEEE Trans. Magn.* **30**, pp.1758-1761 (1994).
- Verweij, A.P., and R. Wolf, "Field errors due to inter-strand coupling currents in the LHC dipole and quadrupole", *CERN int. note AT-MA 94-97* (1994).
- Verweij, A.P., et al., "Ramp rate induced quenches in the one-metre dipole model magnets for the CERN LHC", *IEEE Trans. App. SC* **5**, pp. 1020-1023 (1995).
- Verweij, A.P., and H.H.J. ten Kate, "Super coupling currents in Rutherford type of cables due to longitudinal non-homogeneities of dB/dt ", *IEEE Trans. SC* **5**, pp. 404-407 (1995).