

**TO: DISTRIBUTION**  
**FROM: C NEUMEYER**  
**SUBJECT: NSTX TF JOINT VOLTAGE DROP SIGNAL PROCESSING**  
**REQUIREMENTS**

## 1.0 Digitizer Requirements

- 1.1 CAMAC digitizers shall be provided with 5ksamples/channel and  $f \leq 5\text{kHz}$
- 1.2 Total number of channels is 72 joints plus 1 maintenance current measurement plus 4 amplifier gain encoding =  $72+1+4=77$  channels

## 2.0 Maintenance Mode

- 2.1 Interface shall be provided at or near the instrumentation rack in the test cell for connection of a laptop
- 2.2 EPICs display shall be available to set up digitization rate via the laptop
- 2.3 Operator will manually initiate current flow and manually trigger the digitization via the laptop.
- 2.4 Digitized data will be identified and retrievable by time and date
- 2.5 Pairs of data sets corresponding to positive current flow and negative current flow shall comprise a “test” and be processed together to determine the effective joint resistance. Whether a particular data set corresponds to positive or negative current flow will be evident from the polarity of the data.
- 2.6 Processing of data set pairs associated with a test shall consist of the following:

Calculate average magnitudes of injected current over positive and negative injection intervals...

$$\langle |I_p| \rangle = \frac{\sum_1^n |I_p|}{n}$$
$$\langle |I_n| \rangle = \frac{\sum_1^n |I_n|}{n}$$

Calculate the average magnitude of current over the positive and negative injection intervals...

$$\langle I \rangle = \frac{\langle |I_p| \rangle + \langle |I_n| \rangle}{2}$$

Confirm that the magnitude of the difference between the average magnitudes of current injected during positive and negative injection intervals is less than a set fraction of the overall average....

$$\frac{|\langle I_p \rangle - \langle I_n \rangle|}{\langle I \rangle} \leq Limit$$

Take average of “n” samples of voltage (after applying gain factor to raw digitizer data) during positive injection interval for each joint “i” (more advanced filtering may be included in the future)...

$$\langle V_p^i \rangle = \frac{\sum_1^n V_p^i}{n}$$

Note: This will result in a positive number.

Take average of “n” samples of voltage during negative injection interval for each joint I (more advanced filtering may be included in the future)...

$$\langle V_n^i \rangle = \frac{\sum_1^n V_n^i}{n}$$

Note: this will result in a negative number.

Calculate effective joint resistance for each joint “i”...

$$R^i = \frac{\langle V_p^i \rangle - \langle V_n^i \rangle}{2\langle I \rangle}$$

2.7 Processed data to be stored and trended for each test, uniquely identified by date and time (of completion), shall include the following:

- Resistance of each joint
- Collective Mean and Standard Deviation of all joint resistances
- Separately amongst 48 outer and 24 inner layer joint groups
  - Highest joint resistance and ID number of same
  - Lowest joint resistance and ID number of same
  - Largest increase in joint resistance since prior measurement and ID number of same
  - Largest decrease in joint resistance since prior measurement and ID number of same

### 3.0 Pulsed Mode

- 3.1 Digitizers will be automatically triggered based on the normal shot cycle sequence.
- 3.2 Data for the TF pulse current shall be obtained via the TF SUM current digitizer.
- 3.3 Graphical overlays shall be provided, with zooming capability, as follows:

- Any subset of the 72 joint voltage waveforms, up to and including all 72, superimposed for the same specified shot, with option for automatic update/refresh to the current shot
- Any subset of the 72 joint voltage waveforms, up to and including all 72, superimposed for a specified set of shots or range of shots

Set up of graphical overlay shall provide feature for selecting starting group of data to include either 1) all 72 or 2) all 48 outer or 3) all 24 inner joints.

### 3.4 Signal processing

- 3.4.1 TF current flat top interval shall be determined by processing the TF SUM current digitizer and looking for the change in current derivative. SOFT interval shall be defined as a 50mS interval beginning 50mS after the start of TF flat top as detected by the software processing. EOFT interval shall be defined as a 50mS interval ending 50mS prior to the end of TF flat top as detected by the software processing.
- 3.4.2 Average TF current during the SOFT and EOFT intervals shall be computed as follows, where n is the number of samples during the 50mS period:

$$\langle I_{SOFT} \rangle = \frac{\sum_{nsoft}^{nsoft+n} I}{n}$$

$$\langle I_{EOFT} \rangle = \frac{\sum_{neoft}^{neoft+n} I}{n}$$

- 3.4.3 Effective TF joint resistance for each joint “i” shall be calculated for the SOFT and EOFT intervals based on the average voltage across the joint during those intervals as follows:

$$\langle R^i_{SOFT} \rangle = \left[ \frac{\sum_{nsoft}^{nsoft+n} V^i}{n} \right] \div \langle I_{SOFT} \rangle$$

$$\langle R^i_{EOFT} \rangle = \left[ \frac{\sum_{neoft}^{neoft+n} V^i}{n} \right] \div \langle I_{EOFT} \rangle$$

3.5 Processed data to be stored and trended for each shot shall include the following:

- Resistance of each joint at SOFT and EOFT
- Collective Mean and Standard Deviation of all joint resistances at SOFT and EOFT
- Separately amongst 48 outer and 24 inner layer joint groups
  - Highest joint resistance and ID number of same (1 to 72) at SOFT and EOFT
  - Lowest joint resistance and ID number of same at SOFT and EOFT
  - Largest increase in joint resistance since prior measurement and ID number of same at SOFT and EOFT
  - Largest decrease in joint resistance since prior measurement and ID number of same at SOFT and EOFT

3.6 Database for processed data shall include tagging/filtering feature allowing explicit identification of shots as being in a specified class, e.g. 3kG TF Only Test shot, etc, Plasma Shot, etc.

Cc:

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