3GPP TSG T WG1/RF SWG meeting#19 ***TSG T1R#19(01)0143***
Berlin, Germany, 9th-11th 2001

Agenda Item: **6.1**

Source: **Agilent Technologies**

Title: **The concept of judgement for BER testing**

Document for: **Information and Discussion**

Introduction

Agilent Technologies has been explaining a basic concept of BER testing. However it seems that the concept is not understood correctly. Before discussing statistical techniques in detail, we would like to explain it again.

BER/FER/BLER are different measurements. But when we discuss the statistical nature of them, they are assumed to be same and behave as a random variable. So BER, FER and BLER are not distinguished in this paper. And only no propagation condition is applied here.

IS98 approach (FER Judgement)

IS98 approach assumes only FER specification and confidence limit are given. Once FER specification and confidence limit are given, the FER limit curve can be plot using Chi-Squared distribution equation. Figure 1 is a copy from IS98 Annex-A. This is exactly same as normlized "early pass" curve with 95% confidence.

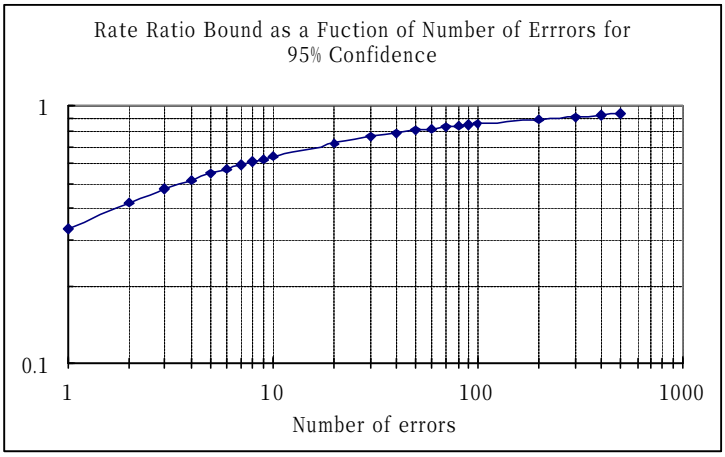

Figure 1. Normalized FER limit curve (IS98 approach)

We can calculate FER limit curves for each FER (e.g. 1%, 0.1% etc.). IS98 requires that "The FER for each test shall not exceed the piece-wise liner FER curve specified by the XXX." So the only area below the curve is "PASS". (Figure.2, FER=0.1%, 95% confidence)

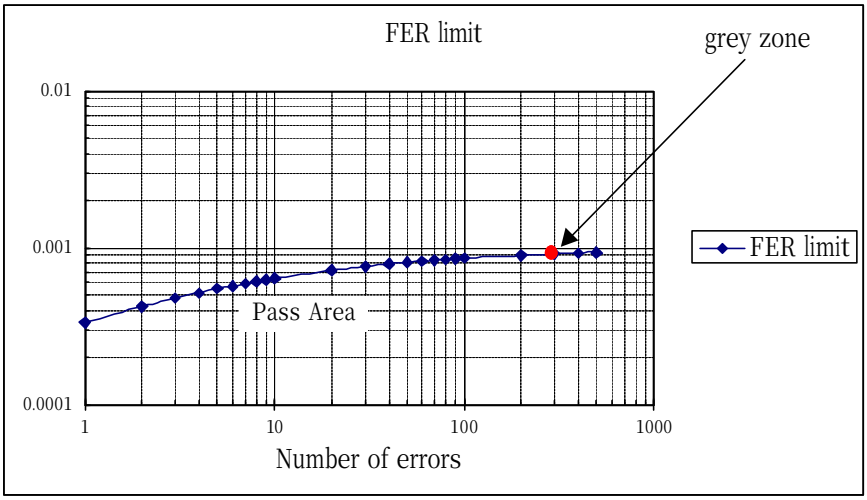

Figure 2. FER curve and Pass area in IS98 approach

When the number of errors is 200, FER limit curve gives 0.00089. Consequently there is no jdugement (neither "Pass" nor "Fail") between 0.00089 and 0.001. Usually this area can be decided as "FAIL". IS98 does not denote any stop conditions. So if measured FER is very close to FER specification (0.0001 in Figure.2), it may not pass or it takes longer.

The following notes are extracted from minutes of T1/RF #14 (Naantali).

[Handling policy for statistical nature of testing] (Number of test iteration, confidence level, etc.)
In order to define the number of test iteration, the method of IS-98 was discussed. This could be applied for statistical nature of testing (BER/BLER measurement and Chapter-8 tests). Mr. Baker pointed out that this is too severe approach, while a relaxation approach can be applied for measurement uncertainty. ("Never pass a Bad UUT" policy") So he recommended a different approach from IS-98 should be taken. There were a lot of discussions, but no conclusion. It was agreed that a calculation method or statistical approach is to be defined to decide the number of test iteration, and confidence level.
T1/RF chairman encouraged all delegates to consider this issue. (OPEN)

It was concluded that the direct application of IS98 approach is too severe for BER/BLER judgement. So we need a remedy for such a grey zone.

Minimum number of samples (Minimum number of error events)

Minimum number of samples is introduced for stop condition. For example, BER spec=0.001, Minimum number of samples = 200,000 (this means the number of error events is 200.). In this case, when 200,000 bits of samples are tested and it results less than 0.001, it passes. (e.g. 0.0009 is passed here, while IS98 approach considers it cannot be judged as PASS.) This is more relaxed than IS98 approach.

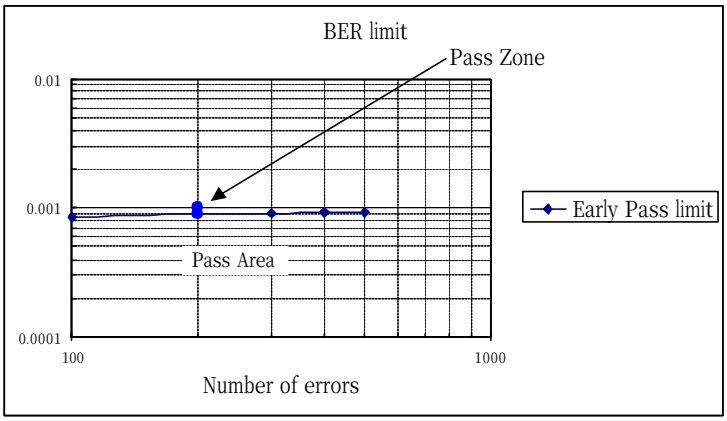

Figure 3. Minimum number of samples (Pass zone added)

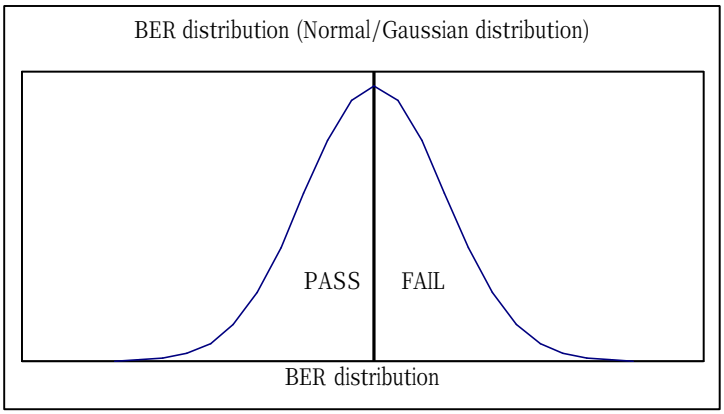

Figure 4. BER distribution (Normal/Gaussian distribution)

Supposing device under test has BER=0.001 nature, test result can be plotted in Gaussian distribution. The center value (mean) is BER=0.001. If test limit is BER=0.001, the possibility that a good device may pass is 50%. (Shared risk)

If this approach is acceptable, we do not need M ("bad" unit multiplication factor). However this approch is still severe, we need another remedy so as to increase the probability that a good device may pass.

"Bad" unit multiplication factor

GSM approcah introduces M ("bad" unit multiplication factor) to compromise the probailities that a good device may pass and a bad device should fail.

Proposal and discussion

Before discussion in detail of statistical equations, Agilent proposes that we should discuss a basic approcah for BER/BLER judgement. Agilent proposal (T1R010130) assumes that all remedies are needed so as to increase the probability that a good device may pass.

Figure 6 shows BER judgement based on T1R010130.

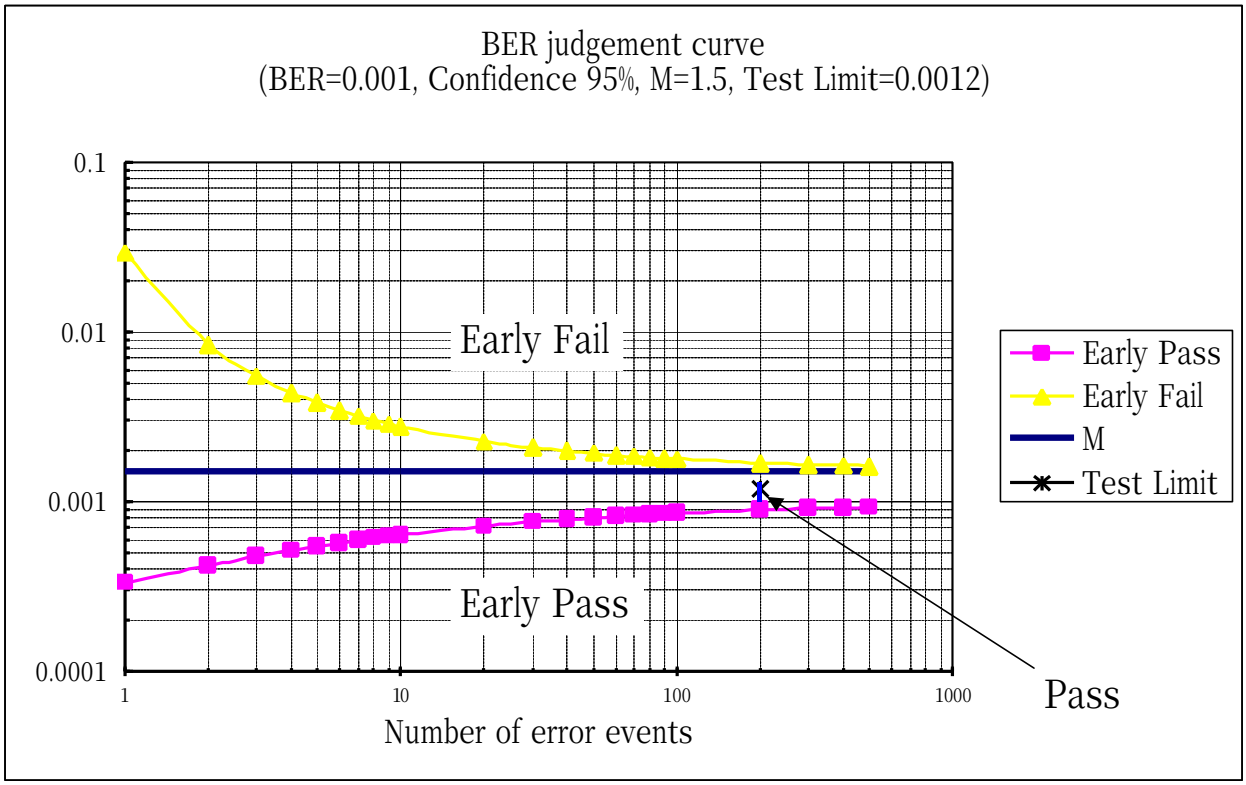

Figure 6. BER judgement (T1R010130)

$$\text{Early Pass Curve}: f(k) = \frac{2pk}{c^2(1-C,2k)}$$

$$\text{Early Fail Curve}: f(k) = \frac{2pk \cdot M}{c^2(C,2k)}$$

k : number of error events, p : BER specification (0.001), C : Confidence (0.95), M : multiplication factor

$c^2(a, \mathrm{n})$: value x such that $\mathrm{P(X > x)} = a$, where X is a chi-square distributed random variable with n degree of freedom

Note1: In T1R010130, Equation F.6.4 (Early Fail) is incorrect. This will be revised in the new CR proposal.

Note2: Figure 7 and Table 1 show the definition of the $X^2(a,n)$.

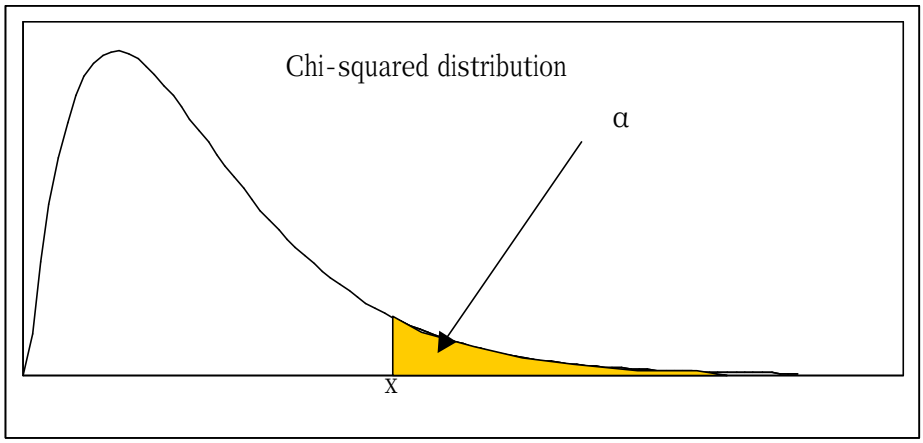

Figure 7 Chi-squared distribution random variable

Table.1 Chi-Squre percentiles

Chi-square percentailes C^2**(a,n)**									
n \ a	0.99	.975	**.95**	.90	.10	**.05**	0.25	.01	.005
1	0.00	0.00	**0.00**	0.02	2.71	**3.84**	5.02	6.63	7.88
2	0.02	0.05	**0.10**	0.21	4.61	**5.99**	7.38	9.21	10.60
3	0.11	0.22	**0.35**	0.58	6.25	**7.81**	9.35	11.34	12.84
4	0.30	0.48	**0.71**	1.06	7.78	**9.49**	11.14	13.28	14.86
5	0.55	0.83	**1.15**	1.61	9.24	**11.07**	12.83	15.09	16.75
….									
12	3.57	4.40	**5.23**	6.30	18.55	**21.03**	23.34	26.22	28.30
….									