Update on the temperature dependence of the frequency response at 850 and 980 nm for automotive grade GI-POF

Takeshi Hirose, AGC

Third-party testing cooperation
Tomohisa HARADA and Manabu KAGAMI, Nagoya Institute of Technology (NITech)

IEEE802.3dh Ad hoc meeting October 18th, 2023

Introduction

AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

Below are action items to discuss for automotive grade GI-POF specifications.
This contribution shows results of checked items.

Item	method	Wave length	frequency response	Attenuation
Low temperature	-40 ºC	850 nm	✓ (Re-measured)	Presented on 13th Sep
		980 nm	✓	
High temperature	105 ºC	850 nm	✓ (Re-measured)	Presented on 13th Sep
		980 nm	✓	
High humid	85 ºC 85 % RH	850 nm		
		980 nm		
Macro bend	One turn around 10 mm diameter mandrel	850 nm	Presented on 13th Sep	Presented on 13th Sep
		980 nm		
Connection	Fiber misalignment	850 nm		
		980 nm		

- Some re-measurements of frequency response were conducted because there was less stability at the previous report presented at September interim.

- The measurement was carried out at Nagoya Institute of Technology.
- The measurement methods reported by Corning, OFS and KDPOF at the IEEE 802.3 OMEGA Study Group in January 2020 were referred.

Reference

https://www.ieee802.org/3/OMEGA/public/jan_2020/perezaranda_OMEGA_02_0120_25G_Corning_fiber.pdf

https://www.ieee802.org/3/OMEGA/public/jan_2020/perezaranda_OMEGA_03_0120_25G_OFS_fiber.pdf

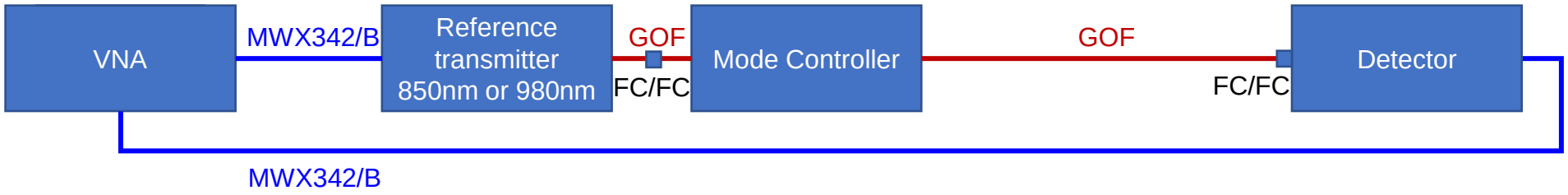
Improving the stability of frequency response measurement

AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

Zero adjustment method for frequency response

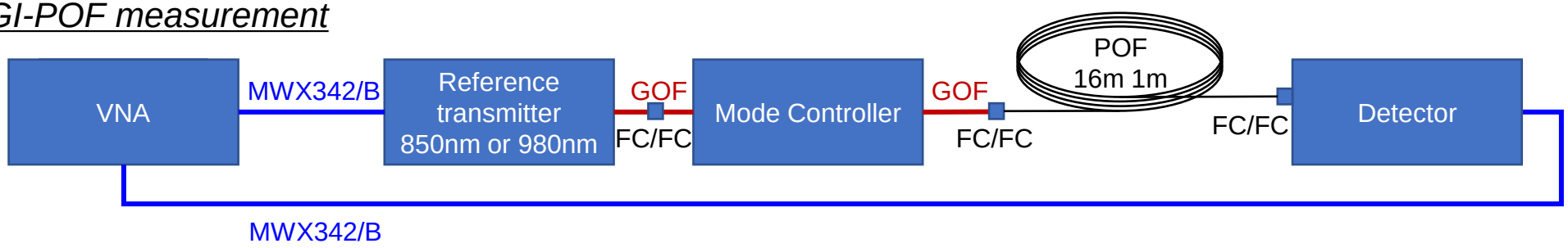
Before measurement of frequency response, the zero adjustment of the measurement system is performed by back to back measurement.

Back to back measurement



After the zero adjustment, the measurement of frequency responses is started by the following system.

GI-POF measurement



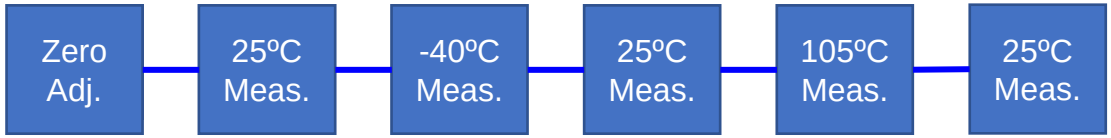
Note : Refer to the appendix for details of the measuring equipment.

The measurement flow

AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

The procedure of the previous measurement for the interim meeting in Sep.

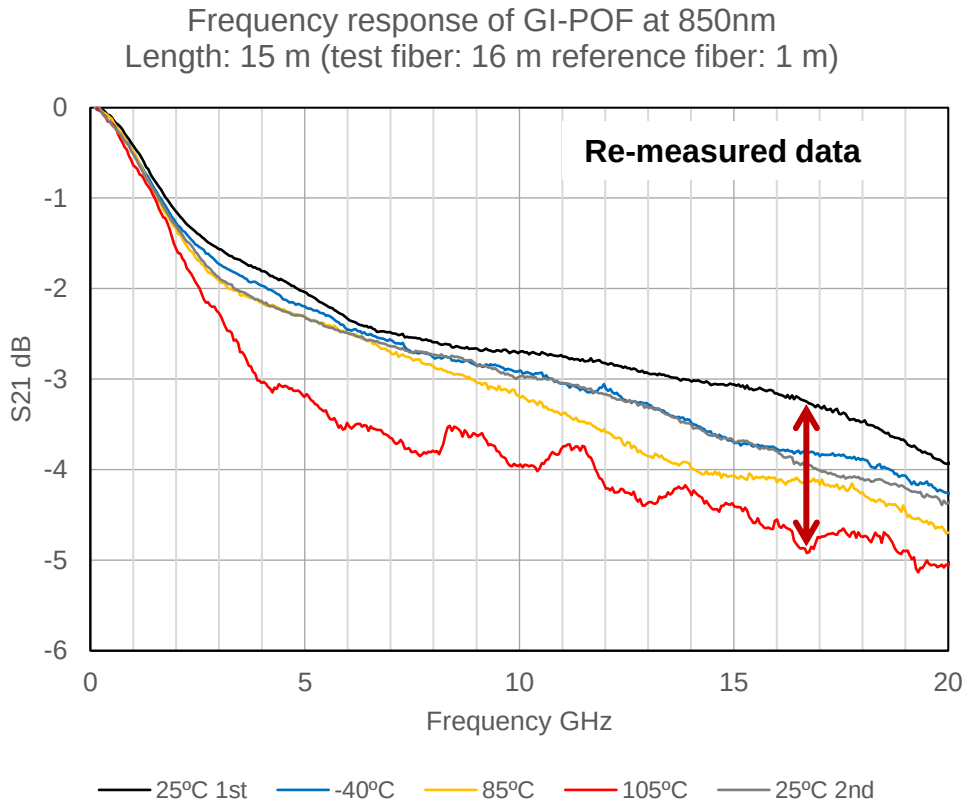
Zero adjustment was performed only for the first time.
No zero adjustment was performed thereafter.



The procedure of the present measurement

Zero adjustment was performed before every measurement.
The measured value at each temperature was the average value of 5 measurements.

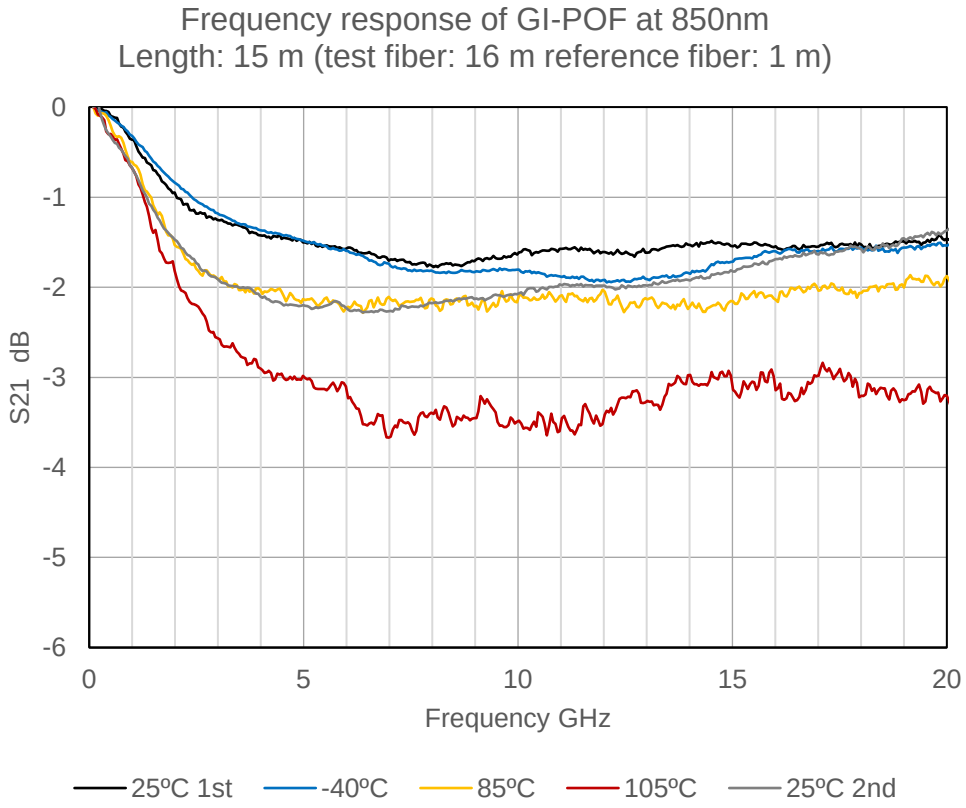
The result of re-measurement at 850nm

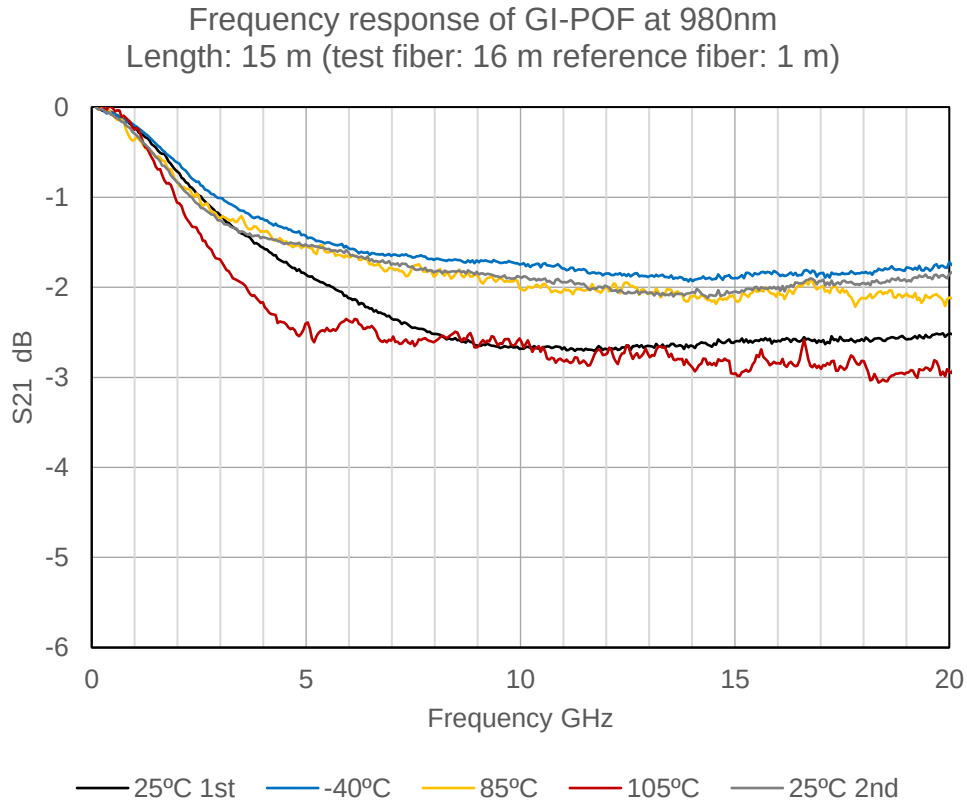


Due to the short fiber length (1 m or 15 m), the measurement results were greatly affected by the fluctuation of the laser light source and the variation of the connection loss with the mode controller. Therefore, zero adjustment and normalization were performed for every measurement this time.
The deviation of the frequency response (S21) profile became smaller ($\Delta \leq 1.8$ to 2 dB) comparing to previous measurement results.
There is still a deviation in the 105ºC results. We will continue to investigate whether it is caused by fiber characteristic or connection between GOF and GI-POF.

Temperature dependence of frequency response at 850 and 980 nm

Comparison between 850nm and 980nm





Temperature dependence of frequency response were measurement at 850 nm and 980 nm with the same sample.(25ºC ➔ -40ºC ➔ 85ºC ➔ 105ºC ➔ 25ºC)
The frequency characteristics of 850nm and 980nm are relatively similar.

Conclusion

Conclusion

AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

- Improving the stability of frequency response.
  To obtain stable measurement results, zero adjustment and normalization were performed for every measurement.
  Deviation of frequency response (S21) profile at 850nm by temperature was less than 2.0 dB .

- Temperature dependence of frequency response at 980nm
  The frequency characteristics of 850nm and 980nm were relatively similar.

We will continue to investigate whether measurement stability is an effect of the fiber itself or the measurement system including effect of connection between GOF and GI-POF.

Thank you for your attention.

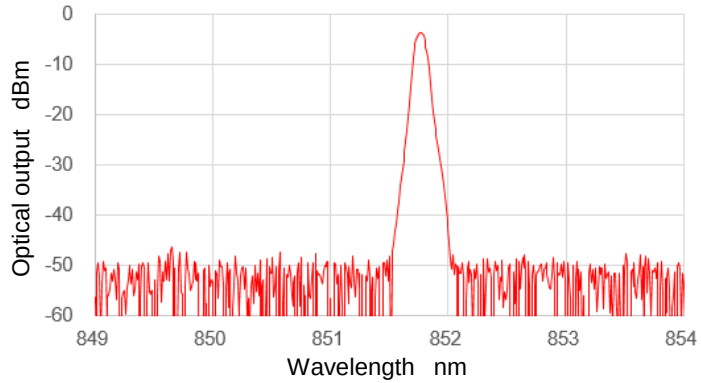
Appendix

AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

Frequency response (1/3)

- Vector Network Analyzer (VNA)
  Keysight “E5080B ENA Vector Network Analyzer”
  - 801 points linear sweep from 100 MHz to 40 GHz

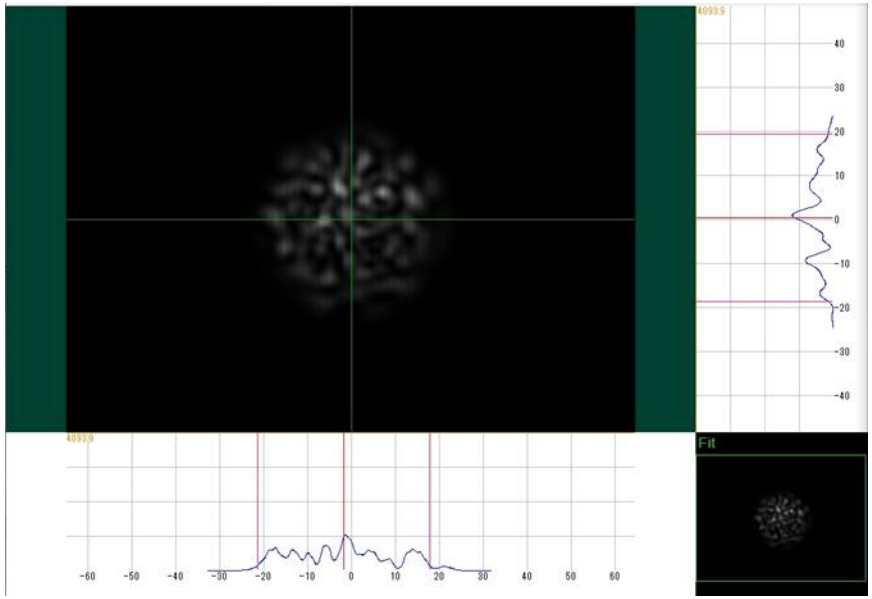
- Reference Transmitter
  Keysight “81490A”
  - Used as a modulated laser light source connected to the VNA.
  - Wavelength: 850 nm, 35 GHz bandwidth



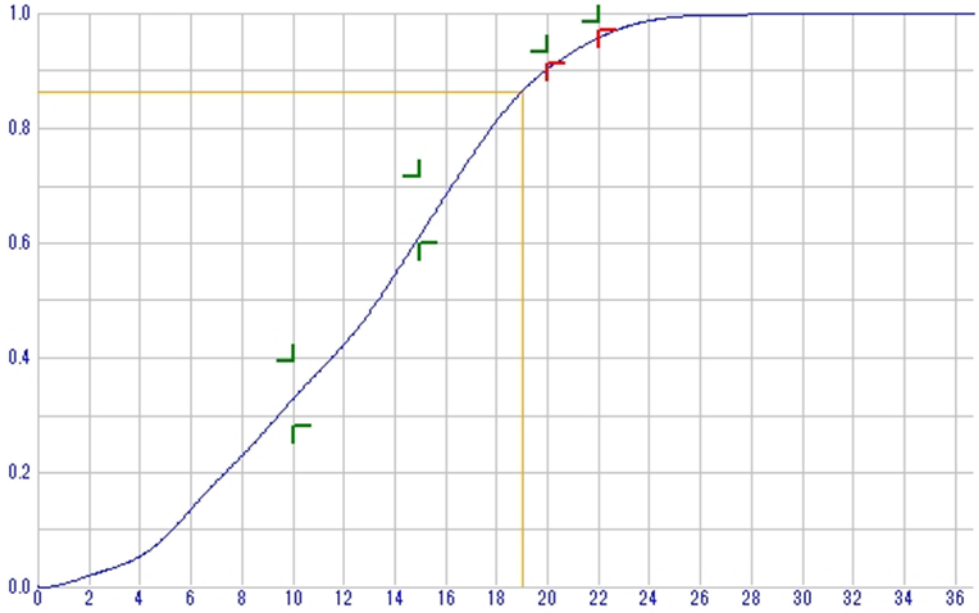
AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

Frequency response (2/3)

- Reference Transmitter
  iXblue ModBox – Customized by Keysight
  - Used as a modulated laser light source connected to the VNA.
  - Wavelength: 980 nm , 40 GHz bandwidth



NFP (Reference transmitter & mode controller)



Encircled Flux (Reference transmitter & mode controller

Frequency response (3/3)

- Lightwave Detector
  Keysight N4377-M40 40 GHz
  - Used for S21 response measurement with VNA.

- Mode Controller
  Arden PHOTONICS LTD “MC-FC-50-N”
  - Mode controller in 50/125 um fiber with FC connectors.

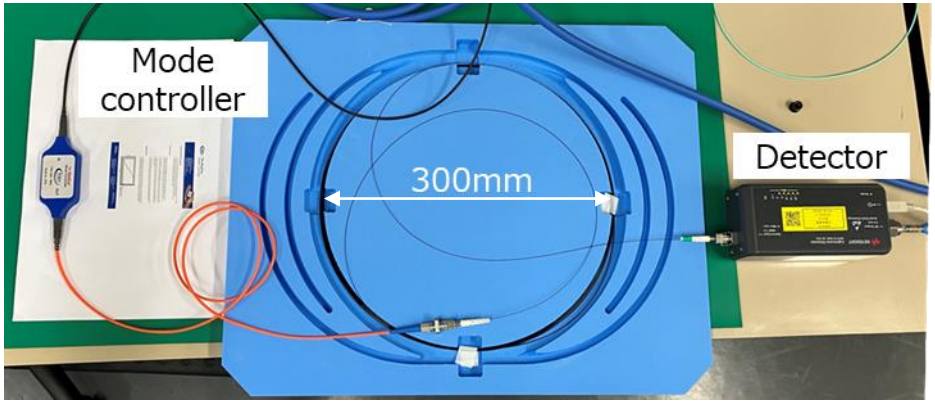
- RF Cable
  JUNKOSHA “MWX342/B” (2.4 mm cable, 40.0 GHz)
  - Used to connect Reference Transmitter and VNA.

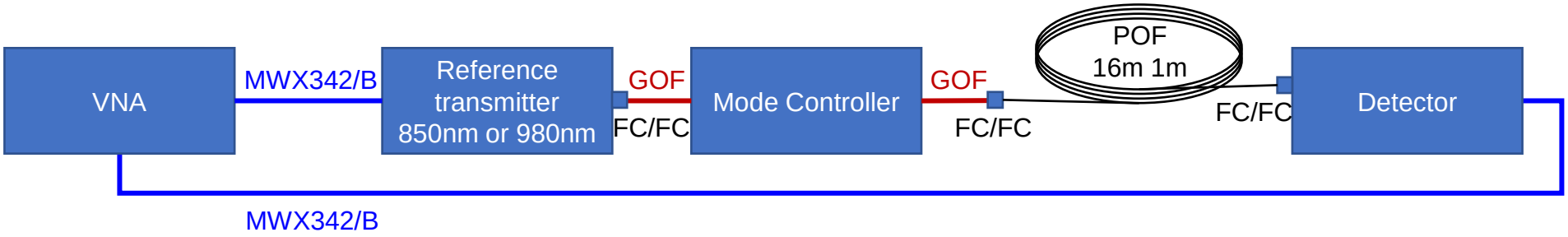
- Thermostatic chamber
  Espec “SH642”
  - -40 to 150 ºC

Test setup for frequency response

AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

Basic Setup

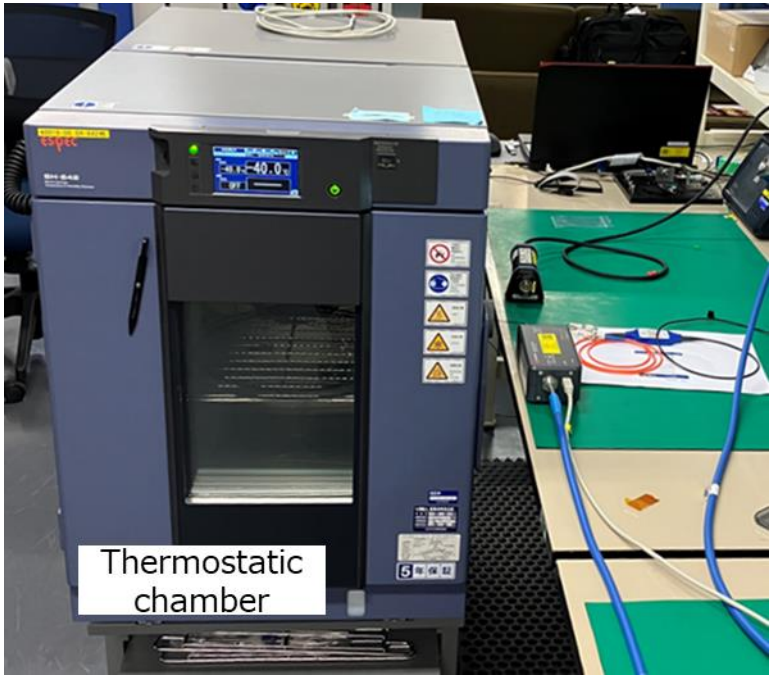


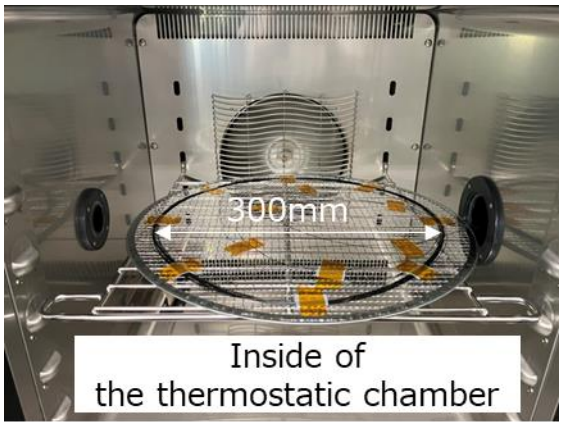


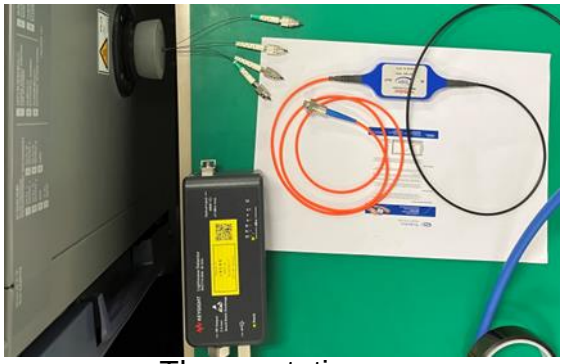
Test setup for frequency response

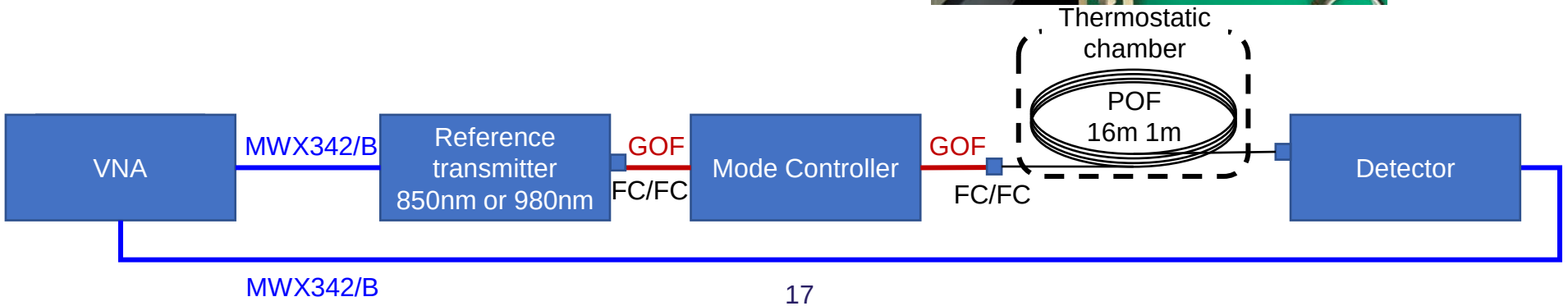
AGC Your Dreams, Our Challenge
Nagoya Institute of Technology

Temperature dependence evaluation









The target specification of GI-POF

AGC
Your Dreams, Our Challenge

IEC A4j Proposal

Attribute	Unit	Limit
Bare fiber diameter	um	490 +/- 5
Bare fiber non-circularity	%	≤ 4
Core-bare fiber concentricity error	um	≤ 6
Core diameter	um	55 +/- 5
Core non-circularity	%	≤ 6
Numerical aperture	-	0.24 +/- 0,025
Attenuation	dB/100 m	10
Minimum modal bandwidth	GHz 15 m	20