MOSCAD RELIABILITY

1. Introduction

Reliability of electronic equipment is not a trivial issue and this note is intended to clarify any misunderstandings in the field. The following reliability terms are commonly used:

Reliability R(t)
The basic formula of R(t) is rather simple:

R(t) = N(t)/N(t=0)

When N(t=0) is the number of products at the initial time (T=0) and N(t) is the number of survival products after a period of time t.

System reliability is defined as the probability that a given system or component will operate without any failure for a given time when used under specified environmental conditions.
The mathematics behind R(t) (especially for complex system) is sometimes quite complicated because it involves different failure distribution functions and mathematical modeling.

In those cases that the system is repairable we use system availability to describe the probability that the system will be in an operation mode at any given time.

System availability A(t) = MTBF / (MTBF + MTTR).

Mean Time Between Failures (MTBF) is meaningful only when the failure rate is constant.

Mean Time to Repair (MTTR) is defined as the average of all time periods taken to restore the failed system or equipment to an operative state, over an infinite length of time.

System availability is a function of a large number of logistic parameters such as:

- Operational and storage environment (temperature, humidity, vibrations, etc.)
- Maintenance procedures (periodic, preventive, etc)
- System configuration and topology
- Availability of spare parts

It is accepted practice to include temperature and vibration as environmental factors when specifying the reliability of a system. While in actual use, a system will however, experience a wide range of environmental stresses. As a result, the actual or "field" reliability may be considerably lower or higher than that experienced in testing or established by calculations. In real life it may often occur that a calculated 10,000 hours MTBF, is found to be a field MTBF of 1,000 hours or vice versa.

In Motorola we tend to use %F/Mo. (which stands for the percentage of failed products during one month) as a reliability figure because it is coherent to every one.

$$\%F/Mo. = \frac{\text{Monthly Operational Hours}}{\text{MTBF}}$$

General confusion concerning the proliferation of reliability standards and the many methods for calculating reliability figures leads to a chaotic situation where various vendors provide different reliability figures, some of them are artificially "treated" to fit the customer requirements.

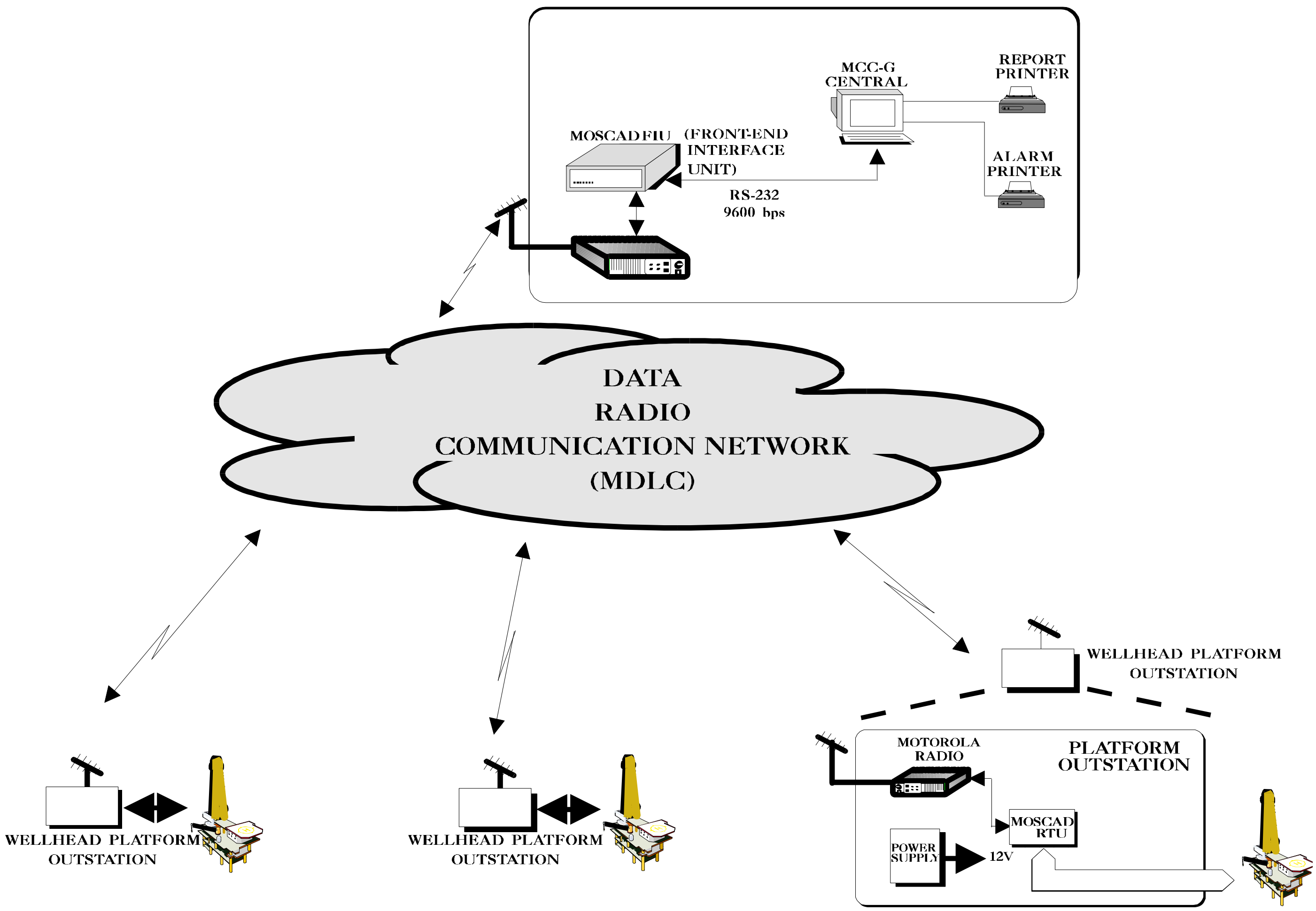
Motorola MTBF figures are calculated from a sample of products tested under Accelerated Life Test (ALT) simulates 8 years of field operation. This clearly is closer to actual field figures than prediction MTBF based on other reliability standards.

Reliability figures for MOSCAD modules are obtained from the Product Development Group. Empirical calculations of system reliability may also be performed for a given system. However, it should be emphasized that a MOSCAD based SCADA system also includes standard software and specific user application software and therefore the total system reliability must also include the reliability of the user application software - and this can not be calculated by the Product Group.

2. Example - System Reliability Calculations

2.1 System Description

The following example shows how to use ALT figures to predict system reliability. The example was taken from the gas and oil field application. The system comprises of one control center at the Master Control Center (MCC), and several RTUs at the wellhead platforms. The communication is implemented by means of a single channel radio network.



NOTE !

It should be noted that the following availability calculations are theoretical and figures are given for reference only. MOTOROLA is under no committment regarding the figures.

2.2 RTU Availability

The following table presents the estimated MTBF figures for the MOSCAD modules. The MTBF calculations were extrapolated from the Accelerate Life Test (ALT) results. Some figures are rather conservative, as the number of failures in the ALT test is not large enough to be act as a representative sample.

Following are the Moscad modules reliability figures:

Moscad Module	%F/Mo.	MTBF (Hr)	R for SMT of 10 Yrs.
Each Module	Less than 0.1	> 720,000	0.88
Power Supply	0.228	250,000	0.65

Basic statistics are required in order to build reliability model for configurations of the MOSCAD system.
Basically we differentiate between two types of module connections: the series and the parallel connection.
Failure will be observed in the parallel connection system only when all items are failed.
For items in "parallel" one must multiply all individual (1-Ri) to calculate the 1- Req.

$$Req = 1- \Pi(1-Ri)$$

In the series connection any failure of an item will cause a system failure, and system reliability will be calculated by:

$$Req = \Pi\ Ri$$

A constant failure rate is assumed for electronic equipment and the unit reliability over System Mission Time (SMT) can be calculated by using the following formula:

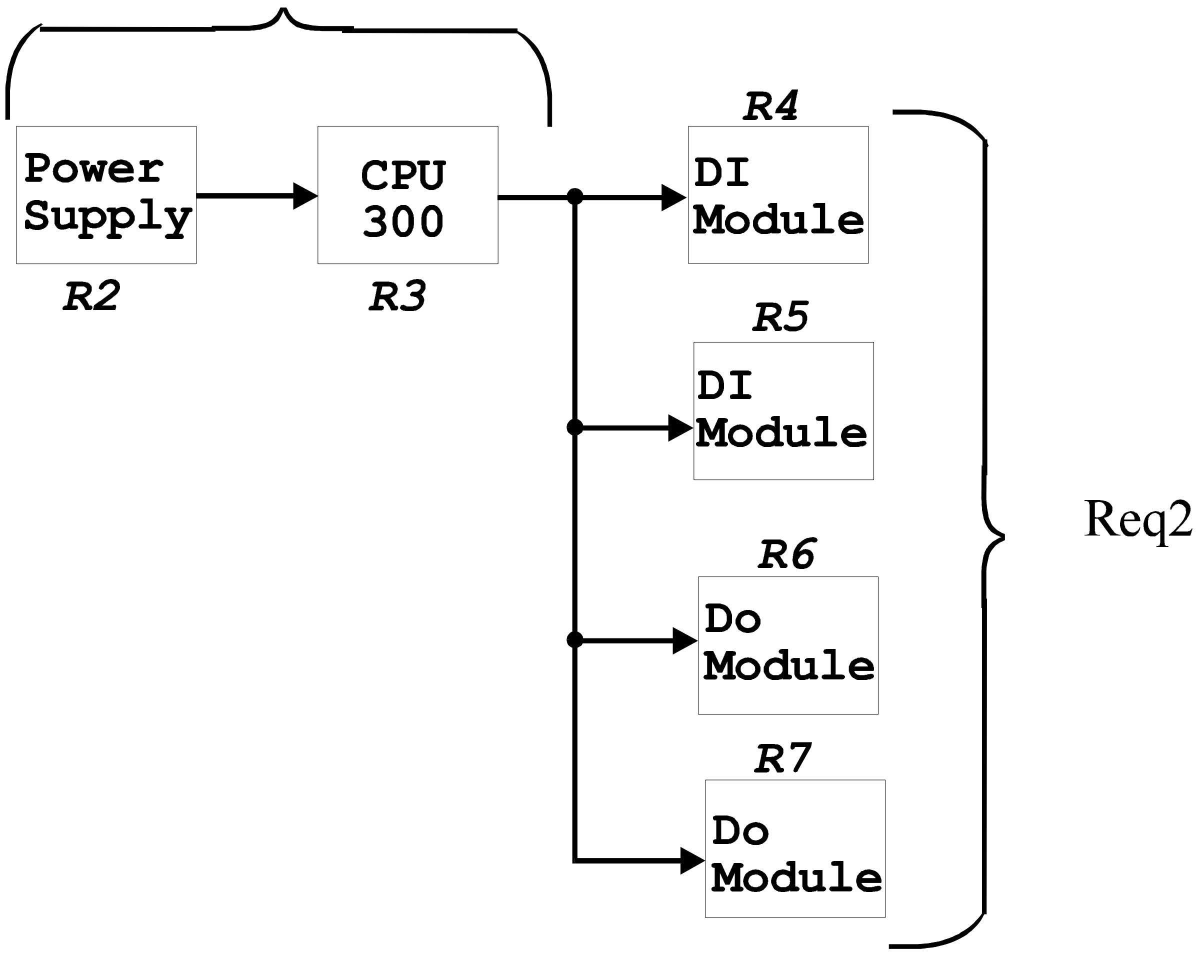
$$R=e^{-SMT/MTBF}$$

For SMT of 10 years (87,000 hours) R will be:

$$R=e^{-87000/MTBF}$$

Following please find a draft of the MOSCAD system to illustrate a reliability calculation

$R_{eq1} = R2 \bullet R3$



$$1\text{- Req2} = \prod_{I=4}^{7} (1\text{- } R_1)$$

$$1\text{- Req2} = (1\text{- } R_4) \bullet (1\text{- } R_5) \bullet (1\text{- } R_6) \bullet (1\text{- } R_7)$$

$$\text{Req2} = 1 - (1\text{- } R_4) \bullet (1\text{- } R_5) \bullet (1\text{- } R_6) \bullet (1\text{- } R_7)$$

$$R_1 = e^{-\frac{SMT}{MTBFi}}$$

$$Req = Req1 \bullet Req2$$

$$MTBFeq = \frac{SMT}{l\,n\,Req}$$

$$A = \frac{MTBFeq}{MTBFeq + MTTR}$$

In our case:

R2 = 0.65

R3 = R4 = R5 = R6 = R7 = 0.88

R_{eq1} = 0.572

R_{eq2} = 0.999793

$R_{eq} = R_{eq1} \times R_{eq2}$ = 0.571882

$MTBF_{eq}$ = 155,684 Hours

The MOSCAD RTU is a modular product, and includes extensive local and remote diagnostic capabilities. In addition each module has failure mode LED indication, and a CPU MODULE FAIL LED indicating faulty module. Thus we can assume that the MTTR is:

MTTR = 10 Minutes

and availability (A) is:

A = 155684/(155684+0.166) = 0.99999
A = 99.999%

The above result was based on the assumption that: the failure of single I/O modules are not considered as RTU fatal failure .

2.2 FIU (Front-end Interface Unit) Availability

The same calculations can be applied to the MOSCAD FIU at the MCC.

2.3 RF Communication Link Availability

In order to get high channel availability we must aplan for a link fade margin of 30 dB, based on received a signal with a minimum of -100 dBm (approximately 2 mV). Fade margin of 30 dB is equivalent to channel availability of 99.9%. A fade margin of 40 dB is equivalent to channel availability of 99.99%.

2.4 System Availability

Note that by improving the RF link system availability can be improved. The better the fade margin, the better the system availability, so this is a design parameter which should be set-up before installing a system.