

Magnet Measurement Report

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1 Introduction

The magnet test stand was set up in January of 2014, and started to produce data in February of 2014. The stand was set up under Thomas Planche and Kevin Multani. The goal of this stand was stated as being:

- To calibrate the magnetic field versus excitation current sufficiently well that magnets can be repeatedly and reliably driven to known set points.
- To automate the degaussing of magnets using uni-polar power supplies and polarity switching contactors.

In this document it will be outlined the progress made in measuring the magnets for the E-linac, as well as giving an overview of operation of the stand. Other resources for using the stand will also be introduced. A key reference for this document is the Magnet Measurements Specifications document which can be found at http://beamphys.triumf.ca/~tplanche/magnetic_measurements/e-linac_magnets/magnet_measurement_spec/magnet_measurement_spec.pdf

2 Equipment

The main equipment is as follows:

- Lakeshore 3-Channel Gaussmeter
 - 3 Axis probe with rectangular jig
 - 2 Axis probe with Quadrupole jig

- Zeroing chamber (Made at TRIUMF)
- 40A Power Supply
- 250A Power Supply
- Data Acquisition Computer

3 Measurements

Magnet Type:	Completed/Total
Weak quadrupole	41/41
Medium quadrupole	51/52
Strong quadrupole	0/18
ELBD dipole	1/1
EMBD dipole	1/1
EMBT dipole	2/2
Strong dipole (S34)	1/7
Strong EHAT dipole (Y30)	3/3
Dogleg vertical dipole (DLVD)	0/2
Solenoids	2/5
Correctors	2/2 (one of each type)
Total number of magnets:	102/129

Table 1: Status of magnetic measurements. Several of these numbers have been revised from the previous documentation after more magnets were found then planned for. Note that there is one magnet missing from the medium quadrupoles (SN:0002). This magnet has not yet been located. All other magnets for the September deadline are on schedule.

It should be noted that several unplanned measurements have been taken. The most prominent examples of this are:

- BI & Longitudinal measurements for the orange steerers
- BI & Longitudinal measurements for the modified orange steerers
- BI & Longitudinal measurements for Modified Type A
- Longitudinal measurement for the Haimson Coils
- BI & Longitudinal measurements for the Y30 Dipole with the Vacuum Chamber

There are several measurements which were called for in the initial Magnet Measurement Specifications that we have not been performing These are:

- Water Temperature & Flow
- Controlled Temperature Change
- Probe and Jig reversal

3.1 Magnetic Hysteresis

Initially it was planned to try different current waveforms to degauss the magnets. This was never attempted, and instead it was chosen to use

$$I(t) = Ae^{-t/\tau} \sin(2\pi ft), \quad (1)$$

as the standard method for degaussing. This has been working extremely successfully and has been implemented on the E-Linac.

4 Operation

4.1 Hardware Operation

The magnet test stand currently has two power supplies: a smaller 40A supply, and a larger 250A supply which is less precise. Both supplies in addition to supplying power also require a signal input from the temperature interlocks on the magnets.

The 40A has two black cables to supply power, as well as two orange wires connected to the interlock system. One of the orange wires connects to a 5V power supply, which then is hooked with the other orange cable to power the interlocks. In order for the interlock signal to go through, the user must press SHIFT - 3 on the power supply which will then open up a menu. Item number 61 is the requirement that there be a logic IN for the supply to operate. When this option is selected the supply is ready to operate. The 250A supply also requires interlocks, which are wired separately through the polarity switcher. Simply attach to the appropriate terminal. Before any measurements are taken the user should zero the probe. In order to do this, take the probe and place it in the Zeroing chamber. Once inside press the component you wish to zero (X,Y,Z, MAGNITUDE) followed by ZERO PROBE and ENTER. This will need to be repeated for each component, while the magnitude can be ignored. Once the probe has been zeroed, it can

be placed in the magnet. Some magnets will also require water supply for cooling. As of the time of writing there are two sets of water supply hoses hooked up: 1/4 inch and 1/2 inch pipe. Typically the 1/4 inch pipe is used for the quadrupoles, while the 1/2 is used for the much larger dipoles.

4.2 Using the Software

The data acquisition is done through devbn1, one of the servers at TRIUMF. In order to operate the stand it is necessary to first access that server from the computer at the stand, then run the appropriate program. To access the server the user enters:

```
ssh -X username@devbn1.triumf.ca -p 22044
```

The server is running OpenVMS¹, which requires different commands from bash. To access the program the user enters:

```
bin mag_test  
r mag_test
```

The first command brings the user to the appropriate directory, while the second one runs the actual program. Once the program is running the user is presented with a menu with a variety of options for tests to run. COMP TEST runs a full degaussing-BI-degaussing cycle, MAG TEST only does the BI curve, MAG READ will read the value of the field after a current value has been entered, and MAG DEGAUSS only does the degaussing cycle. Each of these commands operates on the 40A power supply. The 250A power supply is used through the analogous HC commands. There are also several other menus used for diagnostics as well as the creation of reference files.

Once a menu has been selected the user will be directed to enter a series of parameters for the magnet being tested. Examples of parameters can be found by looking on the beamphys server at the raw data files. The parameters are given in a heading. http://beamphys.triumf.ca/~tplanche/magnetic_measurements/e-linac_magnets/

After the test has been run it is now necessary to download the data to the local machine. This is done by opening a separate terminal window, repeating the previous step to ssh onto the server, and then entering:

```
set default Rad1:[Data.mag_test]
```

¹https://www.mpp.mpg.de/~huber/vmsdoc/vms-unix_cmd-equivalents.html

Parameter	Explanation
Maximum Current	The max current the test occurs at
Number of Steps	Number of individual points on the BI curve
Delay Time	Time between current set and field read
JIG Position	If multiple positions are used. Set to 1 usually
Number of Probes to read	Either 2 or 3 depending on probe
Serial Number	Becomes part of the name of the data file
Magnet Resistance	Not Necessary, can be found on magnet
Magnet Inductance	Not Necessary, set to 0
Starting Temperature	Only if thermometer is available
Maximum Degaussing Current	See A in equation 1
Period	$1/f$ in equation 1
Number of points per Period	See Number of Steps, but for degaussing
Tau	See Tau in equation 1
Number of periods	Number of degaussing loops

Table 2: This table shows each of the parameters requested by COMP TEST. Refer to Equation 1 if necessary.

This will change the directory to the location of the data. Once here it possible to enter the command:

```
scp2 *yymmdd* "User@tplanchepc.triumf.ca:~/home/User/Desktop"
```

The data will now be loaded to the Desktop, or any other directory selected. This command will only load the data taken on the date indicated in the command (For example 14Aug23 being the 23rd of August, 2014).

It may also be necessary to load data from the degaussing procedure. If this is the case the user can execute:

```
set default Rad1:[Data.mag_test.degauss]
```

The user can then use the scp2 command used above to download degaussing data.

To use the 250A power supply there are additional considerations. In order to start this supply the user must first open the XRC display which is done via the command:

```
xrc
```

Once the display is open, the user must select device ET 197, this is done through the display. It is then possible to control the 250A power supply using the display by first clicking Turn On. One can now use the mag.test program as before.

5 People

It is essential that the user be acquainted with the right people at TRIUMF to assist with the technical aspects of testing magnets. The following list is a guide for any sort of troubleshooting.

Name	Local Number	Group/Area of expertise
Thomas Planche	6381	Magnet Test Stand
Arthur Leung	6284	Electrical
Mike Mouat	7402	Controls
Sing Lee	7509	Software
Curtis Ballard	6201 & 7677	Plumbing

Table 3: Useful people to know. It may also be necessary to talk to the crane operators which is done by heading to their offices in the Meson Hall.

6 Conclusion

The magnet test stand is operational and producing results. At the time of writing all of the magnets for the September deadline with the exception of one have been measured. A core group of people who can assist with the stand has been assembled. Undoubtedly more incidental measurements will happen, which attests to the versatility of the stand and it's success.