Fault-tolerant Instrumentation System for Flash Evaporation Binary Cycle

Miguel Ángel Benítez Torreblanca
MBenitezT@iingen.unam.mx

Abstract

The Flash Evaporation Binary Cycle (FEBC-iiDEA©), is a power generation cycle based on the modification of a Conventional Binary Cycle (CBC), developed by the iiDEA© Group, part of the Engineering Institute of the National Autonomous University of Mexico.

Since its early development, the need of an integral instrumentation system was crucial, along with the monitoring of critical physical variables not only to validate the theoretical data, but also to start the on-site experiments.

The fault-tolerant instrumentation system implemented on the FEBC has the added value of augmenting reliability through hardware redundancy, making use of commercial-grade components, minimizing maintenance costs, and providing monitoring and data acquisition, which could eventually be customized to satisfy the requirements of the parallel projects of the iiDEA Group©, integrating it with a Remote Control and Telemetry System.

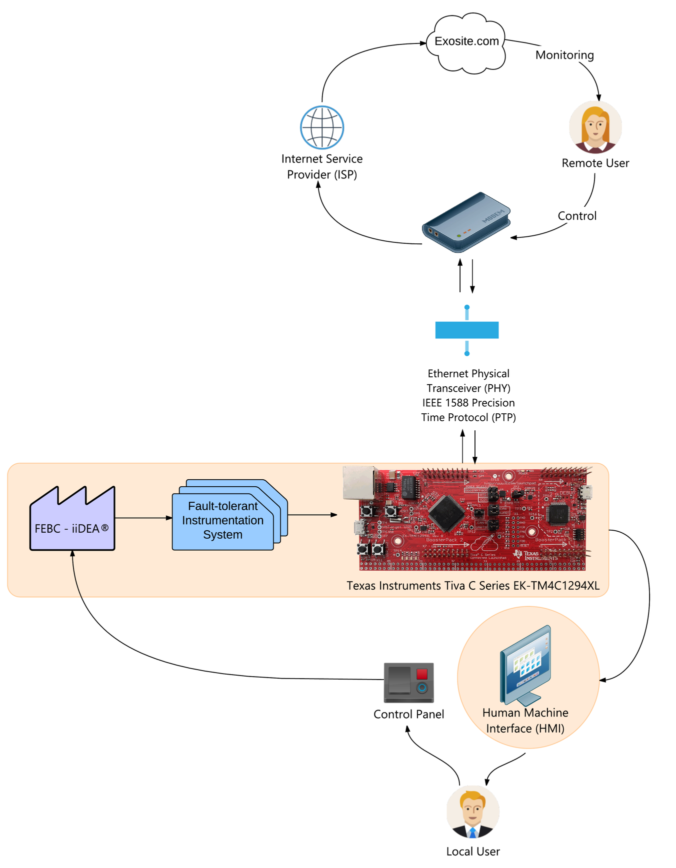


Fig. 1 General outlook of the Instrumentation, Remote Control and Telemetry System

Objective

Develop an fault-tolerant Instrumentation and Data Acquisition System (DAQ) for a Flash Evaporation Binary Cycle, applying hardware redundancy techniques for Power Supply Units (PSU).

Methods

Figure 1 illustrates the general outlook of the Instrumentation, Remote Control and Telemetry System for the FEBC. The focus of this work is the Fault-Tolerant stage of the Instrumentation System, which has the following purposes:

-Evaluation of Pinch point in heat exchanger

-Characterization of pressure drop on orifice plate

-Evaluation of operational conditions for the cyclonic separator

The following sensors are used for monitoring:

(5) Honeywell PX2EN1XX100PAAAX

(8) 4-wire RTD US SENSOR USW3577

Texas Instruments© (TI) EK-TM4C1294XL Evaluation Kit is used as the Data Acquisition System, which receives the analog outputs from the sensors as well as the Power Good (PG) signal from the PSUs.

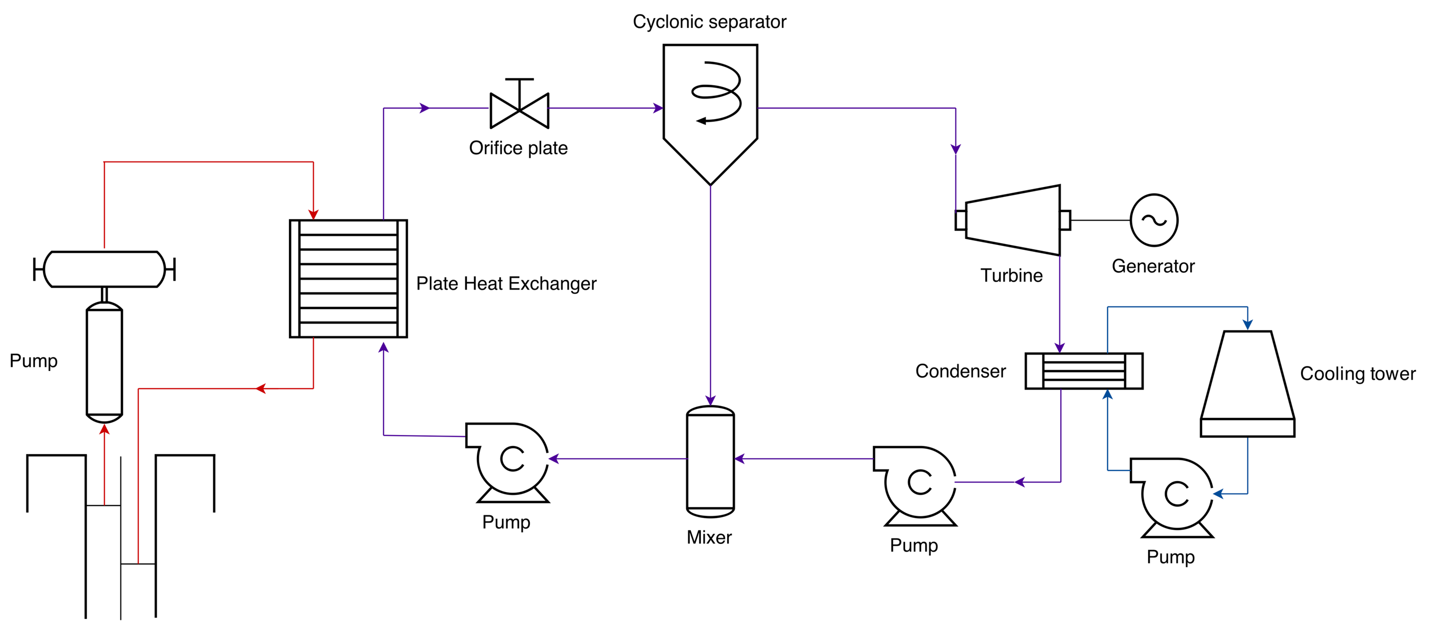


Fig. 2 Flash Evaporation Binary Cycle (FEBC—iiDEA©)

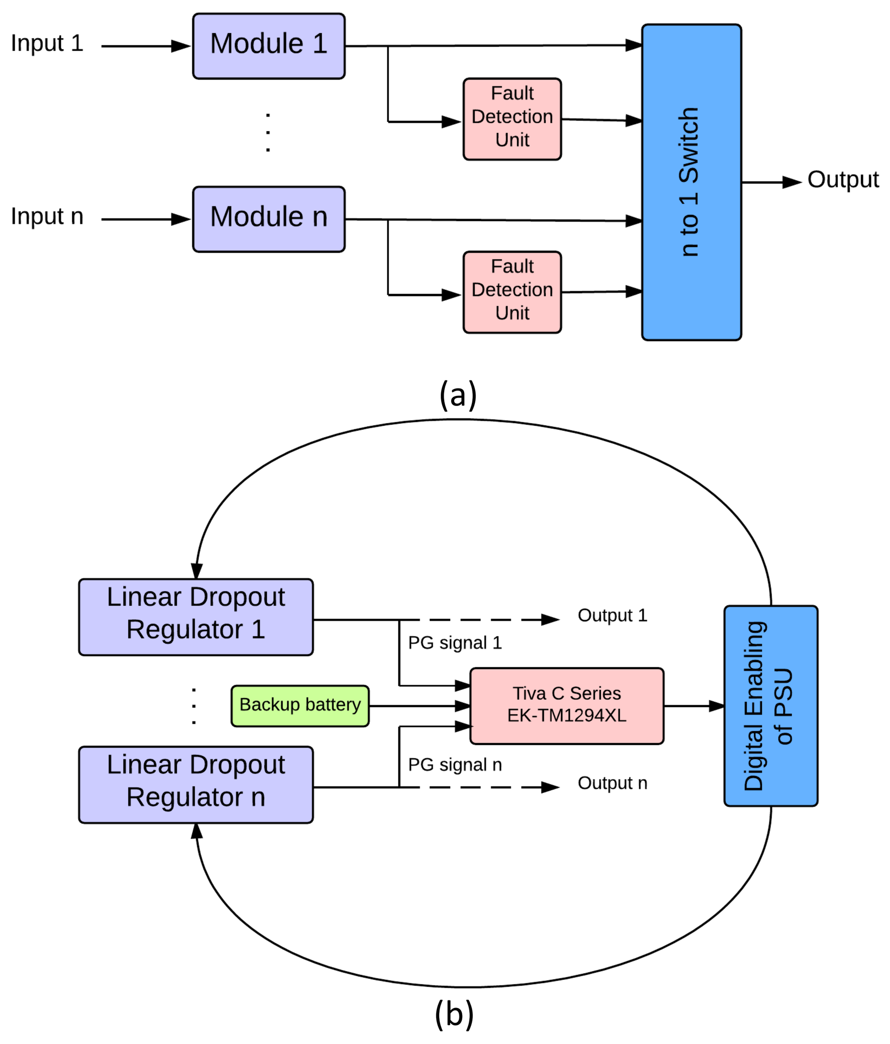


Fig 3. (a) Conceptual design (Standby redundancy with n spares) (b) Equivalent design

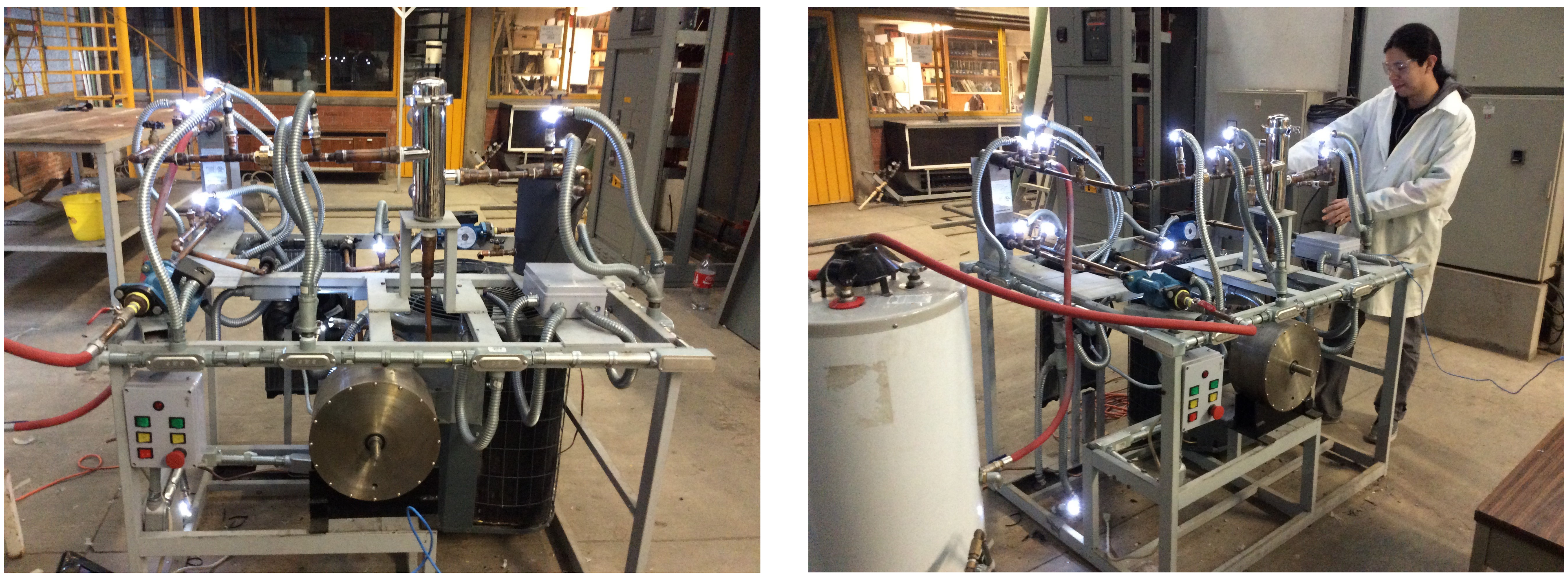
Failure Rates for each component were acknowledged based on manufacturer's reliability data (Texas Instruments) and used in the reliability analysis. In order to improve the overall reliability of the system, Standby Redundancy was used as the topology for the fault tolerant system (Fig. 3a), in which only one module is powered at the same time. In case of a fault-event, a switch powers off and replaces it, powering and enabling a functional module. In the design of the PSUs, the TI TPS series of Linear Dropout Regulators (LDO) were used for 12, 5, and 3.3 [V] rails. For the 12 [V] rail, a series of solid state relays (Photo-MOS, by Panasonic©) were used as enabling module; for each rail, three LDO units were used. Figure 3b shows the simplified and equivalent design for the standby redundancy topology, in which the EK-TM4C1294XL Evaluation Kit is used as Fault Detection Unit and Switcher.

In addition to the above, the EK-TM4C1294XL develops real-time monitoring to a local computer, using a modified version of a data acquisition tool made by Parallax©, called PLX-DAQ.

Results and conclusions

One of the main advantages of this fault-tolerant instrumentation system is that it can be implemented not only on the FEBC, but also on other main projects of the iiDEA© group. On the other hand, the enhanced reliability of the FEBC increases the possibilities of a fault-free on-site experimentation once the prototype is taken to field.

Throughout the laboratory experiments, a modified domestic boiler was used, and according to the theoretical background of the FEBC, water was adopted as working fluid. As a consequence of the experimental tests, the evaluation of the current orifice plate and cyclonic separator (also designed by iiDEA© members) was boosted.



(a) (b)

Fig. 4 (a,b) Modular prototype of FEBC