Task 6: Short period helical superconducting undulator

Gijs de Rijk (CERN)

24th February 2009

DOW task 7.5

Task 5. High Tc superconducting link

- Design of HTS bus: choice of HTS material definition of thermal conditions, requirements for stabilization and quench protection, modelling of quench propagation.
- Design. realization and test of electrical joints and electrical terminations.
- Mechanical design and assembly of a 20 m long superconducting link (26 pairs of 600 A).

Task 5. High Tc superconducting link

The use of HTS material in buses linking superconducting magnets is of great interest for accelerators such as the LHC. Existing buses use Nb-Ti superconductors, maintained at temperatures below 6 K. The use of HTS enables operation at higher temperatures and offers a convenient gain in temperature margin during operation. In the case of the LHC, the use of HTS links is of specific benefit to an upgrade, in that it provides long distance electrical connections between power converters and superconducting magnets. It links cold magnets electrically. In cases where space is limited and the radiation environment is harsh, it also provides more flexibility in the location of the cryostats supporting the current leads. HTS links of the type required for the accelerator technology do not exist yet, and significant work has to be done to develop a long-length multi-conductor operating in helium gas at about 20 K. Considerable R&D

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is being done on HTS cables for electrical utilities, and it might be thought that one could simply apply these technologies. However, at present this work is focused on using single or 3-phase AC conductors with high voltage insulation and liquid nitrogen cooling, and it should be noted that this is still development work yet to be concluded. Particle accelerators require high quasi-DC current carrying links with many cables (up to about 50) in parallel and cooled with liquid or gaseous helium. In the LHC there are over 50000 connecting cables with a total length of 1360 km. Thus the need specific to accelerator applications, is for a new type of link with multiple circuits, electrically isolated at around 1 kV - 2 kV, carrying quasi-DC currents. The design study has to cover the option to use MgB_2 at a temperature of 20 K as well as the electrical connections between HTS and LTS.

- **Sub-task 1: Studies on thermal, electrical and mechanical performance.** Performance tests on short samples of HTS material. CERN, COLUMBUS, BHTS and SOTON will study together the performance of HTS conductors at low temperatures. Existing test stations at CERN and in SOTON, which are used for measurements at 4.2 K, will have to be adapted to enable measurements of critical currents at 20 K. CERN, COLUMBUS and the SOTON will model the quench propagation in the HTS cables and define the requirements for stabilization and protection. CERN, COLUMBUS and BHTS will perform measurements of mechanical properties of short samples at liquid nitrogen temperature.

- **Sub-task 2: Design and test of electrical contacts HTS-HTS and HTS-Cu.** CERN, COLUMBUS and BHTS will prepare short samples and test their electrical resistance at cryogenic temperature. CERN and DESY will design together the electrical terminations of the HTS link.

- **Sub-task 3: Design and assembly of a 20 m long HTS multi-conductor 600 A link.** CERN, DESY, BHTS, COLUMBUS and SOTON will design together a 20 m long link containing 26 circuits operating at 600 A. The design includes both the superconducting bus and the mechanical envelope providing the vacuum insulation. The cryogenic test will be done at CERN. COLUMBUS and CERN will design and test the electrical insulation of the circuits.

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Deliverables of tasks	Description/title	Nature	Delivery month
7.5.1	HTS 20 m 600 A link assembled	P	M40

Mile-stone	Description/title	Nature	Delivery month	Comment
7.1.1	1st annual HFM review meeting	O	M12	
7.1.2	2nd annual HFM review meeting	O	M24	
7.1.3	3rd annual HFM review meeting	O	M36	
7.1.4	Final HFM review meeting	O	M48	
7.2.1	Methodology for the certification of radiation resistance of coil insulation material	R	M24	
7.2.2	Preliminary heat deposition model for a dipole Nb_3Sn model magnet	R	M12	publication on web
7.2.3	Engineering heat deposition model for a dipole Nb_3Sn model magnet	R	M24	publication on web
7.3.1	Dipole Nb_3Sn coils finished	D	M36	2 coils ready for mounting
7.3.2	Dipole Nb_3Sn model magnet finished	D	M42	Ready for cold test
7.4.1	HTS conductor specifications for insert coils	R	M12	
7.4.2	Two HTS solenoid insert coils	D	M24	
7.5.1	Final design report HTS link	R	M34	

budget

EuCARD - WP7 HFM - Task 7.5: HT sc link **v3**

Beneficiary short name [a]	Average direct monthly salary * (€)	Rate for personnel indirect costs (%)	Rate for material and travel indirect costs (%)
CERN	5,900	60	60
COLUMBUS	5,900	20	20
DESY	5,900	60	60
BHTS	5,900	109	0
SOTON	5,900	60	60
...			
...			
...			

27/02/2008 Columbus will use 20 % Flat Rate

* To prevent rounding problems on the cost data, give the monthly salary as a multiple of 100 €

[a] In alphabetic order

Beneficiary short name (all costs in €)	Person-Months	Personnel direct costs	Personnel indirect costs	Sub-contracting cost	Consumable and prototype direct costs	Travel direct costs	Material and travel indirect costs	Total direct costs	Toal indirect costs	Total costs (direct +indirect)	EC requested funding[1]
CERN	10	59,000	35,400	0	42,000	9,400	30,840	110,400	66,240	176,640	52,416
COLUMBUS	4	23,600	4,720	0	44,000	6,000	10,000	73,600	14,720	88,320	28,300
DESY	11	64,900	38,940	0	42,000	9,475	30,885	116,375	69,825	186,200	59,700
BHTS	4	23,600	25,724	0	27,000	6,000	0	56,600	25,724	82,324	29,000
SOTON	7	41,300	24,780	0	0	0	0	41,300	24,780	66,080	21,300
...		0	0	0			0	0	0	0	
...		0	0	0			0	0	0	0	
...		0	0	0			0	0	0	0	
Totals:	36	212,400	129,564	0	155,000	30,875	71,725	398,275	201,289	599,564	190,716
FIXED TARGETS										607,800	191,300
CHECKING THE CONDITION										OK	OK

[1] In principle 30% of total costs

people

STFC-DL

J. Clarke (TL)