Contents

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clear all;
close all;

testfolder = 'C:\Users\Dell\cernbox2\Commissioning\Measurement model\Scaling factor\scripts+mmm\ELENA\';
%  testfolder = 'C:\Users\Dell\cernbox\ELENA tests\MATLAB\Commissioning\matlab\scripts+mmm\ELENA\';
filelist = findtaggedfile(testfolder,'xmeter3_coil5_pos5','txt','multi',RECURSE.ON); nf = length(filelist);
load('200data');
load('PBMD2data')
load('PBMD1data')
% remanent field
Flux0 = [0.001639, 0.0019126, 0.0019468, 0.0018651, 0.0023044, 0.0020895, 0.002134, 0.00185];
load('model_up')
load('model_down')
% --------- analysis parameters --------------
np     =  300000;
kDCCT  =  1;
kH     = -1;
wc     =  2.8579; % coil effective width
refine =  1.0; % interpolation refinement ratio
l0     =  0.9708; % nominal (hard-edge) magnetic length

% --------- preallocate signal arrays ---------
t        = zeros(np,nf);    iav = 9;
I        = zeros(np,nf);
I200       = zeros(np,nf);
IPBMD2        = zeros(np,nf);
Vc       = zeros(np,nf);
BdL      = zeros(np,nf);
Bavg     = zeros(np,nf);
Lm       = zeros(np,nf);
TF       = zeros(np,nf);
V0       = zeros(1 ,nf);
delay    = zeros(1 ,nf);    % delay wrt mid=3 (first magnet in the ring)
mname    =  cell(1 ,nf+1);   mname{iav}='Ring Average'; mname{10}='Cycle Editor';

for f=1:nf,

    mid          = getRXnum(getFileName(filelist{f}),'(?<=MBR)[0-9]+');
    mname{mid}   = sprintf('MBR%d',mid);     if mid==1,    mname{mid}='Reference'; end
    if mid==2,    mname{mid}=[mname{mid}, ' (spare)']; end

    raw          = importdata(filelist{f});

    t(:,mid)  =           raw.data(1:np,1);     dt=t(2,mid)-t(1,mid);
    Vc(:,mid)  =           raw.data(1:np,2);
    I(:,mid)  = kDCCT*lpf(raw.data(1:np,3),dt,200);
    B0(:,mid)  =        kH*raw.data(1:np,4);

    Idot(:,mid) = derivative(t(:,mid),I(:,mid));
%    V0(mid)  = mean(Vc(1:7*5000,f));    % voltage offset computed directly at the start of the measurement
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```
    flux = dt*cumtrapz(Vc(:,mid));
    V0(mid) = (flux(end)-flux(1))/(dt*(np-1));
    Phi(:,mid) = (Flux0(mid) + dt*cumtrapz(Vc(:,mid) - V0(mid)));
    BdL(:,mid) = Phi(:,mid)/wc;
    Lm(:,mid) =      BdL(:,mid)./B0(:,mid);
    TF(:,mid) = clip(BdL(:,mid)./ I(:,mid),[1.1e-3,1.5e-3]);

end

% % ----- machine mean (requires interpolation and delay) -----------------

dT   = dt/refine;
T    = dT*(1:refine*np);
I_   = zeros(refine*np,nf+1);   I_(:,3) = linterp(t(:,3),I(:,3),T);
B0_  = zeros(refine*np,nf+1);
BdL_ = zeros(refine*np,nf+1);
TF_  = zeros(refine*np,nf+1);
Lm_  = zeros(refine*np,nf+1);
t1 = 46e3; t2=52e3; t3=89.5e3; t4=96e3;
t1b = 1.323e5; t2b=1.383e5; t3b=1.758e5; t4b=1.823e5;
t1c = 2.186e5; t2c=2.246e5; t3c=2.621e5; t4c=2.686e5;
for f=1:nf,

    delay(f) = dT*finddelay(linterp(t(:,f)         ,I(:,f),T),I_(:,3));

    I_  (:,f)  =           linterp(t(:,f)+delay(f),  I(:,f),T);
    B0_ (:,f)  =           linterp(t(:,f)+delay(f), B0(:,f),T);
    BdL_(:,f)  =           linterp(t(:,f)+delay(f),BdL(:,f),T);
    TF_ (:,f)  =           linterp(t(:,f)+delay(f), TF(:,f),T);
    Lm_ (:,f)  =           linterp(t(:,f)+delay(f), Lm(:,f),T);
    I_up(:,f) =  I_ (t1:t2,f);
    I_down(:,f) =  I_ (t3:t4,f);
    BdL_up(:,f) =  BdL_ (t1:t2,f);
    BdL_down(:,f) =  BdL_ (t3:t4,f);
    TF_up (:,f)  =  TF_(t1:t2,f);
    TF_down (:,f)  =  TF_(t3:t4,f)        ;

    I_upb(:,f) =  I_ (t1b:t2b,f);
    I_downb(:,f) =  I_ (t3b:t4b,f);
    BdL_upb(:,f) =  BdL_ (t1b:t2b,f);
    BdL_downb(:,f) =  BdL_ (t3b:t4b,f);
    TF_upb (:,f)  =  TF_(t1b:t2b,f);
    TF_downb (:,f)  =  TF_(t3b:t4b,f)        ;

    I_upc(:,f) =  I_ (t1c:t2c,f);
    I_downc(:,f) =  I_ (t3c:t4c,f);
    BdL_upc(:,f) =  BdL_ (t1c:t2c,f);
    BdL_downc(:,f) =  BdL_ (t3c:t4c,f);
    TF_upc (:,f)  =  TF_(t1c:t2c,f);
    TF_downc (:,f)  =  TF_(t3c:t4c,f)        ;
end

I_common = linspace(30, 276, 1000);


I_up(:,iav) = mean(  I_(t1:t2,3:8),2);
I_down(:,iav) = mean(  I_(t3:t4,3:8),2);
BdL_up(:,iav) = mean(BdL_(t1:t2,3:8),2);
TF_up(:,iav) = mean(TF_(t1:t2,3:8),2);
BdL_down(:,iav) = mean(BdL_(t3:t4,3:8),2);
TF_down(:,iav) = mean(TF_(t3:t4,3:8),2);
```

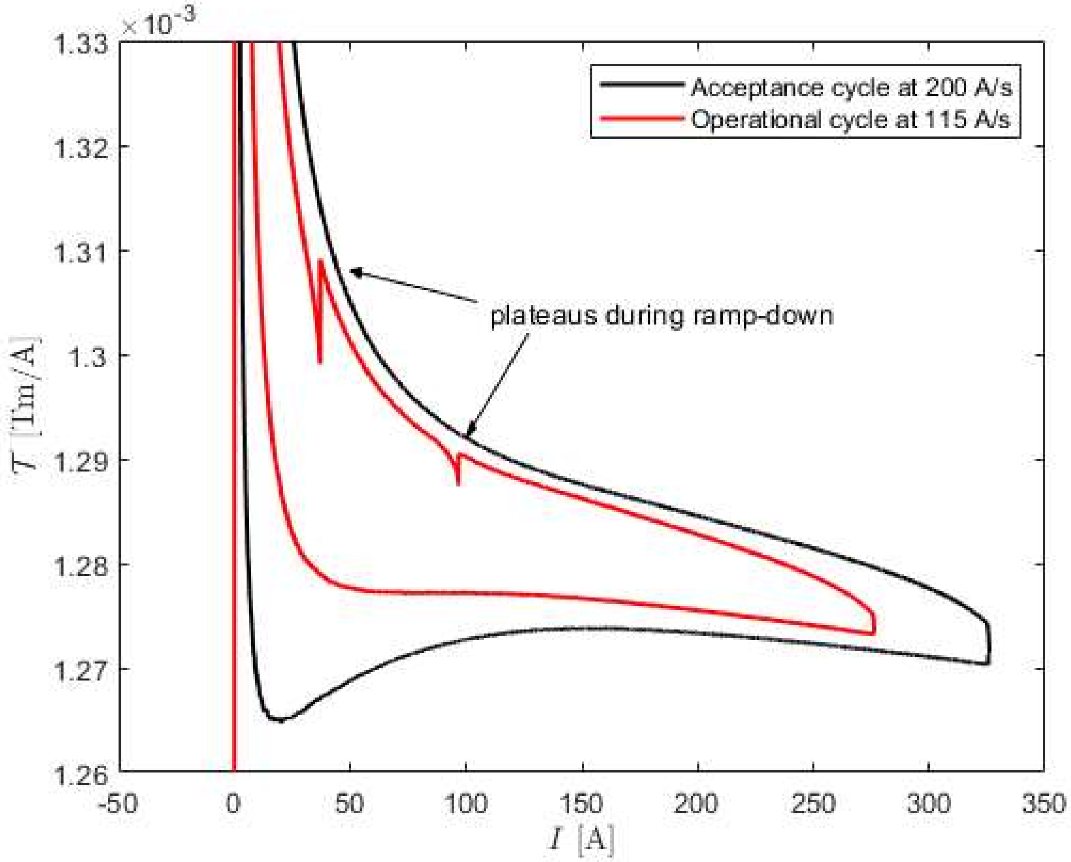
```
I_upb(:,iav) = mean(  I_(t1b:t2b,3:8),2);
I_downb(:,iav) = mean(  I_(t3b:t4b,3:8),2);
BdL_upb(:,iav) = mean(BdL_(t1b:t2b,3:8),2);
TF_upb(:,iav) = mean(TF_(t1b:t2b,3:8),2);
BdL_downb(:,iav) = mean(BdL_(t3b:t4b,3:8),2);
TF_downb(:,iav) = mean(TF_(t3b:t4b,3:8),2);

I_upc(:,iav) = mean(  I_(t1c:t2c,3:8),2);
I_downc(:,iav) = mean(  I_(t3c:t4c,3:8),2);
BdL_upc(:,iav) = mean(BdL_(t1c:t2c,3:8),2);
TF_upc(:,iav) = mean(TF_(t1c:t2c,3:8),2);
BdL_downc(:,iav) = mean(BdL_(t3c:t4c,3:8),2);
TF_downc(:,iav) = mean(TF_(t3c:t4c,3:8),2);

%    ratio_avg_ref_up = TF_up(:,iav)./TF_up(:,1);
%    ratio_avg_ref_down = TF_down(:,iav)./TF_down(:,1);
for f = 1:nf+1
    TF_up_new(:,f) = fitresult(I_up(:,f)).*TF_up(:,f);
    TF_down_new(:,f) = fitresult1(I_down(:,f)).*TF_down(:,f);
    TF_up_newb(:,f) = fitresult(I_upb(:,f)).*TF_upb(:,f);
    TF_down_newb(:,f) = fitresult1(I_downb(:,f)).*TF_downb(:,f);
    TF_up_newc(:,f) = fitresult(I_upc(:,f)).*TF_upc(:,f);
    TF_down_newc(:,f) = fitresult1(I_downc(:,f)).*TF_downc(:,f);
end;

ratio_up=clip( TF_up_new(:,iav)./ TF_up_new(:,1),[0,2]);
ratio_down=clip(TF_down_new(:,iav)./TF_down_new(:,1),[0,2]);
ratio_upb=clip( TF_up_newb(:,iav)./ TF_up_newb(:,1),[0,2]);
ratio_downb=clip(TF_down_newb(:,iav)./TF_down_newb(:,1),[0,2]);
ratio_upc=clip( TF_up_newc(:,iav)./ TF_up_newc(:,1),[0,2]);
ratio_downc=clip(TF_down_newc(:,iav)./TF_down_newc(:,1),[0,2]);

mean_ratio_up=mean(ratio_up);
stdev_up = std(ratio_up);
mean_ratio_down=mean(ratio_down);
stdev_down = std(ratio_down);
ratio_avg_ref = clip(BdL_(:,iav)./BdL_(:,1),[0,2]);
ratio_avg_spr = clip(BdL_(:,iav)./BdL_(:,2),[0,2]);

mean_ratio_upb=mean(ratio_upb);
stdev_upb = std(ratio_upb);
mean_ratio_downb=mean(ratio_downb);
stdev_downb = std(ratio_downb);

mean_ratio_upc=mean(ratio_upc);
stdev_upc = std(ratio_upc);
mean_ratio_downc=mean(ratio_downc);
stdev_downc = std(ratio_downc);
```

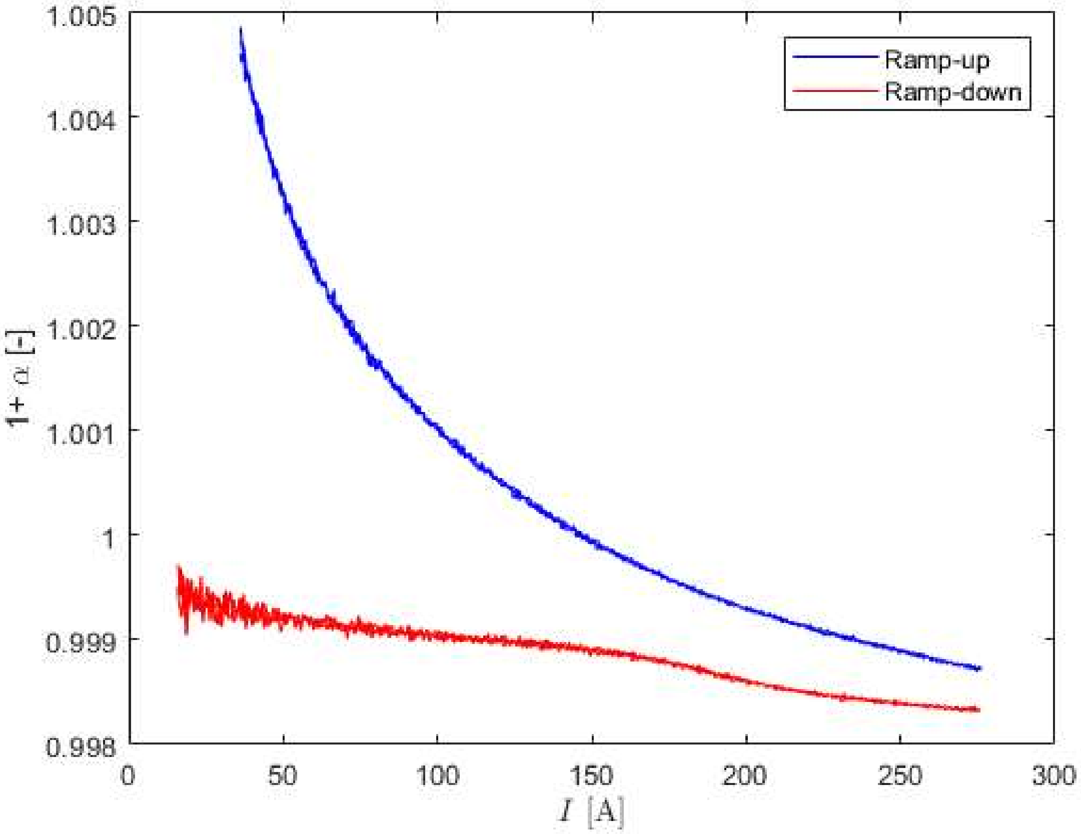
Official calibration values

```
three = [mean_ratio_down; mean_ratio_downb; mean_ratio_downc];
std1 = [stdev_down; stdev_downb; stdev_downc];
mean_alpha_down = mean(three)
st_alpha_down = mean(std1)

three2 = [mean_ratio_up; mean_ratio_upb; mean_ratio_upc];
std2 = [stdev_up; stdev_upb; stdev_upc];
mean_alpha_up = mean(three2)
```

```
st_alpha_up = mean(std2)

% ------------------ plots -----------------------------------------------------
----------------------------------

mid=[1:nf];
mid=[1,iav];
figure;
% plot( curr200, BdL200'./curr200, 'k',  currPB1, BdlPB1'./currPB1, 'b', currPB, BdLPB'.
/currPB, 'r');
plot( curr200(1:7.5e5), BdL200(1:7.5e5)'./curr200(1:7.5e5), 'k',  currPB, BdLPB'./currPB
, 'r', 'LineWidth',1.5);

ylabel('$\mathcal{T}$ [Tm/A]','interpreter','latex');
xlabel('$I$ [A]','interpreter','latex');  ylim([1.25e-3 1.38e-3])
txt = 'plateaus during ramp-down';
text(110,1.304e-3,txt);
arrow([105, 1.305e-3],[50, 1.308e-3], 'Length', 5);
arrow([127, 1.302e-3],[100, 1.292e-3], 'Length', 5);
legend('Acceptance cycle at 200 A/s', 'Operational cycle at 115 A/s');
ylim([1.26e-3 1.33e-3])
figure; grid on;
plot(I_up(:,iav) , ratio_up,'b', I_down(:,iav) , ratio_down,'r',I_upb(:,iav) , ratio_upb
,'b', I_downb(:,iav) , ratio_downb,'r',I_upc(:,iav) , ratio_upc,'b', I_downc(:,iav) , ra
tio_downc,'r');
legend('Ramp-up','Ramp-down');
ylabel('1+ \alpha [-]');
xlabel('$I$ [A]','interpreter','latex');
```

```
mean_alpha_down =
    0.9989
st_alpha_down =
   3.1708e-04
mean_alpha_up =
    1.0003
st_alpha_up =
    0.0014
```





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