# HIRDLS

## HIGH RESOLUTION DYNAMICS LIMB SOUNDER

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Subject / Title: **PSS DESIGN : RELIABILITY ANALYSIS**

Contents / Description / Summary:

This report summarises the PSS reliability analysis..

The four configurations are analysed using two methods: Cold redundancy and parallel redundancy. The two methods are shown to yield similar results.

The results are compared with the required reliability of 0.99 over 6 years. The reliability of a non redundant configuration is also compared with the reliability requirements.

Recommendations are made as to the optimum configuration.

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# SUMMARY OF THE PSS RELIABILITY STUDY

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## 1. INTRODUCTION

A theoretical reliability study was performed in April 1996 order to compare the reliability of possible PSS configurations. An internal report was written to describe the study (ref 1). This project note summarises the conclusions. The methods used are also summarised.

## 2. CONFIGURATIONS

The study assumed that 11 Vicor converters would be required for a non-redundant system. The five configurations analysed are listed below.

1.) Non redundant case.
2.) Two sets of converters switched by the A and B bus.
3.) One backup converter per *type* of converter
4.) One backup per converter, individually switched
(IPU converters switched together by A and B busses.)
5.) One backup per converter.

## 3. SWITCHING

The original report considered relays with a life of 100,000,000 operations, operated 1000 times during instrument life. These had an insignificant effect on instrument life. This conclusion has since been confirmed for relays with a shorter life of 1000,000 operations operated 1000 times during instrument life.

## 4. CONVERTER MTBF

Figures from Vicor indicate a converter MTBF of 2,000,000 hours. An instrument life of 50,000 hours was assumed.

## 5. METHOD

The following methods were used.

## 5.1 RELIABILITY

The standard formula for reliability was used:

$$R = e^{-(\lambda t)}$$

Where R = Reliability
$\lambda$ = Failure rate
t = Time

This formula follows from considering a constant failure rate, and applies to the flat portion of the bathtub curve (ref 2).

## 5.2 STANDBY SYSTEMS

The standard formula for standby systems (ref 3) is:

$$R = e^{-(\lambda t)} (1+ \lambda t)$$

Where R = Reliability
$\lambda$ = Failure rate
t = Time

This formula is derived from the Poisson distribution (Ref 4).

## 5.3 PARALLEL SYSTEMS

The formula for standby systems does not take account of failures to the subsystem which is powered off. Rather than assign an arbitrary figure to this, the reliability of systems running in parallel was calculated. This can be considered as a worst case.

The standard formula for systems in parallel (ref 2) is:

$$R(pair) = 1 - [1-R(unit)]^2$$

This formula is derived by considering the probability of failure (1-R). The probability of two units failing independently is the square of the probability of one unit failing.

## 6. SUMMARY OF RESULTS

The following table summarises the results.

| | | |
|---|---|---|
| 1 | Non redundant case. | 0.7593 |

| | | **PARALLEL** | **STANDBY** |
|---|---|---|---|
| 2 | Two sets of converters, switched by the A and B bus. | 0.9421 | 0.9684 |
| 3 | One backup converter per *type* of converter | 0.9861 | 0.9898 |
| 4 | One backup per converter, individually switched (IPU converters switched together by A and B busses.) | 0.9898 | 0.9949 |
| 5 | One backup per converter. | 0.9933 | 0.9961 |

## 7. CONCLUSIONS

The required reliability is 0.99 over a 6 year period. (ref 5)

A non redundant system gives a reliability of only 0.76, so a backup system of some kind is required.

Only configurations 4 and 5 meet the requirements, though configurations 3 does not fall far short. Configuration 2 gives a reliability of only about 0.95.

A practical implimentation of 5 has now been found, so it is intended to proceded with this configuration.

It is important to realise that the calculations only include the power converters. The reliability of the rest of the system must also be considered. Any degradation due to high operating temperatures must also be considered.(ref 6).

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