Large scale data acquisition system for real time measurement

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Abstract— **Data acquisition systems for large scale mechanical systems, like helicopter turbo-shaft jet engine, are unique and complex systems. In particular, the complexity of such measurement-data acquisition systems for real-time data acquisition should be taken into account. Acquisition of measuring values, detection and visualisation of irregularities and inconsistencies is a separate problem designing and implementing such test stations. Because of that, such test stations are designed and implemented independently depending on the requirements of the users. Realization of measuring equipment and software realization is especially complex depending on the type of engine, the number of measuring parameters and the required precision. This paper presents the realization of such system for testing, measurement and acquisition of parameters turbo-shaft helicopter jet engines Gazelle type and MI-8 engine helicopter type. The data-regulation system is realized in such way that it can be easily expanded depending on the user's request and the engine type.**

Keywords – data acquisition system, large scale system, turbo-shaft engine, Advantech, Labview, Centos.

I. INTRODUCTION

The turbo-shaft jet engine [1-6] test cell is a system that enables monitoring of engine parameters during the testing, detection and signalisation all of necessary parameters, detection and adjustment of incorrect engine operating modes, full adjustment of engine operating modes as well as final testing of engines in order to issue certificates of the correct operation of the engine and its installation in the aircraft. Parameter acquisition, parameter monitoring, real-time measurement and calculation of engine characteristics during its testing and operation are one of the key elements of the jet engine service. This step is necessary to determine if the engine is properly repaired, fit and whether it meets all the necessary conditions in order to reassembly the engine into the aircraft. The safety and reliability of the engine after the overhaul can only be confirmed, before assembly, on the test bench. Measurements of all engine parameters, calculation of engine characteristics, and discovery of all deficiencies prior to assembly on the test bench, are eliminated and all possible consequences of unreliability or inconsistency during engine overhaul are minimized.

The realized system consists of a computer module responsible for collecting and processing data from motors and parameters within the test cell. The acquisition box located in the test cell, near the test engine and contains all sensor and converters that collect measured parameters from the motor, filtered it and amplified and forwarded to the computer module. There are, also, sensor elements that are outside the acquisition box for collecting data (variables) within the cell and the cable system for transmitting measured data and signals to a computer module. Each of these elements is specifically designed and realized and by connecting all elements into the system it is possible to reliably and synchronized operation of the entire system. A detailed block of the test cell is given in Figure 1.

II. COMPUTER MODULE SYSTEM

The computer module system consists of an industrial PC computer with Intel I5 processor (4-core processor system). 2 analogue data acquisition cards and 1 digital data acquisition card are responsible to collect all data from the sensors

mounted onto the engine and inside the test cell. Advantech PCI DAQ cards are selected to obtain reliable data acquisition. Analogue acquisition card is Advantech PCI 1741U-AE capable to collect 64 independent analogue single ended data or 32 differential analogue data [1]. This card is capable to collect the data with the sampling rate of 250 KHz. This card has 16 byte analogue to digital converter capable to acquire different analogue data signal (+/-5V, +/-10V, +/-2.5V) it has auto calibration mode and advanced DMA transfer system to the memory. Digital data acquisition card is PCI 1750-BE [2]. This digital data acquisition card is capable to collect 16 independent digital inputs and to realize 16 independent digital outputs. It has one compare-capture independent digital line capable to realize independently counting some external data. The computer module has a special graphics system that supports 2 high-resolution monitors for detailed visualization of all measured data. The secondary memory module is thus positioned to allow the storage of all the measured values over a longer period of time. A detailed block diagram of the computer module is shown in Figure 2. The computer module has a separate enclosure where the computer is located, connection elements from the test cell and a protective UPS system. UPS allows the entire acquisition system to run smoothly for another shorter time (about 15 minutes) in the event of a current power failure (network voltage) so that the parameters can be recorded even in the event of a power failure. The computer module has an additional printer that allows printing of data according to the needs of the user. The transfer of measured quantities and their storage can be accomplished with an external (external) portable disk. The collection and storage of the measured sizes as well as their processing, displaying, printing of certain promising interests, the production of the final test report is carried out by specially designed software developed on the platform of LabVIEW Professional 2007 for Linux of National Instruments [3]. Through the LabVIEW acquisition software package from National Instruments, user software for collecting, processing, visualizing, displaying measured sizes and alarm states, plotting the necessary charts in real time and producing a final test report on the user's request. The computer module is intended to be a modular type, with a high degree of redundancy. Redundancy is provided in two levels, direct replacement of an industrial PC with identical backup with identical features and implemented software.

Within the computer module cabinet, there are also some converters that allow the collection of data from the sensor systems that are not within the acquisition box described in the next paragraph. These are temperature sensors in the cell, barometric pressure inside the cell, fuel flow meters, differential pressure gauges on the engine air intake, current and voltage of the motor generator and micro-switches that enable the detection of open and closed doors in the cell. A detailed block diagram of the computer module is given in Figure 2.

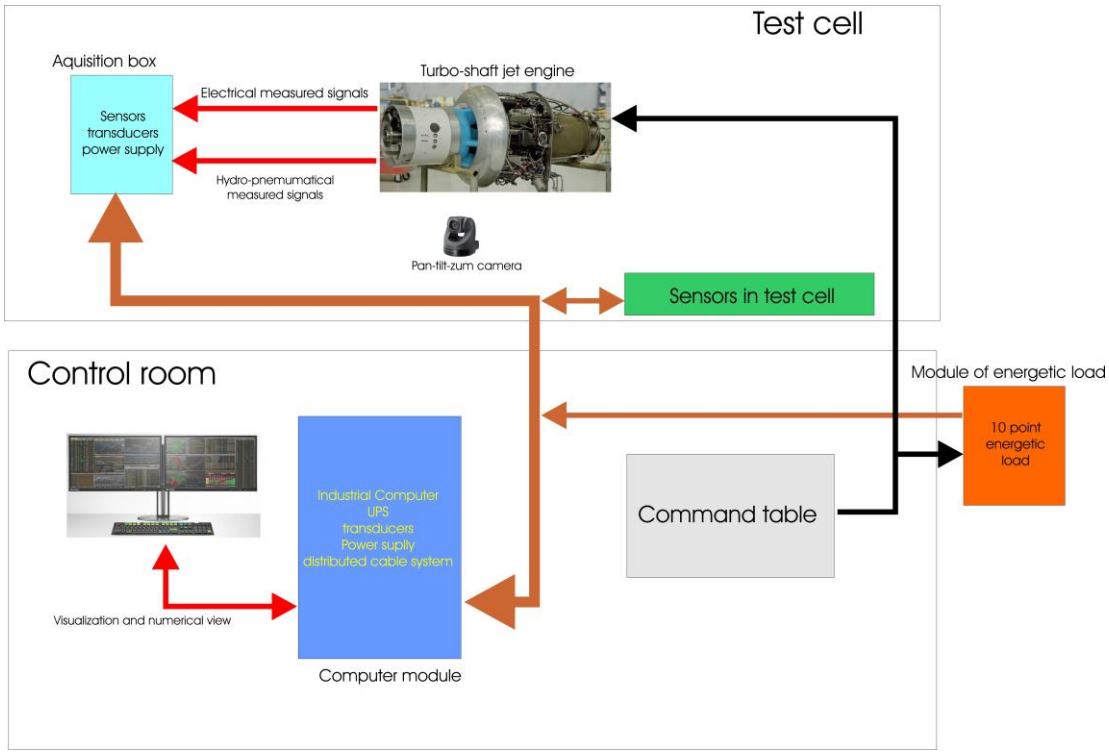

Figure 1. Block diagram of the realized test cell.

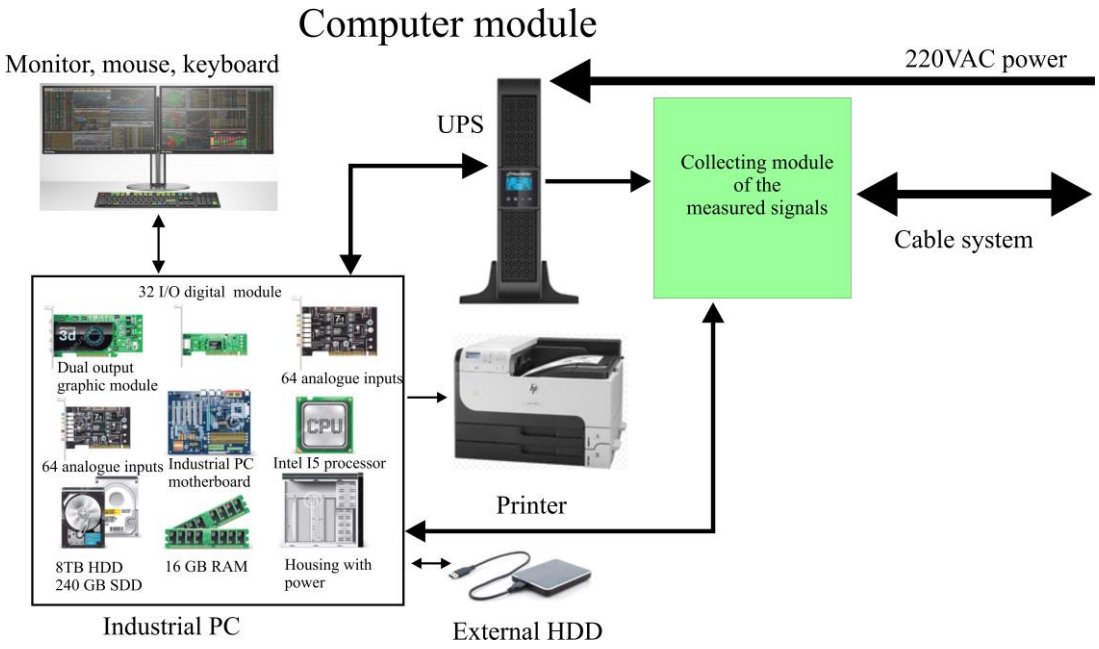

Figure 2. Computer module block diagram of the realized test cell.

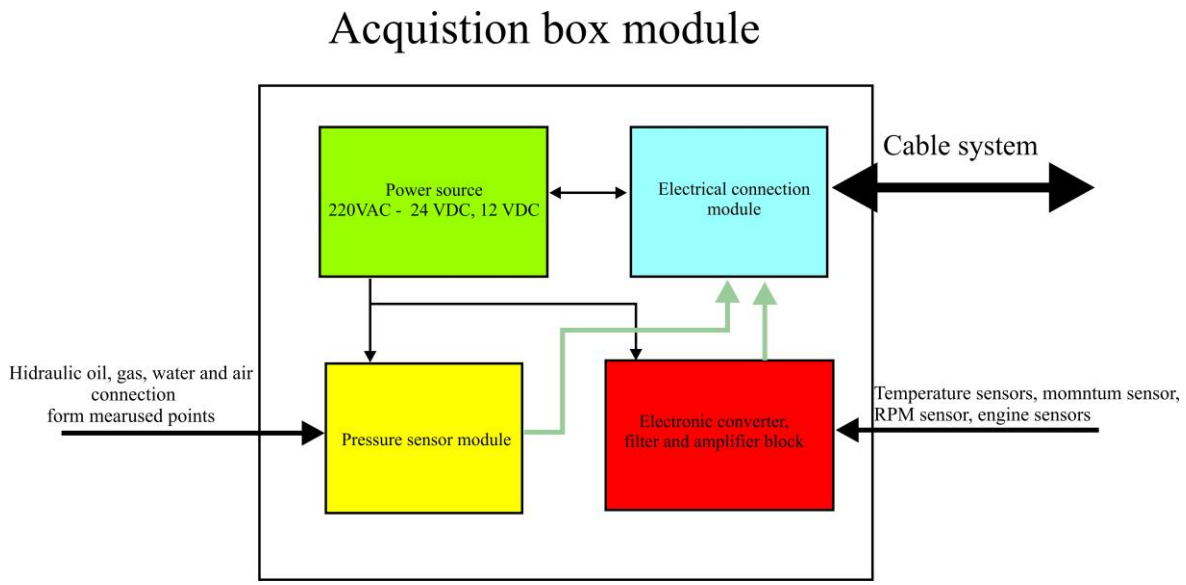

Figure 3. Acquisition data box detailed block diagram.

III. DATA AQUISITION BOX

The acquisition box module is a special element of the acquisition system which consists of the metal cabinet itself designed to be of such dimensions and characteristics as to be easily transferable to the stand of the engine. This allows easy assembly and demounting from different engine mounts. A detailed block diagram of the acquisition module box is shown in Figure 3. The system is so designed that it can accept a wide range of measurement signals, collect them, amplify and filter it, and thus transfer it to the computer module. For this purpose, the module of the sensor box consists of three independent units. The first unit makes the sensors themselves mounted inside the box. Within the box there is a wide range of pressure sensors that are mounted so that they can easily connect with the measuring points on the engine with the appropriate hydraulic connections. The other parts of the sensor box module are mutual electronic converters that accept and amplify the measured sensor values that are mounted directly on the engine. It is a varied set of temperature sensors, torque, and angular rotation speed of the engine shaft. Some of the detected sensors are the individual

that come together with the motor (integrated in its structure) and the signals (measured sizes) from these sensors are directly brought into the sensor box by the appropriate cable and connector, they are intensified and filtered within the box and then by the appropriate cable system from the box forwarding to the computer system for processing. The second set of sensors are specific types of sensor mounted on the motor and signal acquisition and amplification of the measured signals is also introduced into the sensor box module and then filtered, amplified and forwarded to the computer system. Inside the sensor box there is also a power source module, a system that generates the appropriate operating voltages for individual sensors installed inside the sensor box or outside the sensor box mounted on the test engine. These are shaft rotation speed sensors, engine torque, engine vibration and the absolute encoder for angle measurement.

IV. SOFTWARE MODULE

The software subsystem is a special element of the test station. It involves the acquisition and development of measurement software acquisition and software (graphical-alphanumeric) interface based on the licensed LABVIEW platform, National Instruments. The software subsystem involves the collection of measured signals, their processing in real time, the graphical and alphanumeric display of the measured signals, and the calculation of the identified engine characteristics during real-time testing. The software also stores the measured/calculated sizes on the secondary memory of the computer module. Graphical and/or alphanumeric visualization will be performed according to the principle of displaying the main measured values, the graphical representation of the engine characteristics in real time, the display of the variable values that emerge from the range, the display of alarm states (alerts), the selection of additional displays of the measured sizes as desired by the user. The software subsystem allows the printing of parameters, individual or consolidated according to the specification, copying files, manipulating files, storing data, producing a final test report.

The software subsystem also performs data analysis during the data collection. If some measured signals of some calculated engine characteristics are abnormal the light and acoustic alarm is activated, depending on the degree of disagreement of the measured parameters. The software system allows the choice of engine type at the start of the test and, based on the selected type of engine, opens a suitable base with engine characteristics and a unique number of tested engines. The test date is also a feature that the software module remembers during data update.

V. CONCLUSION

In the paper a data acquisition systems for large scale mechanical systems, like helicopter turbo-shaft jet engine, are unique and complex systems is presented. In particular, the complexity of such measurement-data acquisition systems for real-time data acquisition should be taken into account. Acquisition of measuring values, detection and visualization of irregularities and inconsistencies is a separate problem designing and implementing such test stations. Because of that, such test stations are designed and implemented independently depending on the requirements of the users. Realization of measuring equipment and software realization is especially complex depending on the type of engine, the number of measuring parameters and the required precision. This paper presents the realization of such system for testing, measurement and acquisition of parameters turbo-shaft helicopter jet engines Gazelle type and MI-8 engine helicopter type. The data-regulation system is realized in such way that it can be easily expanded depending on the user's request and the engine type.

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