COMPARATIVE ANALYSIS OF DIFFERENT CONFIGURATIONS OF PLC-BASED SAFETY SYSTEMS FROM RELIABILITY POINT OF VIEW

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Abstract

The report presents the study of a comparative analysis of distinct multiplex and fault-tolerant configurations for a PLC-based safety system from a reliability point of view. It considers simplex, duplex and fault-tolerant triple redundancy configurations. The standby unit in case of a duplex configuration has a failure rate which is k times the failure rate of the standby unit, the value of k varying from 0 to 1. For distinct values of MTTR and MTTF of the main unit, MTBF and availability for these configurations are calculated. The effect of duplexing only the PLC module or only the sensors and the actuators module, on the MTBF of the configuration, is also presented. The results are summarized and merits and demerits of various configurations under distinct environments are discussed.

Summary of Results

The MTBF of the wind tunnel safety was estimated to be about 100 hours, those for the PLC module and sensors/actuators module were estimated to be 250 and 168 hours, respectively. The factor by which the simplex system MTBF increases by using redundancy is dependent on the value of the MTTR. It is given in the table below. **(All the tables in this section assume 100% use factor.)**

Table 1

MTTR (HOURS):	4	24	168	720
Duplex (Cold, $k = 0.1$):	24.6	5.7	2.5	2.0
Duplex (Hot, $k = 1$)	14	3.6	1.8	1.6
3MR	5	1.5	.93	.86

Duplexing only the PLC module leads to an increase in the system MTBF by a factor given in the table below:

(Recall estimated MTTF values. For PLC module: 250 hours; for sensors/actuators module: 168 hours; for the whole simplex system: 100 hours).

Table 2

MTTR (HOURS):	4	24	168	720
Duplex (Cold, $k = 0.1$):	1.66	1.60	1.47	1.41
Duplex (Hot, $k = 1$)	1.65	1.54	1.37	1.31

Duplexing only the sensors/actuators module leads to an increase in the system MTBF by a factor given in the table below.

(Recall estimated MTTF values. For PLC module: 250 hours; for sensors/actuators module: 168 hours; for the whole simplex system: 100 hours).

Table 3

MTTR (HOURS):	4	24	168	720
Duplex (Cold, $k = 0.1$):	2.41	2.14	1.74	1.62
Duplex (Hot, $k = 1$)	2.35	1.95	1.53	1.42

Observe that partial duplexing leads to a modest increase in the system MTBF. Duplexing only the PLC module leads to a smaller increase than what we would get if we duplex only the sensors/actuators module.

Duplexing only the processor, memory, and interface modules and leaving the input/output and sensors/actuators modules simplex leads to virtually no increase in the system MTBF.