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Computer-Aided Testing of Electrical Machines: Software Development

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The Emerson Electric Company Machines and Drives Laboratory is designed for computer controlled research and testing of machines and drives. It is used by the faculty and graduate electrical engineering students for research and by the undergraduate students for power engineering education. Computer-aided testing is accomplished by near real-time computer control of the machines and simultaneous data acquisition. Computer control is versatile, precise, and rapid, thus offering many capabilities. Data acquisition can be done at a swift sampling rate to allow for a sufficient number of test data points to be gathered on the state of the motors. The data are easily processed or displayed for quick feedback on a test run.

The laboratory consists of six identical independent stations. Each has its own computer, machines, machine drives, and sensing devices. The computer controls the machines through their respective drives and collects data through measuring devices. A dynamometer consisting of a dc motor with a regenerative drive is used as the load or source of mechanical torque on the test machine. Computer controls are implemented for both the test motor and the dynamometer.

Two modes of operation are provided—automatic and monitor. The automatic mode utilizes algorithms (programs) that control and sample data as specified in the program. The advantages of this method are its quickness and low overhead processing. This allows tests to be run in a short period of time, reducing overheating and damage to the test motor when it is operated beyond its ratings. For example, the load on a test motor can be varied from no load to full load to blocked rotor in 6 to 10 s, before serious overheating can occur. With the sampling of all data channels up to 50 times per second, a sufficient number of data points are obtained to plot a smooth and accurate characteristic curve.

The second mode of operation is called the monitor mode. It has two submodes—manual and computer. In the manual submode the dynamometer, the machine drives, and the controls are operated manually from controls on the machine drive panels, which are independent of the computer. In this mode the computer's only function is to sample and display the measurement data. These data are updated with every scan of the transducers. The computer screen is used like a multimeter to display all the measurement values in proper units on the CRT terminal. This feature enables the user to perform calibrations and check out the equipment, wiring, and polarities prior to running each experiment. For example, in a synchronous machines experiment, the student is required to synchronize a three-phase generator with the line power supply as a manual procedure. Then performance tests are done under computer control.

In the computer submode the drives and machines are operated via the computer keyboard, and the measurement data are displayed on the CRT terminal in real time. Facilities are provided for raising and lowering the analog output controls by repeatedly pressing the U (up) and D (down) keys. The relays in the system may also be changed by selecting one and pressing T to toggle its status. The value of all analog output controls and all the transducers are updated constantly, on the screen, as they change.

The hardware system, shown in Fig. 1, was described in greater detail in earlier papers. It is described briefly to enable the reader to understand some detail of the system that is being monitored and controlled.

The software is described in greater detail, since it required the bulk of the development effort. Two key programs are 1) the interactive monitor, which enables system operation in the manual mode or the computer mode with control inputs from the keyboard; and 2) the RAMP subroutine which provides incremental increase/decrease of parameters for automated test programs described below.

The next three programs were developed to perform tests on specific types of machines. They are the induction, dc, and synchronous machines programs. Initial setting of parameters for the tests is done via the keyboard with prompts from the computer. The test is run under computer control and data sampling to completion. Test data are stored for subsequent listing and curve plotting.

Three sources of error are described: 1) transducer response times 2) data skew due to sequential sampling, and 3) machine and drives response times. In cases where these errors have been detectable, extending the run time of the experiment has provided data that are sufficiently accurate for curve plotting. Run times of 6 to 20 s have yielded "good" results.

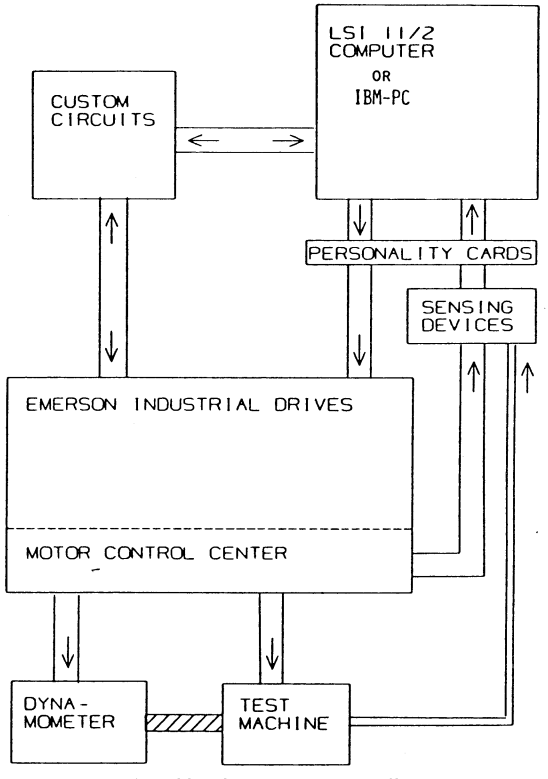

Fig. 1. Hardware system diagram.