# Current Density in 2G HTS Tape in an External Magnetic Field

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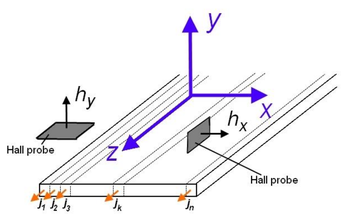
**In this paper we had a goal to study critical current density distribution across a tape in a background magnetic field. We suggested the combined method. First, we measured current distribution by use of a single Hall probe with moving mechanism. Then we measured field across a tape by a set of several Hall probes placed on a single substrate. By comparison of data from these two experiments we could verify data obtained from the set of Hall probes and precisely determine its position at a tape. Then we can to measure current distribution of current density across a tape inside a magnet. The details of measuring method and results of current distribution measurements across a width of 2G HTS tapes are presented.**

## Reconstruction of a current from a magnetic field



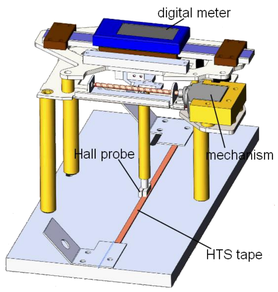

The conversion is based on Biot-Savart law: $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I[\vec{r}\times d\vec{r}]}{r^3}$ HTS tape imagine as many parallel sub-tapes then Biot-Savart law can be represented as:

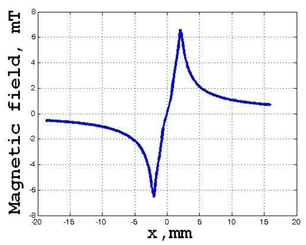
$$h_x = \frac{j(y-\eta)}{2\pi\{(x-\xi)^2+(y-\eta)^2\}}d\xi d\eta; \qquad h_y = -\frac{j(x-\xi)}{2\pi\{(x-\xi)^2+(y-\eta)^2\}}d\xi d\eta, \quad (2)$$

here **η** and ξ are dimensions of across of HTS tape [2], vertical (**$h_y$**) and horizontal (**$h_x$**). Their thickness are very small (**η**) and could be neglected.

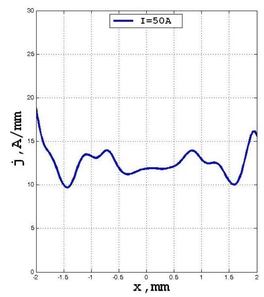
$B_i = \sum_k A_{ik} j_k$ where $A_{ik} = -\mu_0 \frac{(x_i-\xi_k)d\xi}{2\pi\{(x_i-\xi_k)^2+(y_i)^2\}}$ for $h_y$ component of 2G HTS tape, $j_k$ – current density in **k**-th sub-tape. The solution of this nonlinear equa was described with Tikhonov's regularization [3] and was realized before in [4].

## Continuous method

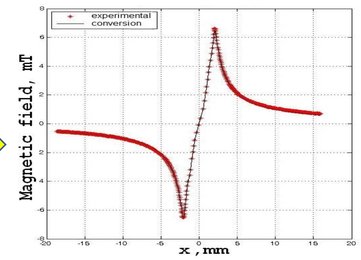



**Magnetic fields from HTS tape with transport current 50 A. No external field.**

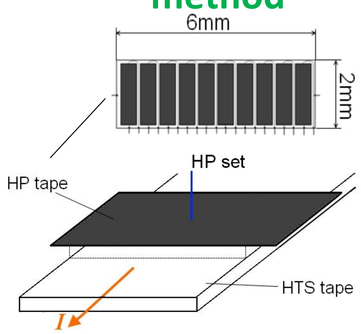


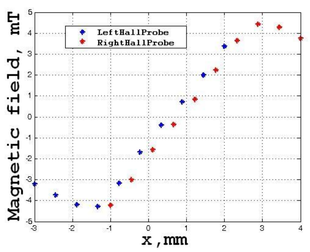

**Distribution of current across 2G HTS tape without external field.**



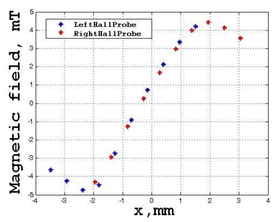

**Magnetic fields from HTS tape and comparison with reversal conversion from current density distribution to fields.**

## Discontinuous (discrete) method

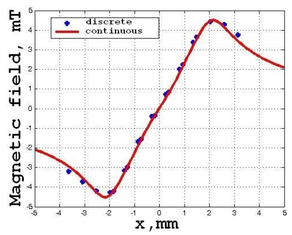



**Magnetic fields from HTS tape measured by discrete HP sets without adjusting.**

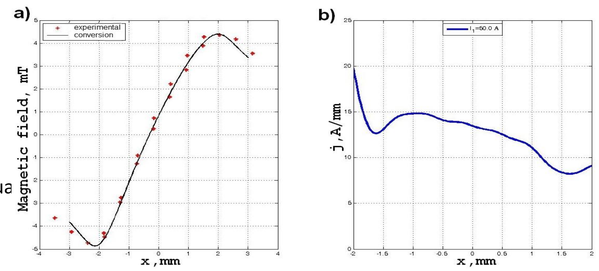



**Magnetic fields from HTS tape measured by discrete HP sets with adjusting.**

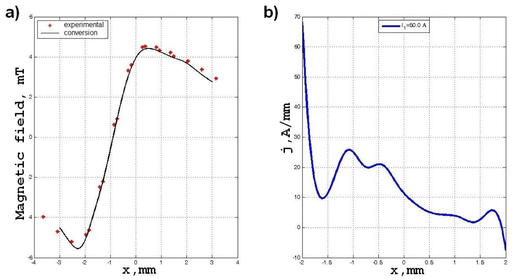



**Combined method. Adjusting discrete measurements to the continuous ones permits to find out exact positions of discrete HP sets**

## Results




**The HTS tape in external parallel magnetic field 30 mT: a) magnetic field measured by HP sets (marks) and reversal conversion from current density distribution to fields; b) current density distribution reconstructed**




**The HTS tape in external perpendicular magnetic field 30 mT: a) magnetic field measured by HP sets (marks) and reversal conversion from current density distribution to fields; b) current density distribution reconstructed**

## Conclusion

**We presented the method of measurements of current density distribution across a width of HTS tapes in external magnetic field by using discrete Hall probes sets. The positions of discrete Hall probes sets are first verified by continuous measurements by Hall probe that improves accuracy of discrete measurements. Knowledge of transverse current density distribution permits to predict the behavior of HTS tapes when used in electro-technical devices. It also permits to study current density redistribution in HTS tapes in magnetic fields and with changing transport current.**

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[2] Per Christian Hansen, Regularization: Tools A Matlab Package for Analysis and Solution of Discrete Ill-Posed Problems, Numerical Algorithms, 1994, Volume 6, Issue 1, pp 1-35
[3] Pavol Ušák, The measurement of current distribution in superconducting tape. Comparison of destructive and non-destructive methods, Physica C 384 (2003) 93–101
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