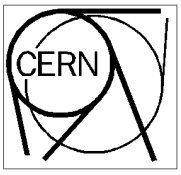

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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Back-End Opto-transceiver Module (TRx) Test Procedure

v.1.1

NGK INSULATORS LTD

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Revision History

Version	Date	Notes
1.0	7 August 2003	First draft
1.1	13 October 2003	Small changes to Table 2 and pre-production qualification procedure. Thermal test added.

1. Quality Assurance Programme outline

The aim of this document is to define the procedures involved in the testing and lot acceptance of the back-end opto-transceiver modules (TRx) manufactured by NGK Optobahn. The resultant test-data will be compared to the module specifications leading to the acceptance or rejection of the batch under consideration.

1.1. Documentation

All test results will be documented in the form of a pre-production qualification report or a lot acceptance report depending upon the nature of the batch to which the results pertain. Copies of these reports will be sent to the manufacturer and will be copied into the CERN document archive (EDMS). Direct access to the documents in EDMS is restricted to members of CMS.

1.2. Delivery Schedule

The production of DOHs will proceed in Batches. The predicted numbers to be delivered are shown in Table 1.

Table 1: Delivery schedule (as specified in order but subject to change).

Batch	Batch Description	Quantity	Delivery date forecast Delivery to CERN
T0	Pre-production	25	July 31, 2003
T1	Series production	20	September 30, 2003
T2	Series production	100	November 28, 2003
T3	Series production	100	January 5, 2004
T4	Series production	100	February 27, 2004
T5	Series production	55	March 31, 2004
	Total	400	

1.3. Quality Assurance programme overview

The quality assurance programme overview is shown in Table 2. The table shows the tests to be carried out during lot acceptance testing and pre-production qualification, together with the test target specifications from the technical specification for the TRx module (CMS-TK-ES-0017).

The test procedures for pre-production qualification and lot acceptance testing are described in Sections 2 and 3. Details of the methods are found in Section 4.

All tests are carried out at room temperature unless otherwise noted. All batches delivered from the manufacturer shall have a compliance certificate attached. The test procedures carried out by CERN will not cross-check all specifications.

Table 2: Test-program overview

#	Spec to be tested	min	typ	max	unit	CERN testing	
						Pre-production Qualification	Lot Acceptance
5.1	Bit Rate	2		80	Mb/s	③	③
5.2	Bit error rate			10^{-12}		③	③ TBD
5.3	Skew			1	ns	③	
5.4	Jitter			0.25	ns	③	
5.5	Operation rate[1]		4000		hrs/year		
5.11	Number of Tx channels	4				① ③	① ③
5.12	Number of Rx channels	4				① ③	① ③
5.13	Module Size		40x35x10		mm	②	②
5.21	Differential input voltage	±400	±600		mV	③	③
5.22	Input impedance		100		Ω		
5.23	Differential output voltage		±600		mV	③	③
5.24	Output impedance		100		Ω	③	③
5.25	Power supply	3.1	3.3	3.5	V	③	③
5.26	Power dissipation			2	W	③	③
5.31	Wavelength	1260	1310	1360	nm		
5.32	Average launch power	-13		-3	dBm	③	③
5.33	Optical modulation amplitude	-12		-3	dBm	③	③
5.34	Rx sensitivity			-20	dBm	③	③
5.35	Rx saturation (d.c.)	-4			dBm	③	③
5.36	Optical connector		MPO			①	①
5.51	Operating temperature	0		70	°C	③	
5.52	Operating humidity			60	%RH		
5.53	Storage temperature	-20		70	°C		
5.54	Reflow temperature			260	°C		

① Visual inspection

② Geometrical measurement

③ Electrical /Optical test

[1] NGK will measure the failure rate of these modules.

2. Pre-production Qualification Procedure

No failures related to the manufacturing process are allowed in the pre-production samples. Failure means that a device does not meet all the required specifications.

In the case of device failure, the cause of failure will be determined by CERN and/or the manufacturer. If required, a larger quantity of devices may be subjected to tests, or more detailed testing carried out, in order to satisfactorily diagnose the cause of failure.

In failures are found that are due to the manufacturing process, the manufacturer is expected to resolve any problems and to re-supply a batch of new TRx for qualification. If a satisfactory solution cannot be found, CERN reserves the right to disqualify the product.

If device failure occurs due to reasons not associated with the manufacturer or the manufacturing process, CERN reserves the right to modify the TRx specifications and test procedures and to request a re-supply of a new pre-production batch of devices.

2.1. Pre-production Qualification Flow

The set of 25 samples from the pre-production batch will be tested according to Table 3 and the flow diagram in Fig. 1. Details of each test are given in Section 4. If a device fails the tests will continue, if possible, so that the amount of maximum information can be passed back to the manufacturer for process evaluation and improvement.

Table 3: Sample sizes for use in pre-production qualification testing.

Test Number	Test Procedure	Sample Size
1	Visual Inspection	25 TRx: 100% of batch
2	Geometrical measurement	25 TRx: 100% of batch
3	Optical/Electrical test	25 TRx: 100% of batch

3. Lot Acceptance Procedures

This section describes the lot acceptance procedure. The flow diagram is shown in Fig. 1 and details of the specific tests are given in Section 4.

3.1. Lot Acceptance Flow

Sample size for lot acceptance is at least 10% of TRxs for each month of production, with a minimum of 5 samples. These samples are chosen at random from the batch under test.

No failures at the lot acceptance level are allowed. Furthermore the samples used for lot acceptance will pass sequentially through all of the procedures in the order they appear in Fig. 1. After use in the final test, the test samples used for lot acceptance will be used, along with the other delivered modules, for production of Front-end controller (FEC) cards.

In the event of failure of an early test, the full test program will be carried out if it remains possible. This will allow the maximum amount of feedback information to be given in the lot acceptance report.

The TRx will not be burned-in at the module level. The transceiver will be burned-in mounted on a FEC card (TBD).

Failures during burn-in will not necessarily lead to the rejection of a batch of devices. However, if failure during burn-in is related to a manufacturing process, the manufacturer is expected to repair or replace the failed device.

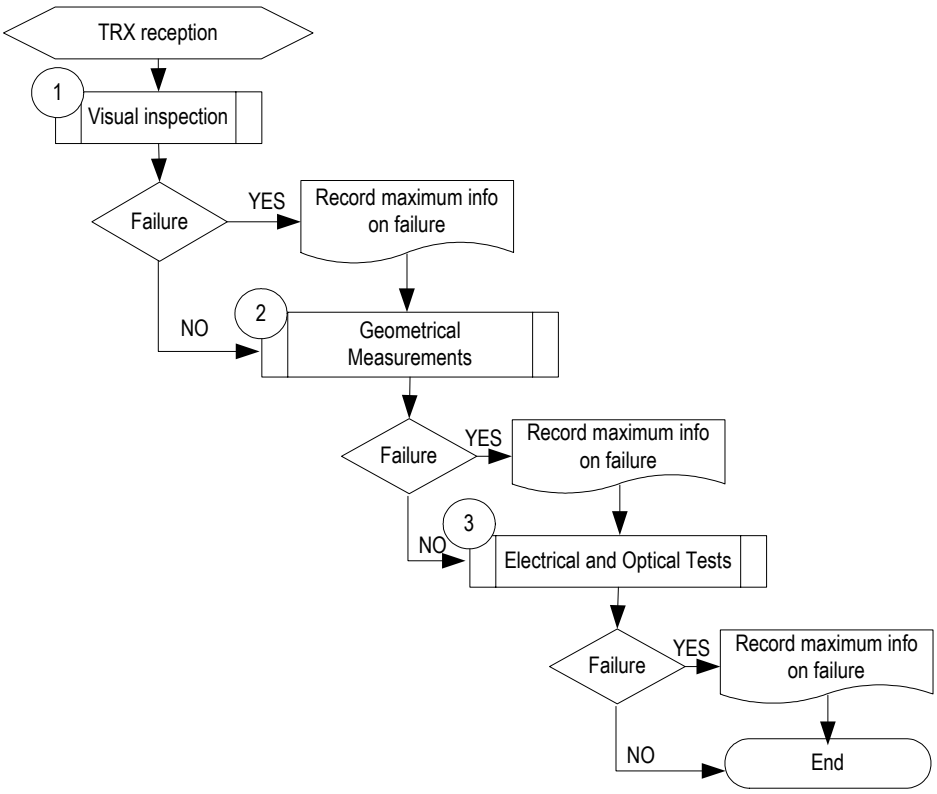

Fig. 1: Flow-chart of (a) pre-production qualification and (b) lot acceptance procedures

4. Test Descriptions for pre-production and lot-acceptance

4.1. Visual inspection ①

The TRx, including the MPO-connection point shall be checked for visible defects, using a microscope if necessary.

TRxs with defects that are considered to be important enough to degrade the performance and/or lifetime of the component in the final system will be rejected.

4.2. Geometrical measurement ②

The dimensions of the TRx will be measured with appropriate instruments.

The dimensions of the TRx should agree with those given in the NGK specification.

4.3. Optical/electrical tests ③

The TRx under test is connected to the setup shown in Fig. 2, and Fig. 3 illustrates the flow of the subsequent optical and electrical measurements.

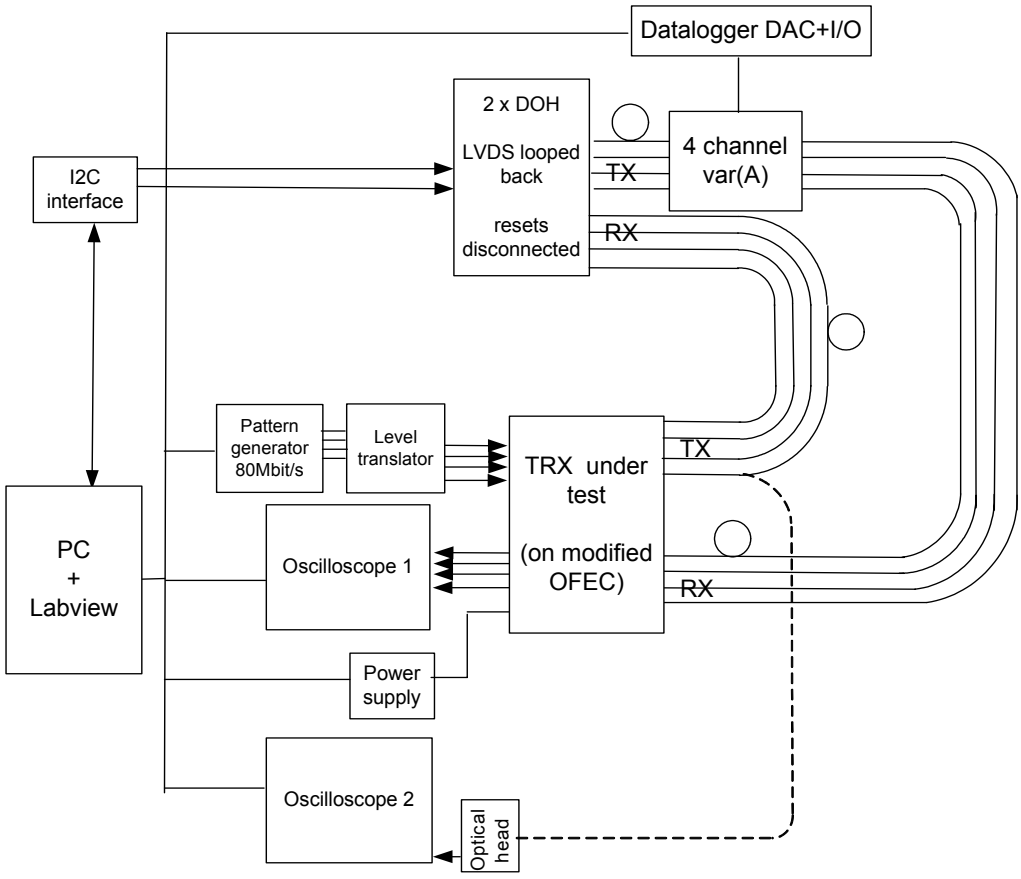

Fig. 2: Test setup for measuring TRx optical and electrical characteristics

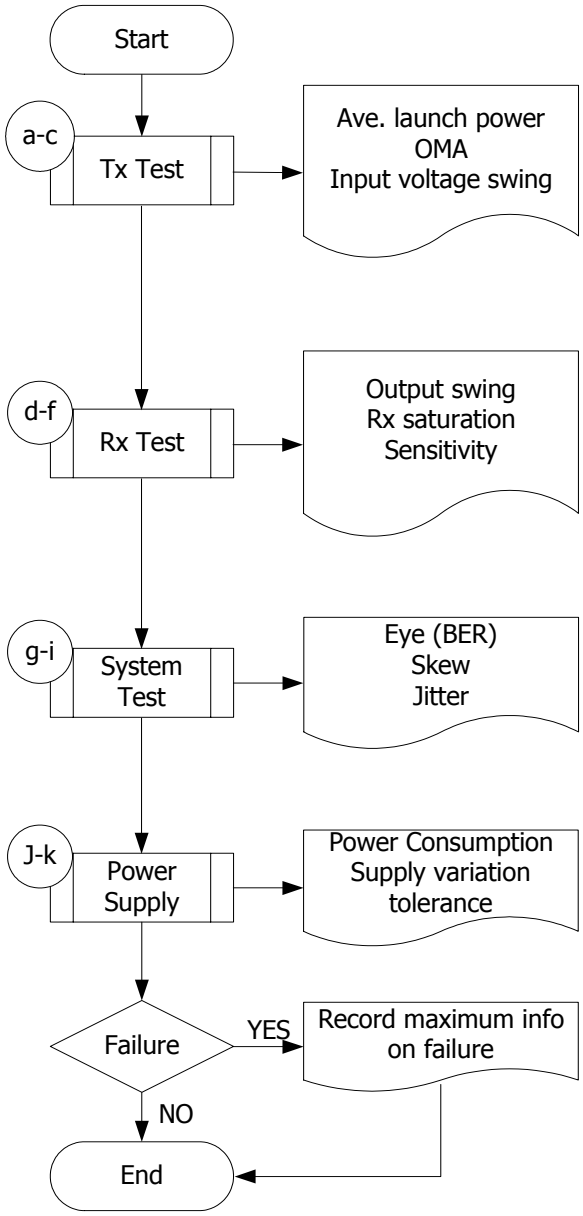

Fig. 3: TRx Optical/Electrical Test Sequence

4.3.1. Tx Test

The following measurements are made on all 4 optical output channels, one at a time using a 80Mbit/s input signal.

(a) Average launch power (spec 5.32)

With ±400mV input on each of the 4 channels in parallel, the average optical launched power is also measured with the optical head.

The values shall lie within the specified range of –13 to –3dBm.

(b) Optical modulation amplitude (OMA) (spec 5.33) and (c) input voltage swing (spec. 5.21)

With ±400mV input on each of the 4 channels in parallel, the output OMA is measured using an optical head coupled to an oscilloscope.

The values shall lie within the specified range of –12 to –3dBm.

4.3.2. Rx Test

On both clock CK and data DA channels the following measurements are made after calibrating the output of the reference DOHs and variable attenuators. The input voltage swing is set to ±400mV on all four electrical inputs to the TRx. A pseudo-random bit pattern will be used (PRS-7 for example at 80Mbit/s) to drive the 4 TRx channels.

(d) Output voltage swing (spec 5.23)

The output voltages from the TRx (with appropriate termination) are measured with electrical probes.

The output voltage swing should be compatible with the specified value of 600mV typical voltage swing (CML) into 100Ω termination. This measurement indirectly checks the output termination of the module.

(e) Receiver saturation (spec 5.35)

The dc saturation level is measured on each channel TRx optical input by increasing the dc power output of the corresponding laser channel on the reference hybrid.

The saturation level shall be greater than –4dBm.

(f) Receiver sensitivity (spec 5.34)

The electrical output of the TRx is then monitored whilst increasing the variable attenuation on one optical input channel at a time, whilst the other channels operate without additional attenuation, such that the power in the attenuated channel eventually decreases below 10μW.

The TRx should function with an open and clean eye diagram for OMA<10μW. To measure the eye-diagram a mask may be used, with limits TBD.

If failures occur in this step, the measurement will be repeated with differences in optical power between the 4 input channels being less than 5dB.

4.3.3. System test

(g) Eye pattern (BER) (specs 5.1, 5.2)

The input voltage swing is set to ±400mV on all four electrical inputs to the TRx. A pseudo-random bit pattern will be used (PRS-7 for example) to drive the 4 TRx channels.

The electrical output eye pattern is recorded, with attenuation in the optical links from the reference DOHs such that the input signal OMA is –20dBm on each TRx receiver input.

All channels of the TRx should function with a completely open and clean eye diagram on all four channels. To measure the eye-diagram a mask may be used, with limits TBD.

If there is uncertainty of whether bit-errors would occur under these conditions the measurement will be repeated with a dedicated BER tester.

(h) Skew (spec 5.3)

The optical connections of the TRx under test are looped back, such that the optical output of channel 1 to 4 are connected directly to the receiver channels 1-4 on the same TRx. The skews between the four channels are measured at the electrical output of the TRx.

The skew between any channels on the TRx shall be less than 1ns.

(i) Jitter (spec 5.4)

Again, with the optical connections looped back, as in step (h), the jitter on all four TRx output lines is measured.

4.3.4. Power supply

(j) Power dissipation (spec 5.26)

Using a calibrated power supply the consumption of the TRx is measured. The TRx will be operating during this measurement with a PRS-7 input electrical signal pattern (±600mV) on all four electrical inputs to the TRx and without attenuation of the optical signals from the reference DOHs to the TRx.

The power consumption should be less than 2W (after subtracting the power dissipated on the O-FEC test-card).

(k) Power supply variation (spec 2.25)

The TRx will be operating with a PRS-7 input electrical signal pattern (±400mV) on all four electrical inputs to the TRx and without attenuation of the optical signals from the reference DOHs to the TRx.

The input voltage supply is set to the extremes of the specified range, 3.1V and then 3.5V, and the output electrical eye-patterns are monitored at each voltage setting to check for any significant degradation of the TRx performance. The optical eye-pattern from the TRx transmitters will also be measured to check for any degradation of the transmitter performance.

To measure the eye-patterns quantitatively a mask may be used, with limits TBD.

4.3.5. Operating temperature

Using the measurement setup in Fig. 2, this time with the TRx placed in an oven, the measurement sequence shown in Fig. 3 is repeated at various temperatures between 20°C and 70°C (TBD).

The TRx should perform according to the specifications up to 70°C.