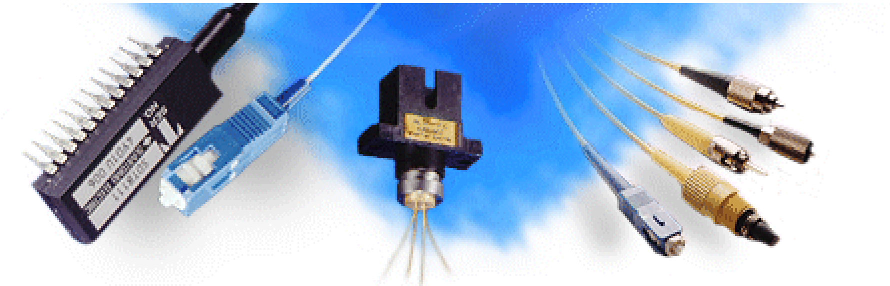

Mar. 7, 2005

Contamination's Influence on Receptacle type Optical Data Link

-The Dust on Endface Experiment for Receptacle Devices-

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Optical Module production Engineering Group
Optical Transmission Components Division
Sumitomo Electric Industries, Ltd

Sumitomo Electric

ExceLight
A Sumitomo Electric Company

Contents

(a) Introduction

what is the Optical Data Link

(b) Critical parameters

which characteristic is sensitive to contamination

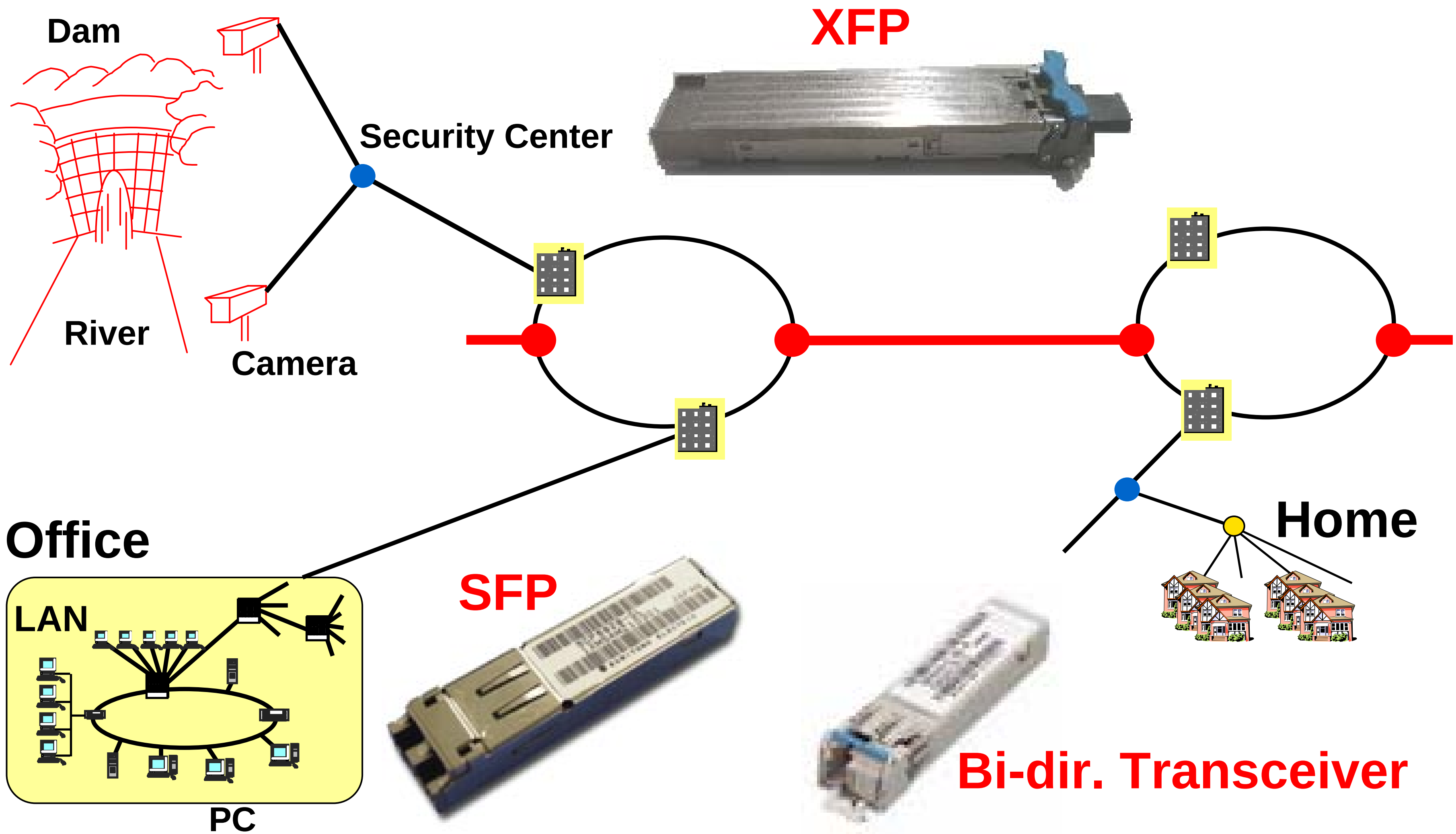
(c) Contaminating Techniques

to make the Non-remobables on Connector Endface

(d) Measurement Techniques

to get the stable value of ORL

(a). Introduction -1
(Network)

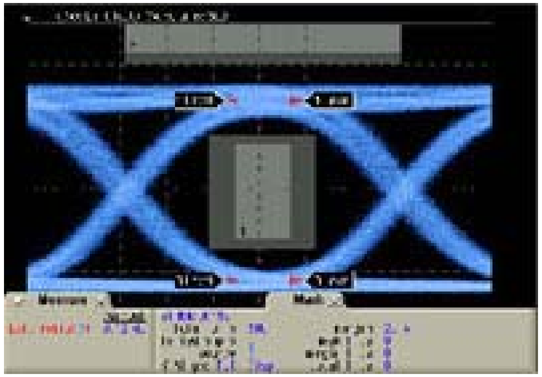


(a). Introduction -2
(Optical Data Link –Tx)

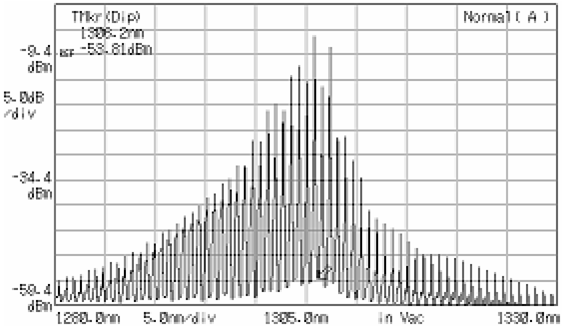
Important Opt-Electrical Characteristics of Optical Data Link

Transmitter side (change Electrical signal to Optical signal)

1. Optical Power
2. Optical Signal Waveform (Pulse Mask, Jitter, Dispersion Penalty)
3. Optical Spectrum (Center Wavelength, Spectral Width, SSR)
4. Physical Contact ability (ORL)
5. Monitor Function (LD bias, Rear Facet)



Optical Signal Waveform



Optical Spectrum

(a). Introduction -3
(Optical Data Link –Rx)

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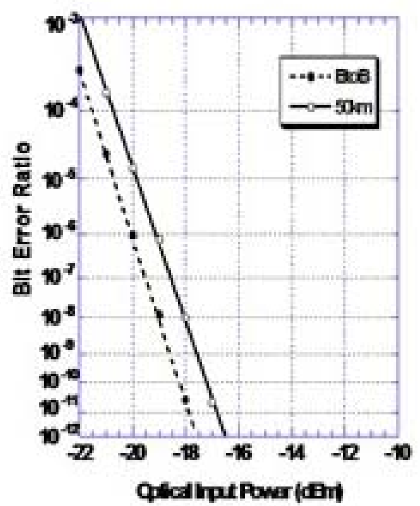
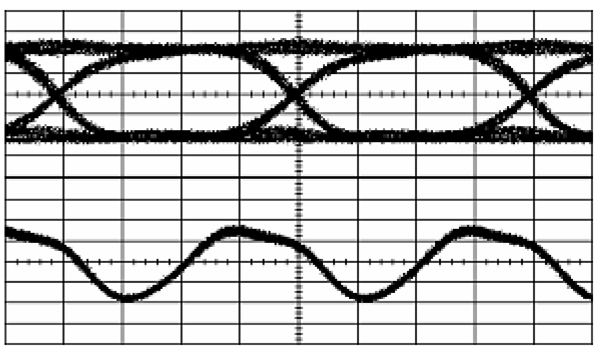
Important Opt-Electrical Characteristics of Optical Data Link

Receiver Side (change Optical signal to Electrical signal)

1. Decoded Bit Error Rate (Minimum Sensitivity, Overload)
2. Optical Return Loss
3. Electrical Signal Waveform (Amplitude, Rise Time)
4. Monitor Function (LOS)



Bit Error Rate Curve

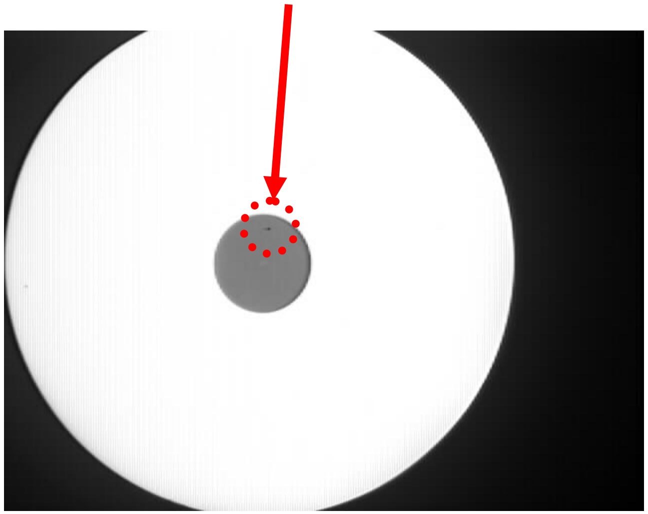


Electrical Signal Waveform

(a). Introduction -4
(Contamination on Connector Endface)

On August, 2000, Visual Inspection has started.

Non Removable



Removable dusts

Cleaning Receptacle Devices is difficult. -> Yield becomes worse.
-> Improve process not to soil the endface.
Improve cleaning technique.
Establish the suitable specification not to become expensive.

Contents

(b). Critical parameter -1
(Sensitive characteristics)

Characteristics Sensitive to Contamination

Transmitter side

1. Optical Power
2. Optical Signal Waveform
   (Pulse Mask Margin, Dispersion Penalty)
3. Optical Spectrum (Spectral Width, SSR)
4. Physical Contactability (ORL)

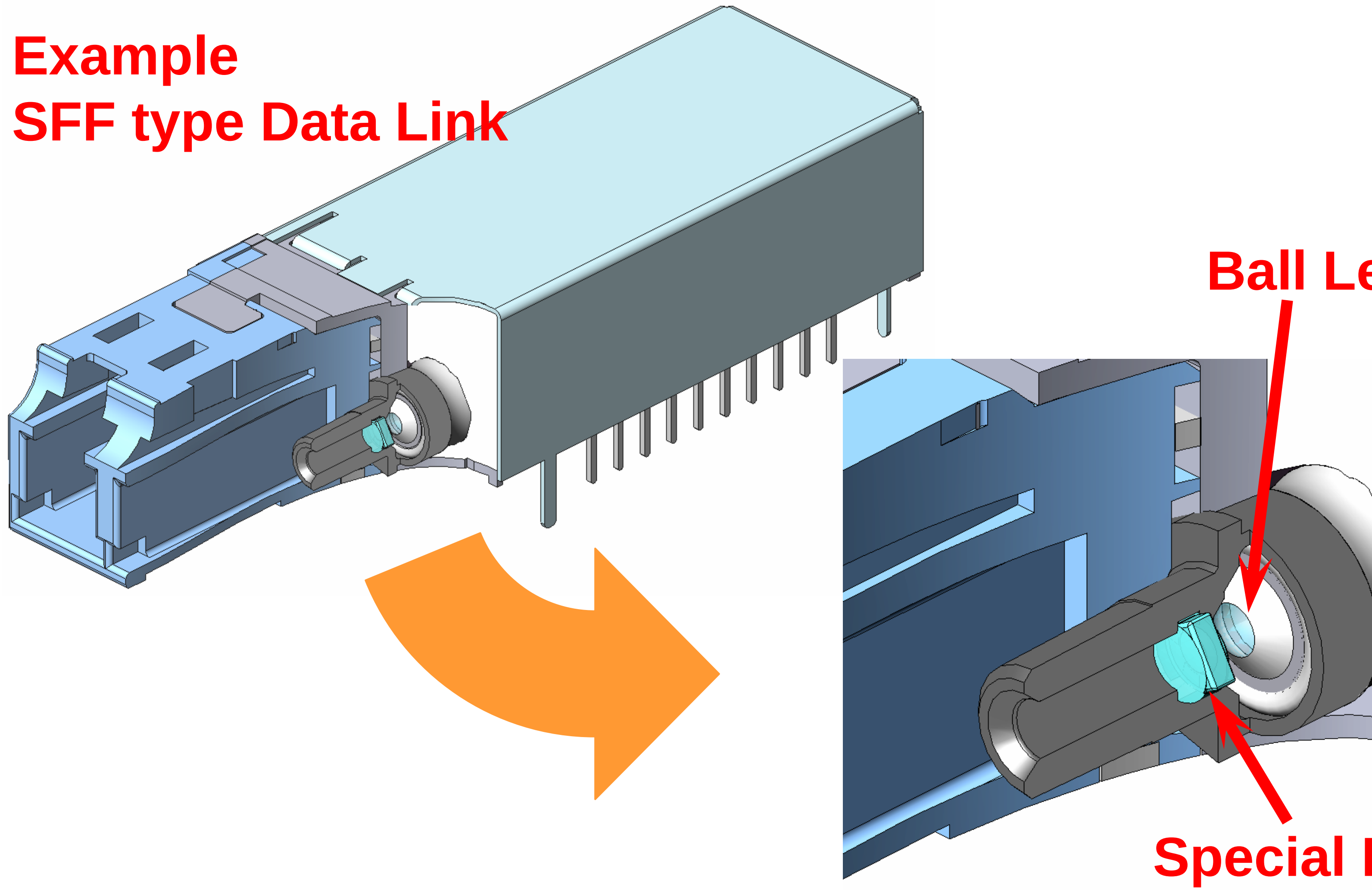
Receiver Side

1. Optical Return Loss
2. Sensitivity (PD sensitivity, Minimum Sensitivity)

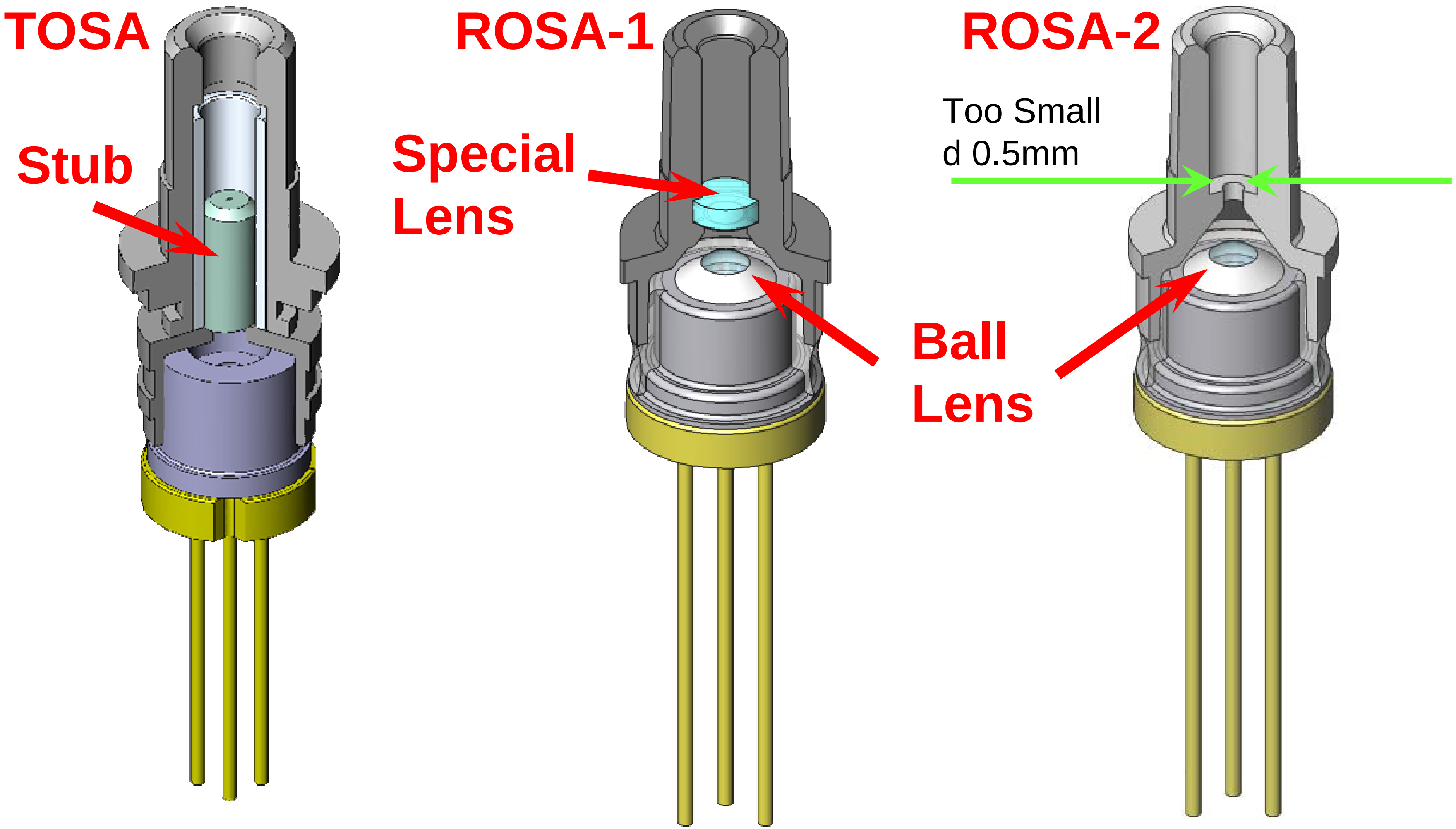
***These are depend on the design of device.**

(b). Critical parameter -2
(Structure of Data Link)

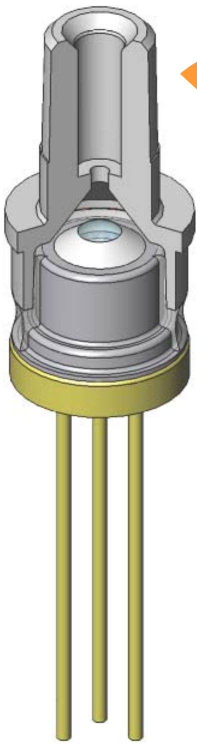
Example
SFF type Data Link

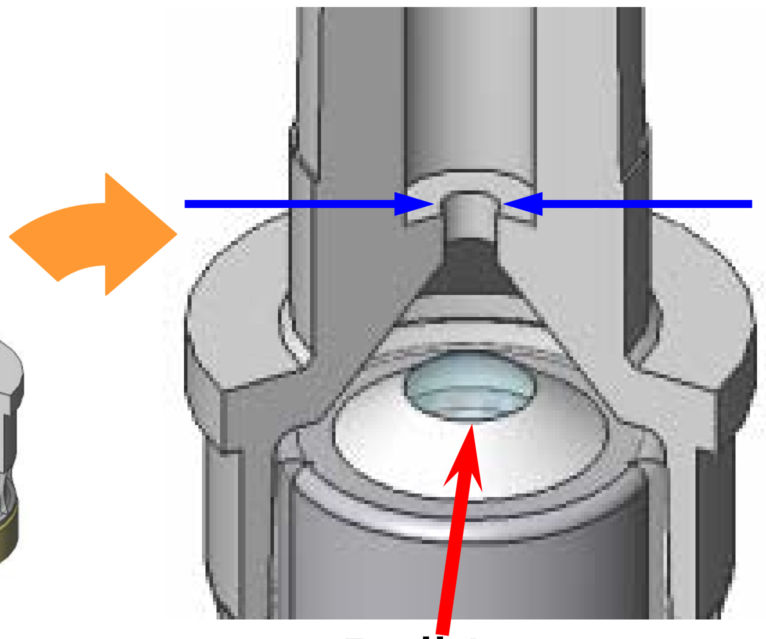


(b). Critical parameter -3
(Structure of OSA)



(b). Critical parameter -4
(Structure of ROSA)





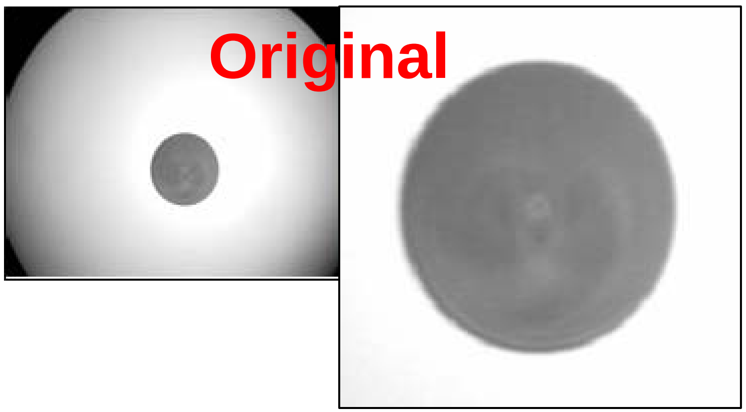
To soil the ball lens is difficult.

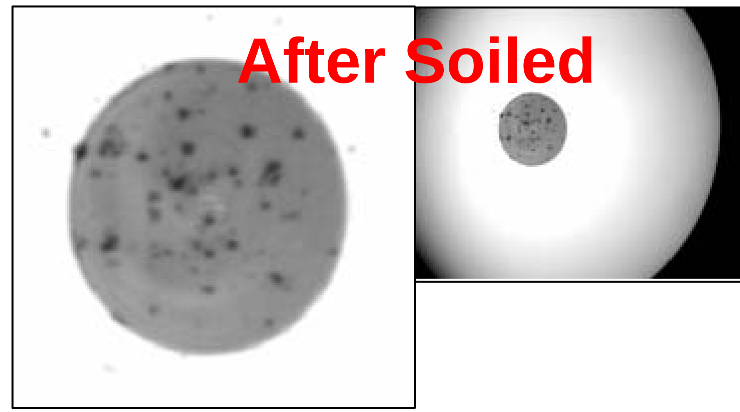
1. Soiling after sleeve attached
   -> Connector stopper hides the lens.
2. Soiling before sleeve attached
   -> Sleeve alignment process avoids the contamination.

(b). Critical parameter -5
(Preliminary Experiment -Transmitter-)

Characteristics sample of Sumitomo's device

Transmitter side



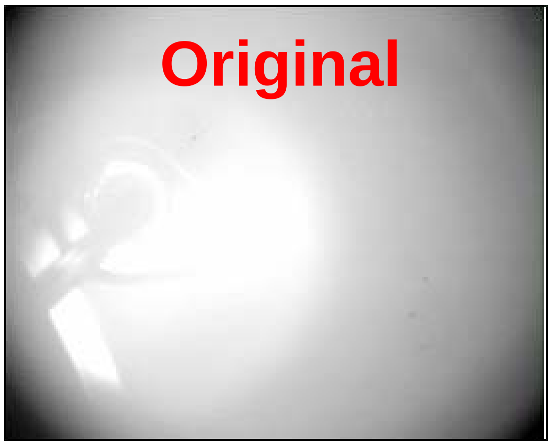


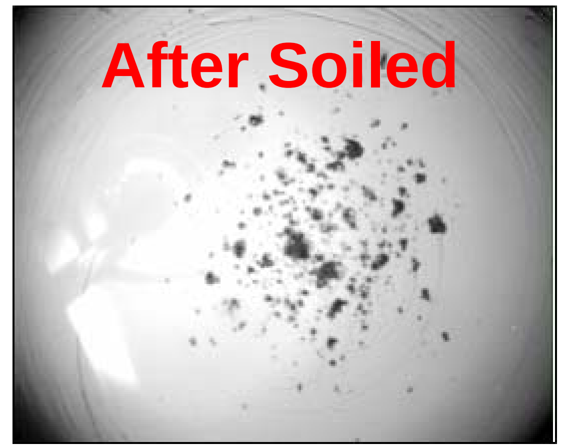
Term	Original	-	After Soiled	Fluctuation
Optical Power	-6.7 dBm	->	-6.7 dBm	0 dB
Pulse Mask Margin	45 %	->	43 %	-2 %
Spectral Width	2.3 nm	->	2.3 nm	0 nm
ORL	58.7 dB	->	33.9 dB	-24.8 dB

(b). Critical parameter -6
(Preliminary Experiment -Receiver-)

Characteristics sample of Sumitomo's device

Receiver side (*Sumitomo uses **Special Lens** to reduce ORL)





Term	Original	-	After Soiled	Fluctuation
PD sensitivity	1.04 A/W	->	1.03 A/W	-0.01 A/W
ORL	35.4 dB	->	23.3 dB	-12.1 dB

(b). Critical parameter -7
(Preliminary Experiment)

Summary

1. The most sensitive characteristic is ORL.

Relation between the position of contamination and ORL will decide the specification of endface.

Contents

(a) Introduction
what is the Optical Data Link

(b) Critical parameters
which characteristic is sensitive to contamination

(c) Contaminating Techniques
to make the Non-remobables on Connector Endface

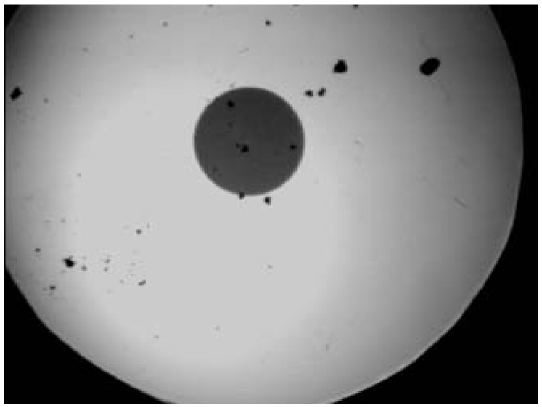
(d) Measurement Techniques
to get the stable value of ORL

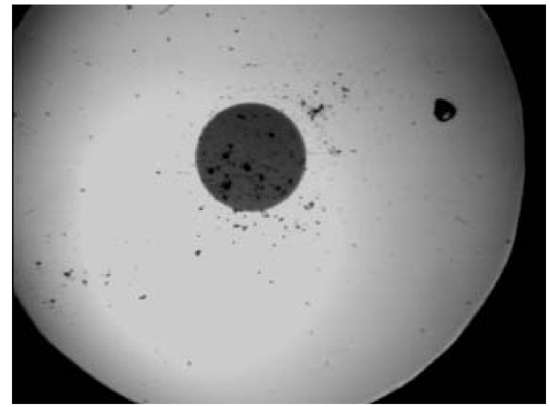
(c). Contaminating Techniques -1
(Difficulty in Receptacle Device)

Mating connector to measure ORL makes dusts spread.

Which state is true when measuring ORL?

Before Mating

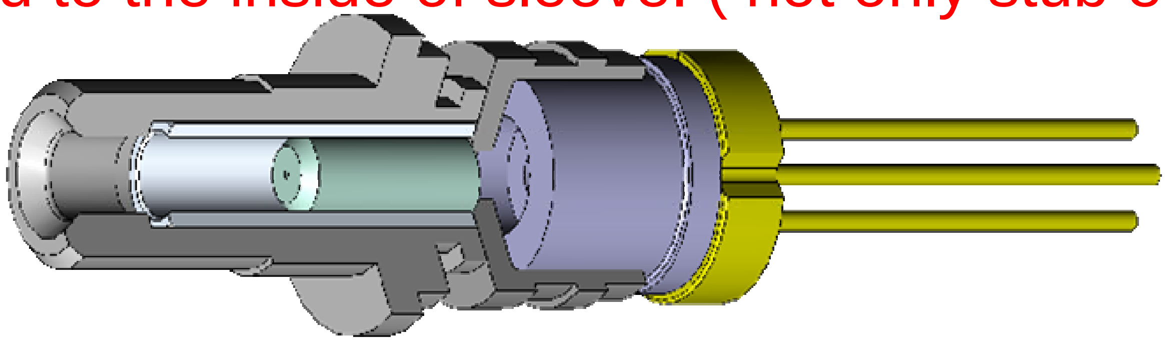




After Mating

Soiling position control is difficult.

Dusts adhered to the inside of sleeve. (not only stub endface)



(c). Contaminating Techniques -2
(Contaminating Procedure -Outline-)

Contaminating Procedure

1. **Inspect** the endface of DUT.

2. **Soil** the optical endface of DUT with fine dusts.

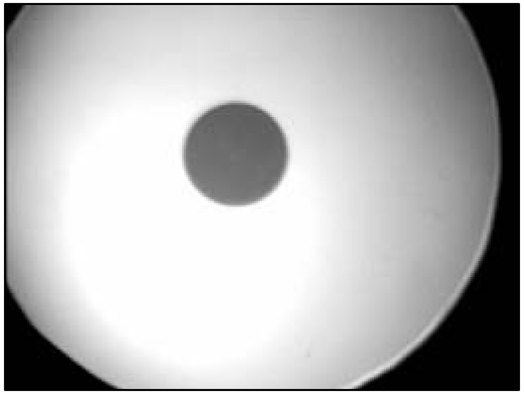
3. **Mate** the dummy connector with DUT
   to fix the dusts.

4. **Clean** the optical endface and sleeve surface of DUT
   to remove the movable dusts.

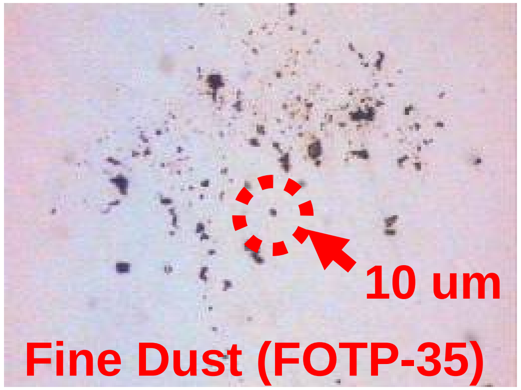
5. **Inspect** the endface of DUT.

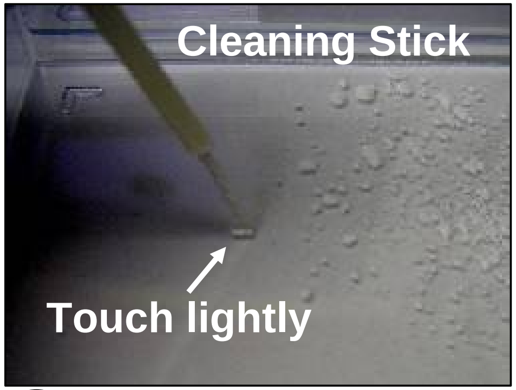
(c). Contaminating Techniques -3
(Contaminating Procedure details -1)

1. **Inspect** the endface of DUT.

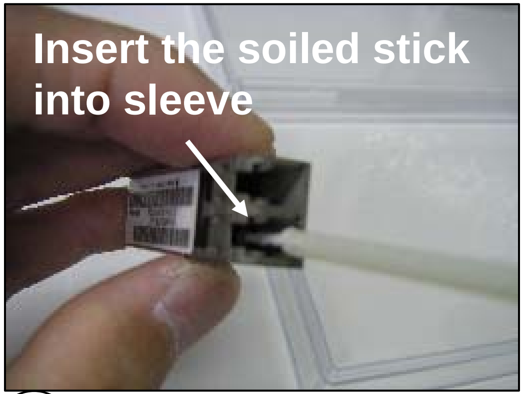


2. **Soil** the optical endface of DUT with fine dusts.





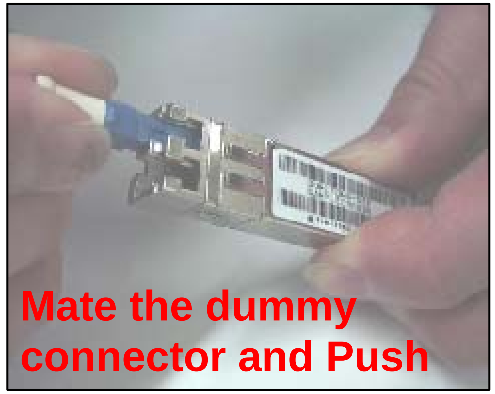
1 Put dusts on the stick



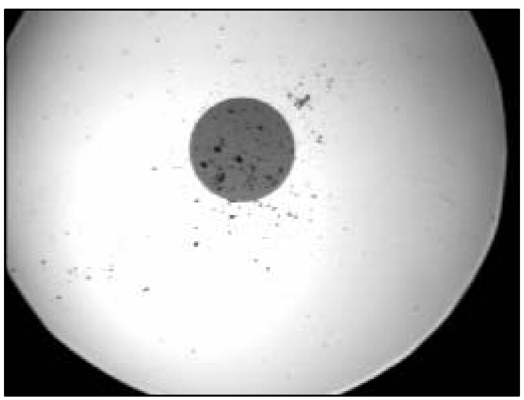
2 Soil the optical endface

(c). Contaminating Techniques -4
(Contaminating Procedure details -2)

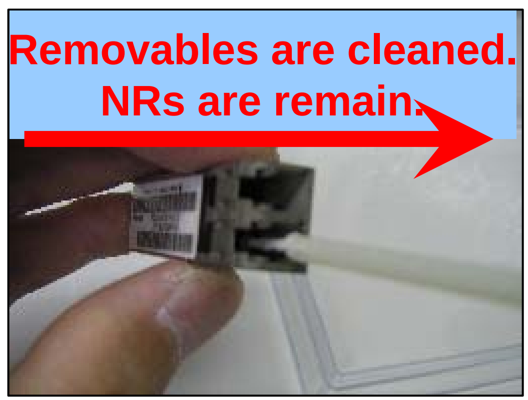
3. **Mate** the dummy connector with DUT to fix the dusts.



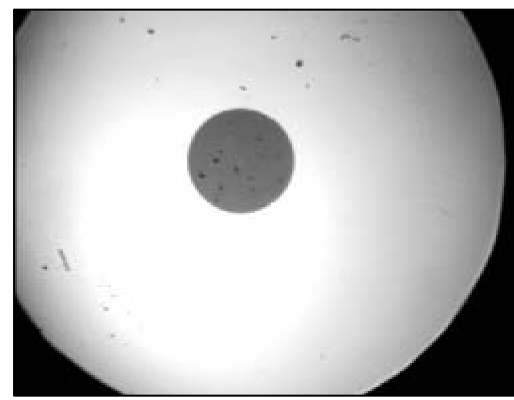
4. **Clean** the optical endface of DUT to remove the movable dusts.



① Endface after soiling

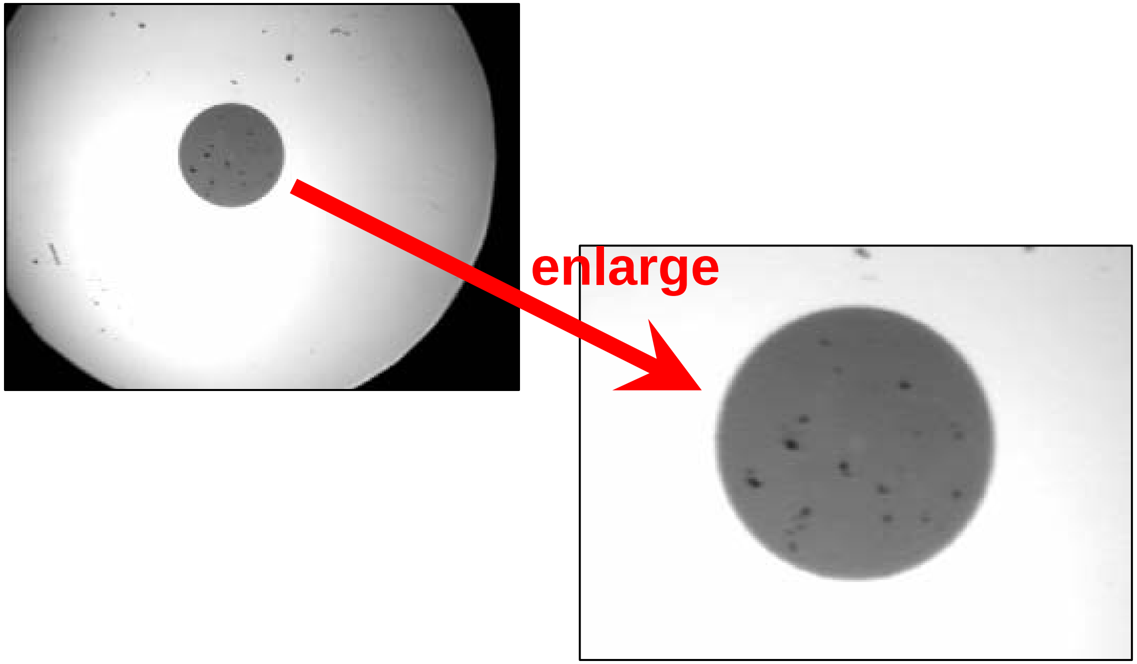


② Clean by using solvent and stick



③ Endface after cleaning

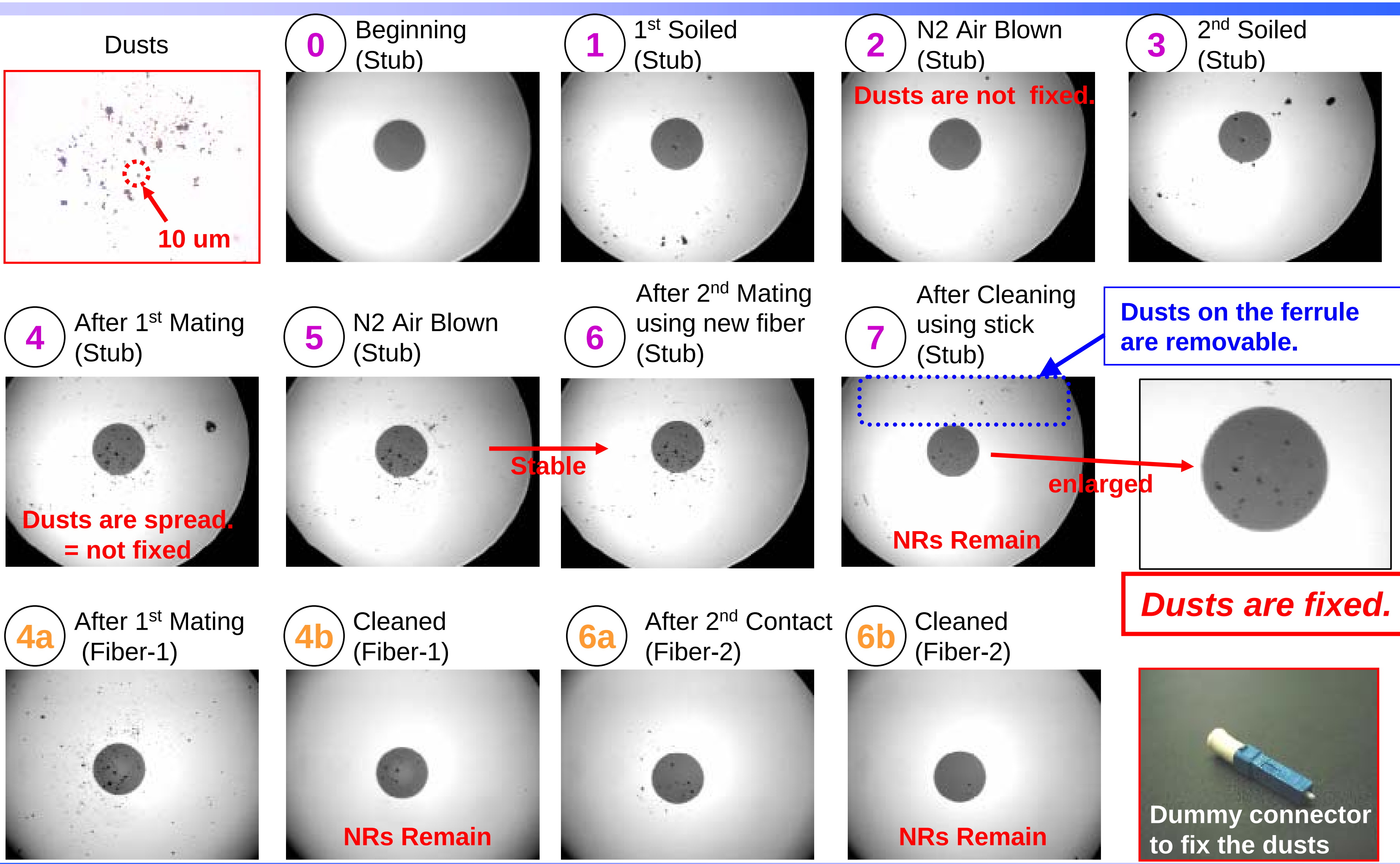
5. **Inspect** the endface of DUT.



Dusts are fixed.

Ready to Measure the Opt-electrical Characteristics

(c). Contaminating Techniques -6
(Trial to fix the dusts)



(c). Contaminating Techniques -7 (Summary)

Summary

1. Mating dummy connector makes contamination stable.
2. Cleaning the inside of sleeve reduces the uncertainty.

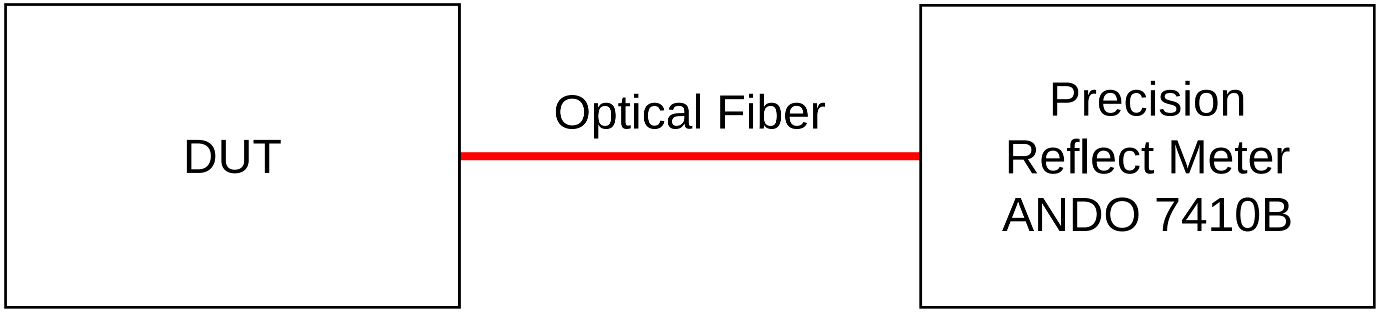
Contents

(d). Measurement Techniques -1
(Contents)

Contents

(d). Measurement Techniques -2
(Measurement Diagram -Transmitter-)

Measurement diagram of Stub ORL



To obtain the stable measurement

1. Set the **resolution** to the minimum limit of instrument.
2. **Inspect** the fiber before mating.
3. **Wait** a few seconds after mating.
   -> We noticed this importance during this experiment.
4. **Average** 10 times measurements.

(d). Measurement Techniques -3
(Experiment Procedure)

Experiment Procedure

1. **Inspect** the endface of DUT and fiber connector and Take picture of both.
2. Mate the DUT and fiber connector.
3. Measure ORL.
4. Demate fiber connector.
5. **Inspect** the endface of DUT and fiber connector and Take a picture of both.
6. **Soil** the optical endface of DUT with fine dusts and Take picture of DUT.
7. Return to step-2

(d). Measurement Techniques -4
(Repeatability of Equipment)

1. Prepare the clean sample
2. Mate the connector to the sample
3. Measure the ORL 10 times

Operator	Aoki
Position	Develop Engineer
Career	5 years
Sample	SCM6328 (clean)
Number of measurement	10
Average ORL (dB)	58.89
Standard deviation (dB)	0.30
Minimum (dB)	58.57
Maximum (dB)	59.44

(d). Measurement Techniques -5
(Mating Repeatability -1 -Procedure-)

1. Prepare the various sample (clean and soiled)
2. Mate the connector to the sample
3. Measure the ORL
4. Disconnect the connector from the sample
5. Inspect both endface (sample and connector)
   Change fiber if connector endface becomes bad.
6. Repeat from 2 to 5

(d). Measurement Techniques -6
(Mating Repeatability -2 -Data-)

Operator	Aoki		
Position	Develop Engineer		
Career	5 years		
Sample	SCM6328 (clean)	SCM6328 (soiled)	SCM6328 (soiled)
Number	10	10	32
Average ORL (dB)	61.23	46.99	23.74
Standard deviation (dB)	1.11	0.73	0.75
Minimum (dB)	60.14	46.22	22.24
Maximum (dB)	63.22	48.25	25.07

*** Standard deviation of good ORL sample is a little bigger.**

(d). Measurement Techniques -7
(Operator Dependence -1 -Procedure-)

1. Prepare the bad ORL sample
2. Mate the connector to the sample
3. Measure the ORL
4. Disconnect the connector from the sample
5. Inspect both endface (sample and connector)
   Change fiber if connector endface becomes bad.
6. Repeat from 2 to 5
7. Change the operator and repeat from 2 to 6

(d). Measurement Techniques -8
(Operator Dependence -2 -Data-)

Operator	All	Aoki	Kaneko	Joe
Position	-	Develop Engineer	Quality Staff	Product Engineer
Career	-	5 years	2 years	18 years
Sample	SCM6328 (soiled)			
Number	65	30	**5**	30
Average ORL (dB)	18.85	18.65	19.09	19.02
Standard deviation (dB)	0.70	0.69	0.54	0.69
Minimum (dB)	17.44	17.44	18.20	17.87
Maximum (dB)	20.83	20.83	19.49	20.18

*** There is little Operator's dependency.**

(d). Measurement Techniques -9
(Randomized Measurement -1 -Procedure-)

1. Prepare the 10 samples
2. Mate the connector to the sample
3. Measure the ORL
4. Disconnect the connector from the sample
5. Inspect both endface (sample and connector)
   Change fiber if connector endface becomes bad.
6. Change the operator and sample and go back to 2
7. Repeat randomized 90 times measurement
   (= 3 operators x 10 samples x 3 times)

(d). Measurement Techniques -10
(Randomized Measurement -2 -Randomize-)

Randomized Measurement Using the Function of Excel

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Next Slide : Analyzed data

(d). Measurement Techniques -11
(Randomized Measurement -3 -data1-)

Summary of Randomized Measurement Classified by Sample Number

Sample	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
Number	9	9	9	9	9	9	9	9	9	9
Average ORL (dB)	67.72	66.11	67.82	66.71	68.44	67.14	66.85	68.47	66.60	68.61
Standard deviation (dB)	4.79	3.24	2.27	5.11	2.65	6.28	4.47	3.48	2.30	3.84
Minimum (dB)	56.35	61.41	63.38	57.85	64.78	51.72	58.09	61.13	63.07	62.93
Maximum (dB)	71.80	70.41	71.36	71.79	70.98	72.64	70.56	72.39	69.54	72.97

*** Standard deviation seems to be worse.**

(d). Measurement Techniques -12
(Randomized Measurement -4 -ORL Changing-)

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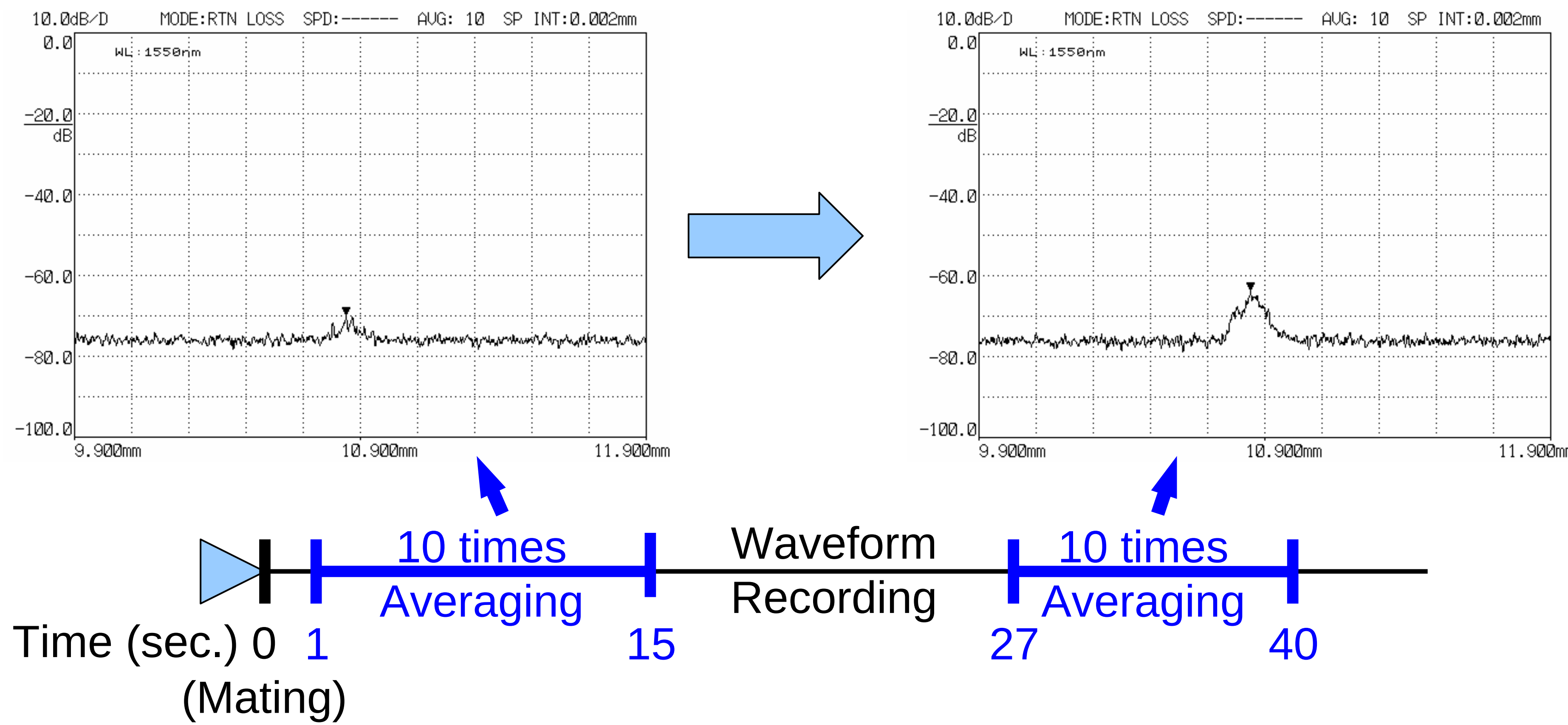
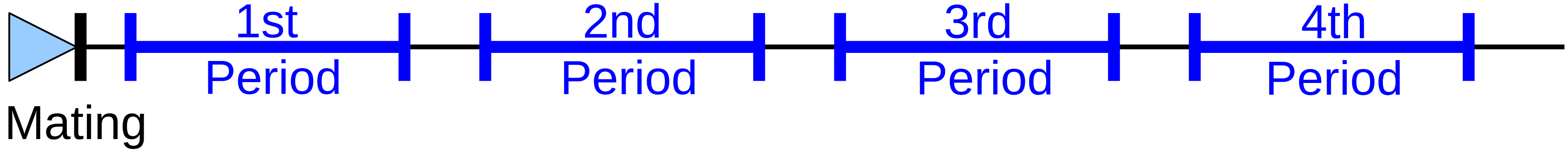
1st period : 70.14 dB

2nd period : 63.75 dB



*** ORL is changing after mating.**

(d). Measurement Techniques -13
(Randomized Measurement -5 -ORL Changing2-)



Measurement	1st	2nd	3rd	4th
ORL (dB) 1st Mating	70.14	63.75	63.92	63.88
ORL (dB) 2nd Mating	68.44	63.62	62.42	63.39
ORL (dB) 3rd Mating	69.40	63.55	64.02	63.72

*** Time dependence of ORL shows good repeatability.**

(d). Measurement Techniques -14
(Randomized Measurement -6 -data2-)

Wait 30 seconds after mating and Measure.

Sample	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
Number	9	9	9	9	9	9	9	9	9	9
Average ORL (dB)	58.91	57.28	57.94	57.61	59.53	60.04	59.50	59.49	58.95	57.75
Standard deviation (dB)	0.76	0.63	0.81	0.98	1.16	0.42	1.59	0.78	0.84	0.76
Minimum (dB)	58.04	56.46	56.99	55.80	57.98	59.27	56.65	58.39	57.97	56.61
Maximum (dB)	60.30	58.30	59.09	59.40	61.16	60.64	61.09	60.70	60.77	59.06

*** Standard deviation is getting better.**

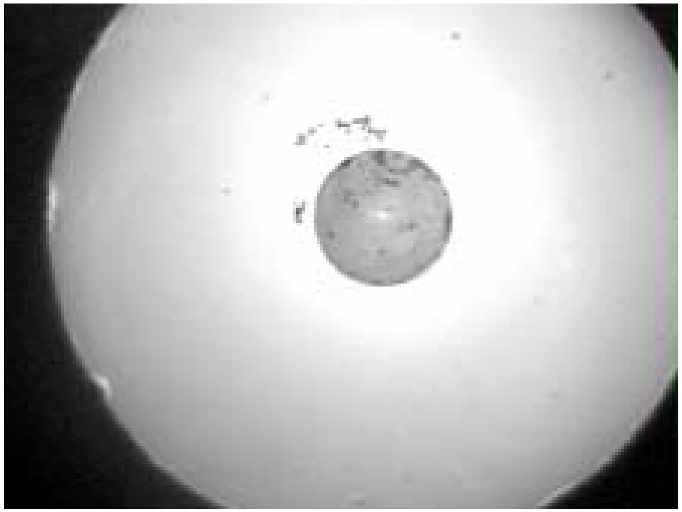
Next : Randomized measurement of bad ORL samples

Randomized Measurement of Soiled Sample

Sample	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
Number	9	9	9	9	9	9	9	9	9	9
Average ORL (dB)	43.10	39.02	31.68	38.26	43.55	35.88	38.83	28.32	39.77	35.90
Standard deviation (dB)	0.95	0.83	1.19	1.36	0.90	1.40	0.56	2.11	1.01	1.66
Minimum (dB)	41.81	37.42	29.42	36.38	42.13	32.99	38.01	25.22	38.42	33.42
Maximum (dB)	44.50	39.93	33.07	40.14	45.08	38.29	39.57	31.34	41.95	38.25

*** Standard deviation is worse.**

(d). Measurement Techniques -16
(Randomized Measurement -8 -Bad ORL-)



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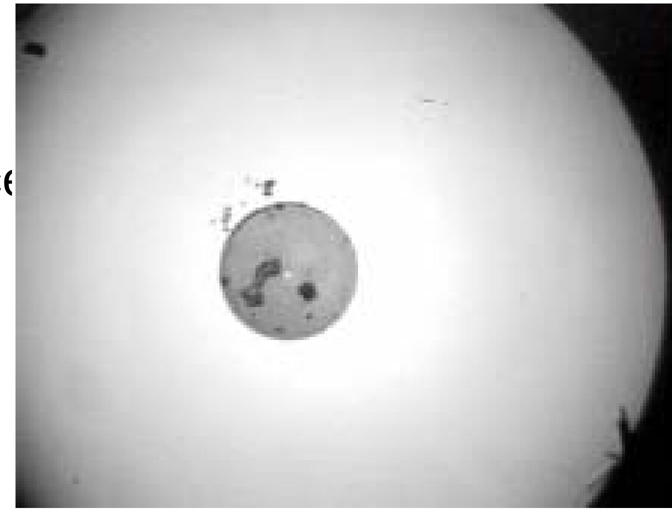


No.7 : ORLave=38.83dB
ORLstd= 0.56dB

No.8 : ORLave=28.32dB
ORLstd= 2.11dB

Contamination near core causes
both Average value and Standard deviation of ORL bad.

Analyzing the relation between the position of contamination and ORL will decide the specification of endface.

(d). Measurement Techniques -17
(Summary)

Summary

1. The error of ORL measurement is up to 1.2 dB.

2. Including the error caused by equipment 0.3 dB.

3. With the consideration of ORL specification
   including this measurement error,
   Analyzing the relation between the position of
   contamination and ORL
   will decide the specification of endface.

(d). Measurement Techniques -18
(Receiver)

Contents

(a) Measurement Diagram

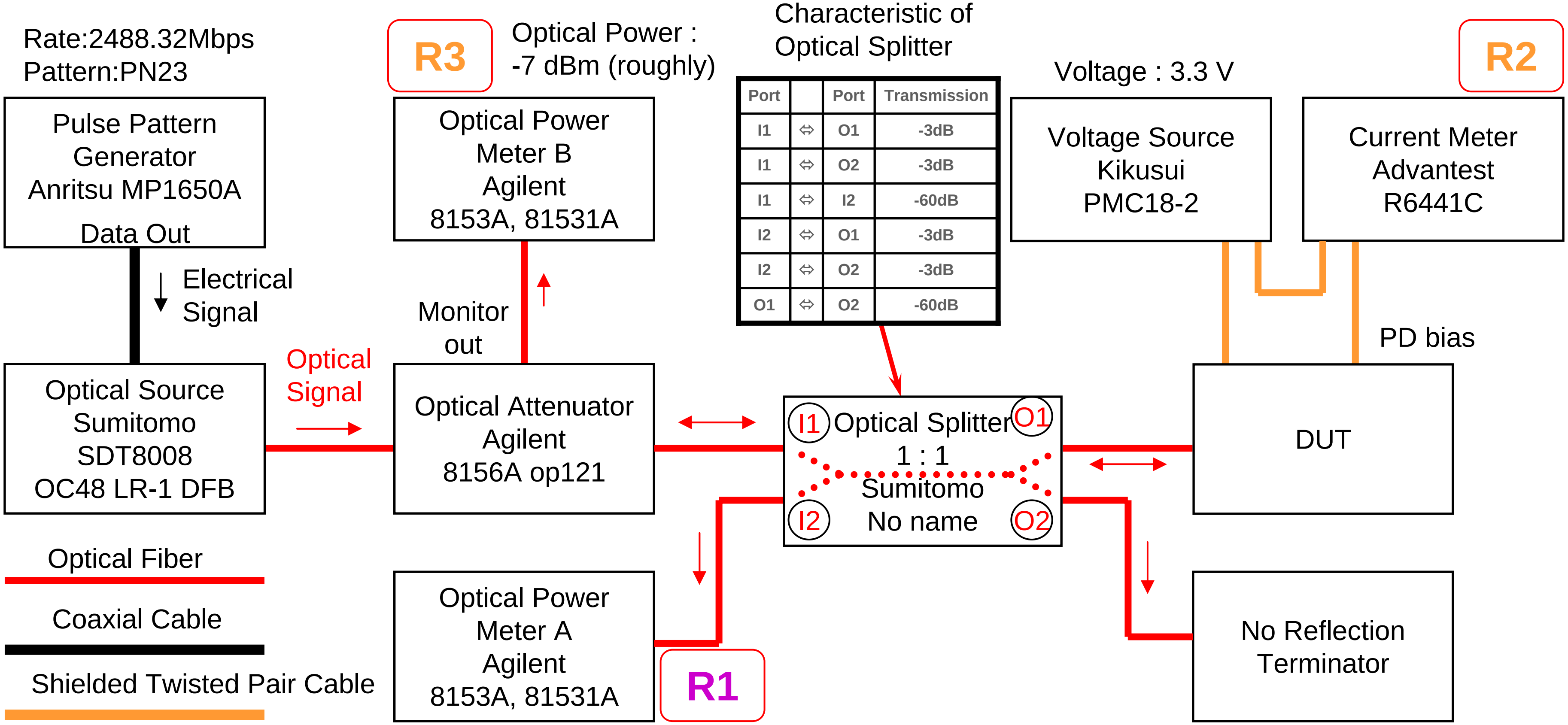
(b) ORL Calibration

(c) ORL Measurement

Measurement diagram of Receiver ORL

Major Characteristics
R1 : ORL

Sub Characteristics (to check the stability of the test system)
R2 : Photo Current
R3 : Optical Input Power



Characteristic of Optical Splitter

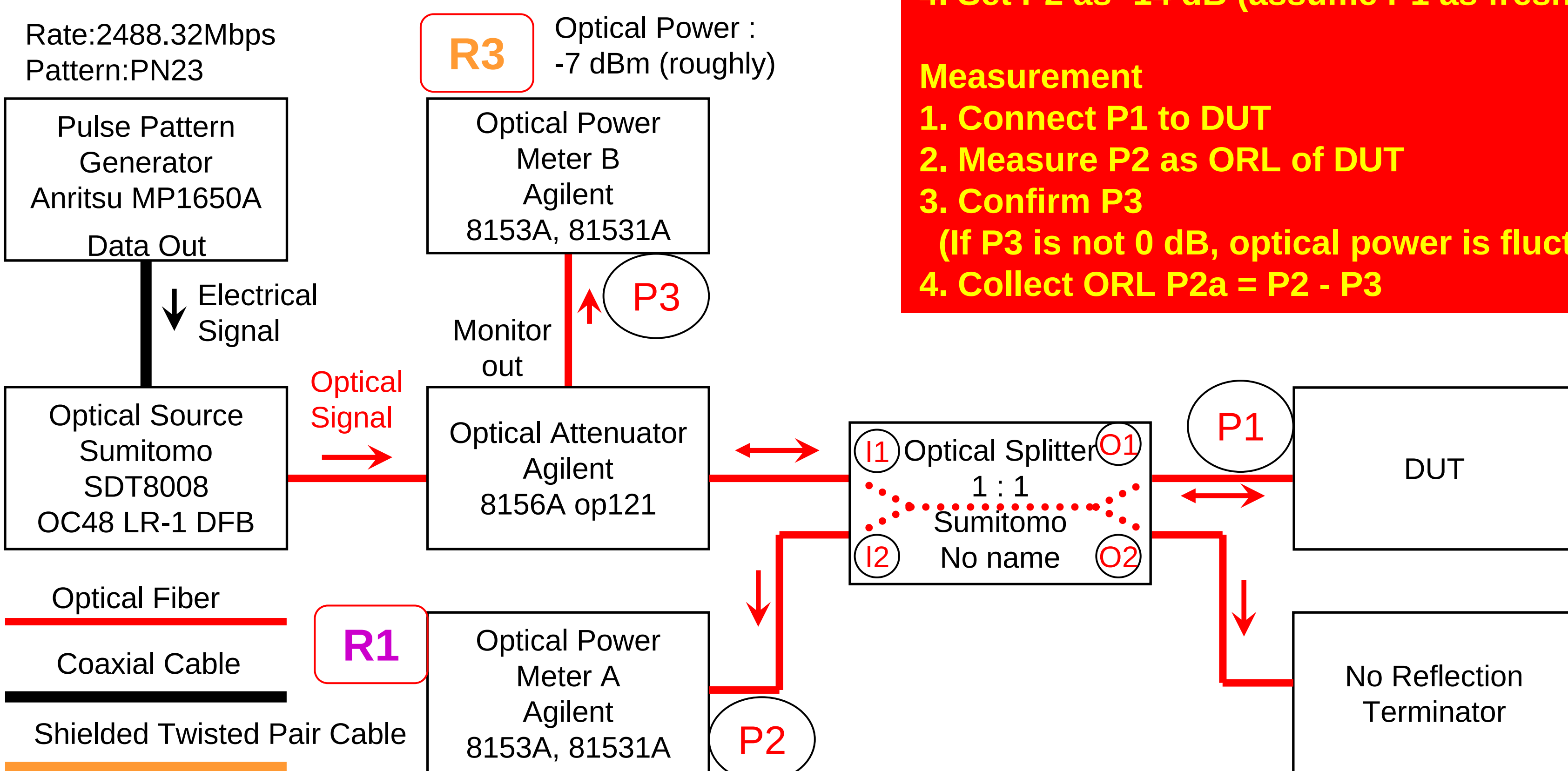
Port		Port	Transmission
I1	⇔	O1	-3dB
I1	⇔	O2	-3dB
I1	⇔	I2	-60dB
I2	⇔	O1	-3dB
I2	⇔	O2	-3dB
O1	⇔	O2	-60dB

(d). Measurement Techniques -20
(Calibration of Receiver ORL -1)

Explanation of ORL calibration

Initial Calibration
1. Set P1 to -10 dBm by Optical Attenuator
2. Set P3 as 0 dB
3. Open P1
4. Set P2 as -14 dB (assume P1 as fresnel)

Measurement
1. Connect P1 to DUT
2. Measure P2 as ORL of DUT
3. Confirm P3
(If P3 is not 0 dB, optical power is fluctuated)
4. Collect ORL P2a = P2 - P3



(d). Measurement Techniques -21
(Calibration of Receiver ORL -2)

Example of ORL calibration

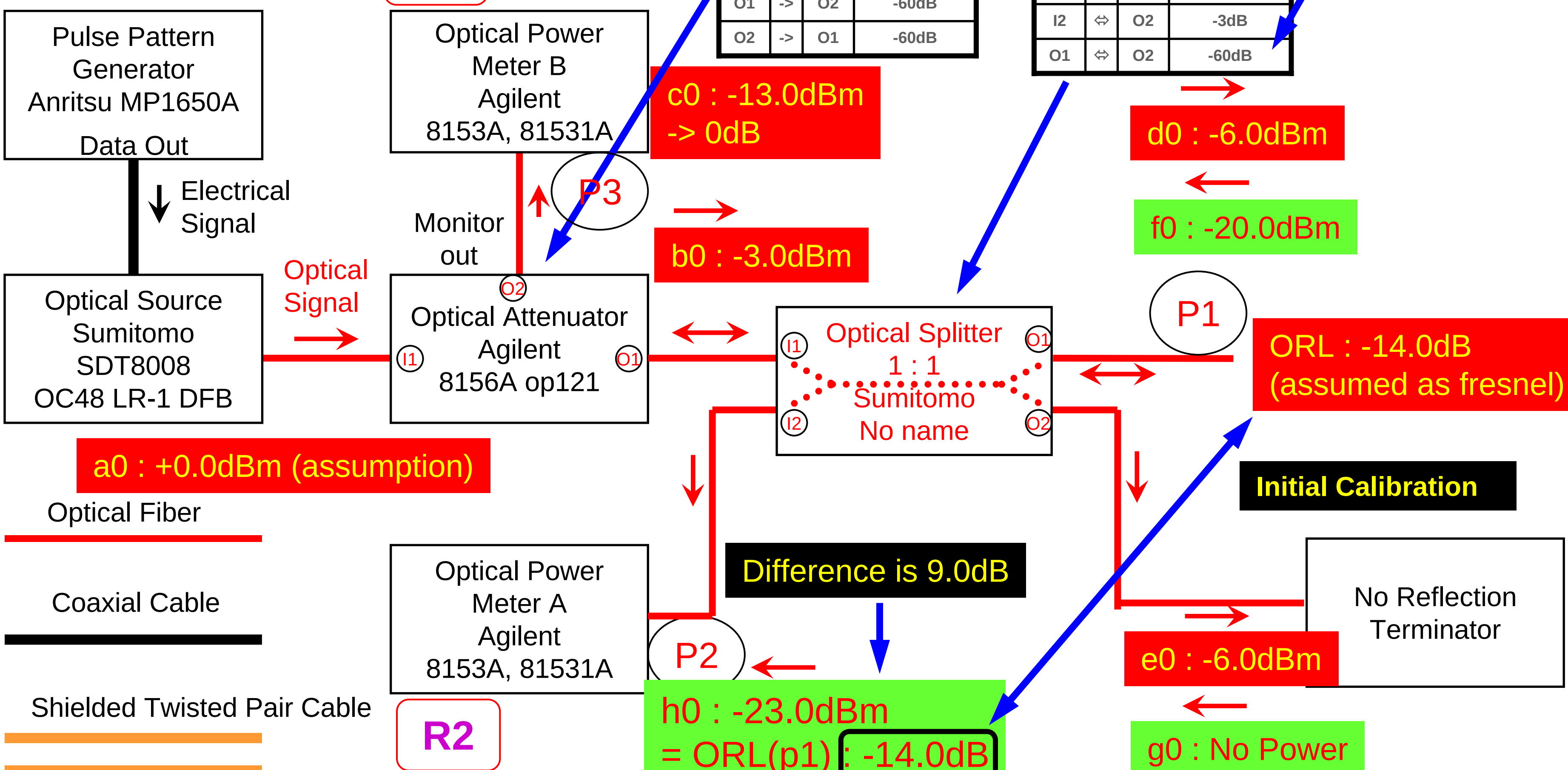
Rate:2488.32Mbps
Pattern:PN23

R3 Optical Power : -7 dBm (roughly)

Port		Port	Transmission
I1	->	O1	-3dB
I1	->	O2	-13dB
O1	->	O2	-60dB
O2	->	O1	-60dB

Port		Port	Transmission
I1	⇔	O1	-3dB
I1	⇔	O2	-3dB
I1	⇔	I2	-60dB
I2	⇔	O1	-3dB
I2	⇔	O2	-3dB
O1	⇔	O2	-60dB

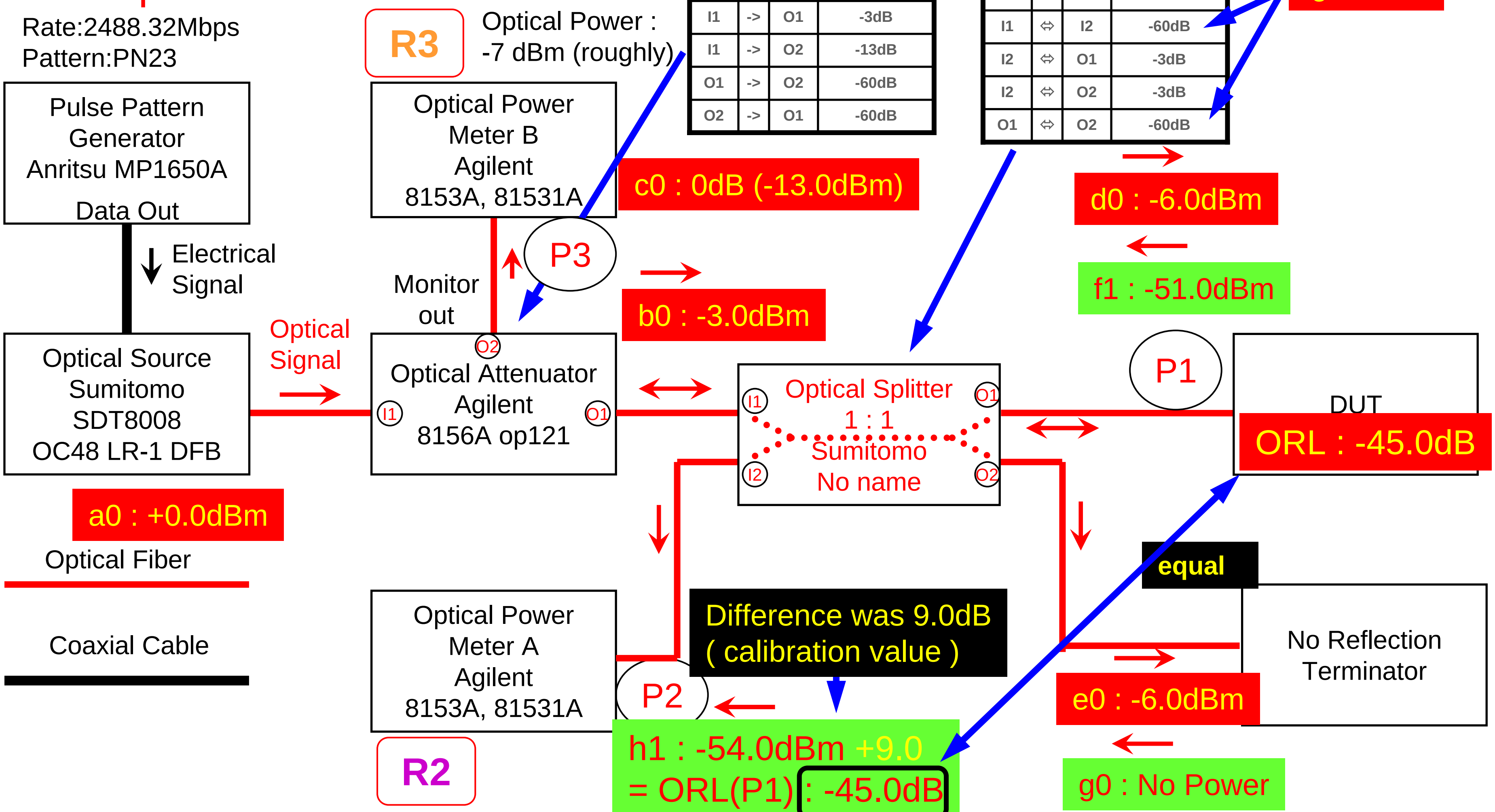
ignorable



(d). Measurement Techniques -22
(Measurement of Receiver ORL -1)

Example of ORL measurement -1

Rate:2488.32Mbps
Pattern:PN23



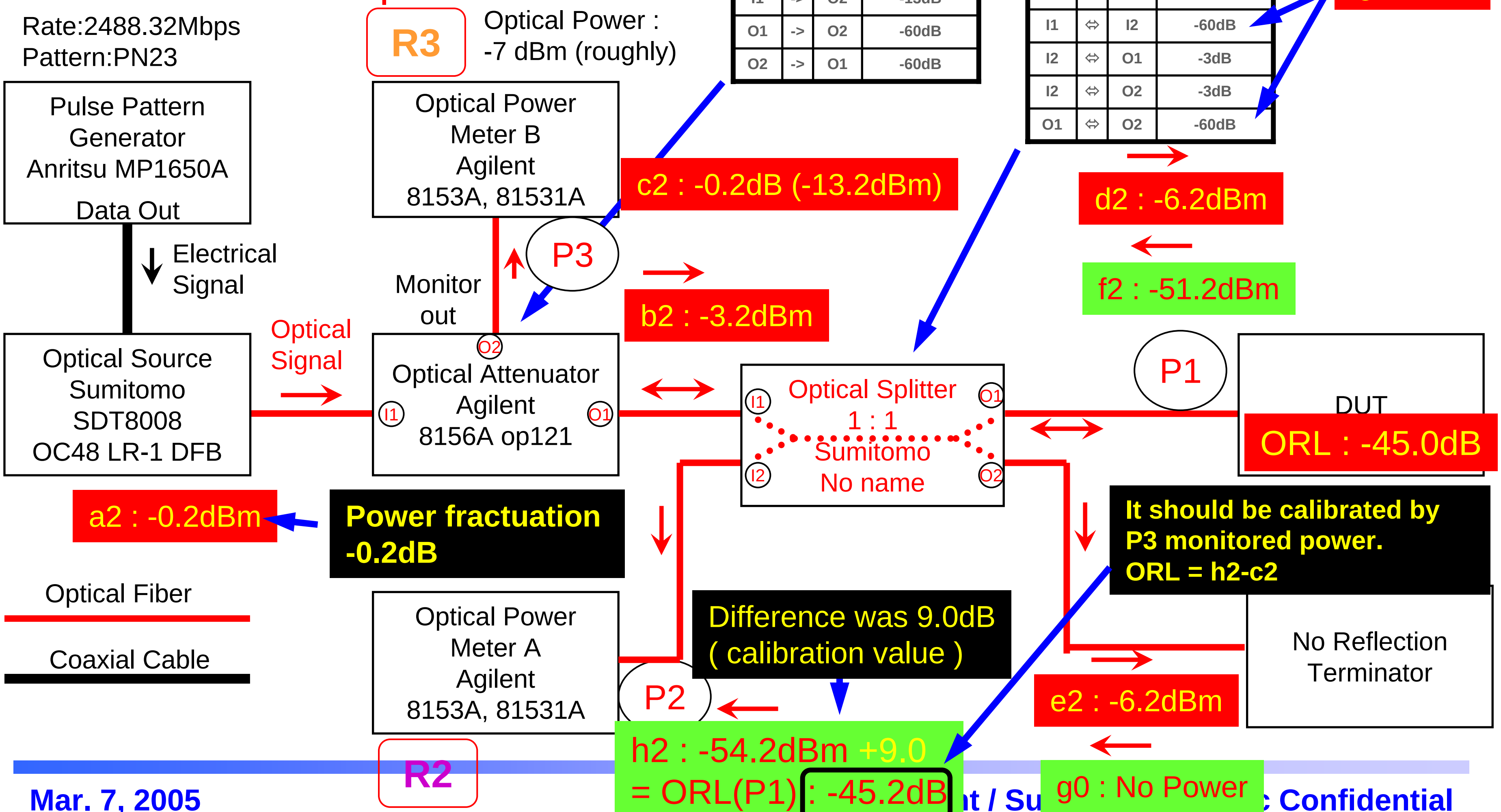
Port		Port	Transmission
I1	->	O1	-3dB
I1	->	O2	-13dB
O1	->	O2	-60dB
O2	->	O1	-60dB

Port		Port	Transmission
I1	⇔	O1	-3dB
I1	⇔	O2	-3dB
I1	⇔	I2	-60dB
I2	⇔	O1	-3dB
I2	⇔	O2	-3dB
O1	⇔	O2	-60dB

(d). Measurement Techniques -23
(Measurement of Receiver ORL -2)

Example of ORL measurement -2
Under the Source power fractuation

Rate:2488.32Mbps
Pattern:PN23



Port		Port	Transmission
I1	->	O1	-3dB
I1	->	O2	-13dB
O1	->	O2	-60dB
O2	->	O1	-60dB

Port		Port	Transmission
I1	⇔	O1	-3dB
I1	⇔	O2	-3dB
I1	⇔	I2	-60dB
I2	⇔	O1	-3dB
I2	⇔	O2	-3dB
O1	⇔	O2	-60dB