Data Acquisition and Analysis

Data Acquisition System Overview

The IOTech DAQ2000 (see Appendix B for detailed specifications) data acquisition board will be connected to several instruments: it will record data from the slip-rings, receive pulses from the encoder, measure the magnetic field generated by the magnet, and control the motor, via a motor drive (fig. XVII).

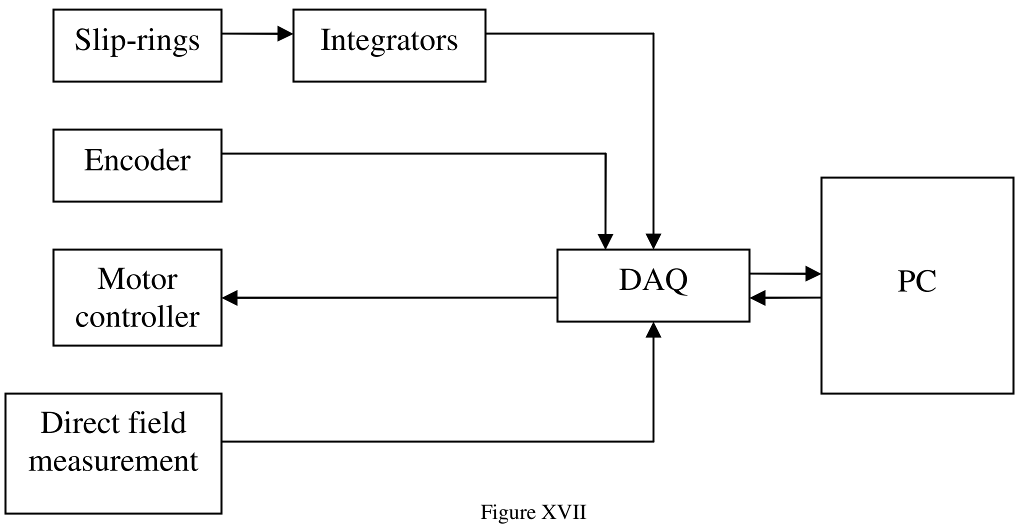

Figure XVII

Data from the slip-rings is preprocessed using physical integrators. Their role is to integrate the raw voltage generated by the coil. Therefore, the output voltage from the integrators is proportional to flux magnitude. This value is measured directly by the DAQ board.

The encoder provides information about the position of the shaft: 1024 pulses are generated for each revolution. These pulses are used to trigger the DAQ board; therefore flux will be measured at fixed angles of the shaft's rotation.

Magnetic field readings are taken at the beginning of each measurement set, and provide a reference for the evaluation of the performance of the rotating shaft measurement system (the slip-rings in particular).

A motor controller, connected to the DAQ board, is used to adjust motor speed.

Data Collection Process

All data collection and processing is automated. In data acquisition mode, at a given frequency, flux measurements are triggered by the encoder. The data we collect will be flux as a function of shaft angle.

The encoder is used as a trigger to ensure that the difference between the angles at which two flux measurements are taken is constant, thus eliminating errors introduced by variations in motor speed. Because shaft angle is a function of time we can obtain flux as a function of time, taking into consideration that the speed of the motor is variable.

The LabView application will be used to configure the DAQ board, control the motor, collect data from the slip-rings, and save the data to an external file.

Motor drive algorithm:

- At the beginning of a cycle the program enters data acquisition mode
- At each frequency we test the program waits for the shaft to stabilize
- Data is collected during three revolutions
- When data acquisition ends the program enters accelerated wear mode and the shaft speed is maintained at 10 Hz
- After a certain number of revolutions the cycle is finished and the next is one starts

The data for each cycle will be saved in a different file by LabView, the file will be compressed using zip algorithm and sent to the processing server (PUB) via HTTP for analysis. To avoid data corruption we calculate the MD5 checksum before sending it and check that the file received has the same MD5 checksum. The data will remain as backup on the acquisition server until the Romanian team confirms that the data received is ok.

As data is received on our server, it is archived (and backed up to a RAID volume) and passed to the processing application (a Matlab program). The processing application exports its results to a HTML document so we can see the progress of the experiment almost in real-time.

What follows is an estimation of the amount of information expected to be collected.

One data collection cycle may generate at most 25MB of raw data (in text format). We expect to compress it to less than 10MB. The testing system will achieve about 34 measurement cycles per day. For a 100 day test period, the amount of data expected to be received and stored is of the order of 500MB - 1GB.

These calculations are based on a 20000 revolution test cycle. At this rate we expect to achieve 68 million revolutions in 100 days.

<u>Data processing</u>

The raw data that we will receive consists of flux (as provided by physical integrators connected to each slip-ring) and time; these measurements will be triggered by the encoder, 1024 times every rotation. This is roughly the setup currently used at CERN and we will be comparing our measurements with data from their current system.

Data will be analyzed as we receive it. Also, all the data we record will be archived and saved, in case we decide to change the processing algorithm.

The encoder will be used as trigger for the data acquisition system. When triggered, it measures the output of the three encoders and records the time of the measurement.

Output from an integrator represents the amount of flux through the rotating coil at any given time (possibly shifted by an additive constant, which originates from drift in the integrators). This value is a function of shaft angle, and ideally is not influenced by the shaft rotation speed. By plotting flux measurements as function of shaft angle we should ideally see a sine form.

We must compensate for the integrator drift by calculating the average measured flux over one or more complete revolutions and adjusting all measured values by this amount, such that the sum of the adjusted values equals zero (within given accuracy limits).

Qualitatively, in the flux graph any deviation from a sine wave should be caused mainly by slip-ring noise or variations in the magnetic field. Comparing the output from all three integrators will allow us to evaluate which part of the deviation is caused by the slip-rings themselves.

Using information gathered with each of the slip-rings we are interested in evaluating the error in magnetic field measurement. We will fit the corrected measurements from each slip-ring with to a sine function. Its amplitude is proportional to the magnetic field strength. We calculate this value for all data sets and we compare it with the actual value of the field (which will be measured directly – e.g., via Hall gauge).

Depending on the received data, we may decide to perform other types of analysis, e.g., to determine the spectral distribution of noise at different rotation speeds. This will be possible, because all data received is archived in its original form for later processing.