LAMBDASCOPE

Performance Verification Report for

FT-400 All Fiber High Temperature Sensor

(January 20, 2022)

Summary

In this report, we presented the measurement results of a novel all-fiber high temperature sensor (Model: LAMBDASCOPE FT-400). The results showed that, in reference to an industrial standard thermometer, our high temperature sensor have good accuracy (+/-5 ^{o}C), excellent linearity (99.8%) and robust fiber durability, which is suitable for harsh industrial applications.

1. Introduction

We, at LAMBDASCOPE, have developed a novel all-fiber temperature sensor for industrial and medical applications where the immunity to EMI interference is absolutely critical. The performance specifications have been reported in a separate data sheet, which includes the following critical parameters as listed in Table 1.

Model Type	FT-400
Default Fiber Type	SM
Wavelength	1310nm
Probe Temperature Range	-50 to 300(^{o}C)
Probe Temperature Accuracy	+/-5 ^{o}C
Thermal Shock	< 2^{o}C/min.
Ambient Temperature Accuracy	0.5 ^{o}C
Sensor Probe Size	100mm (Dia.)*
Fiber Pigtail Length	2m
Sampling Time	<2.5min.
Operating Temperature	-40 - +85 ^{o}C

Table 1. Critical performance specifications of FT-400 All-Fiber Temperature Sensor.

In order to demonstrate its performance capabilities, we have set up an experimental apparatus in our laboratory as illustrated in Figure 1. The temperature sensor FT-400 is housed in an environmentally ruggedized outdoor waterproof enclosure and connected to a fiber probe. The

fiber probe is specially designed to withstand high temperature harsh industrial environmental conditions, e.g. high temperature oil and/or strong EMI interference. The fiber is wound into a coil in diameter of 10cm to minimize the physical size and is submersed in oil filled beaker in the test. The beaker is placed on a hot plate and gradually heated up to 220 ^{o}C with a stirrer to keep the oil constantly stirring in order to minimize temperature gradient. A computer with GUI collects the data from the sensor via USB cable and saves the results from both the fiber probe measurements as well as the thermometer for the display. A temperature reference was provided by a thermometer (Omega Model HH127) for performance comparison purposes.

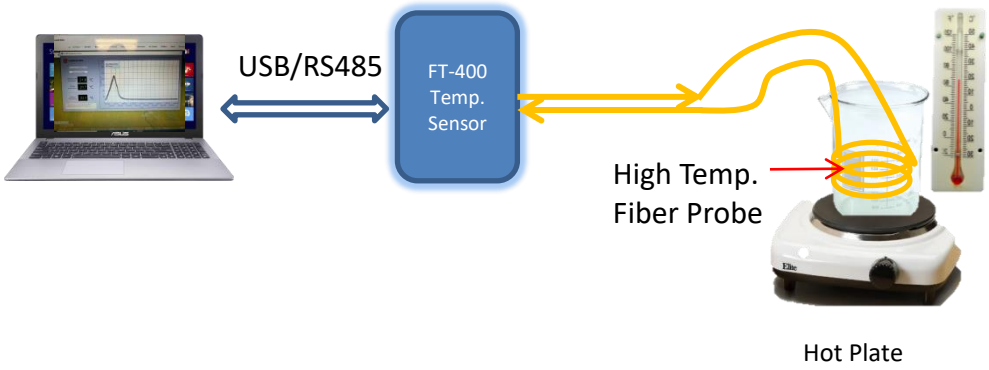


Figure 1. Experimental Setup: the FT-400 Temperature Sensor is connected to high temperature probe which is submersed in oil filled beaker. The beaker is heated on a hot plate with a stirrer. GUI collects and saves the data on a computer for display and further processing.

2. Experimental Results

In the experiment, we heated the oil gradually at approximately the rate of 2 ^{o}C/min to make sure that the fiber probe is sufficiently and thoroughly thermally conducted and the thermal gradient in the oil is minimized. The data is captured by GUI as shown in Figure 2 below.

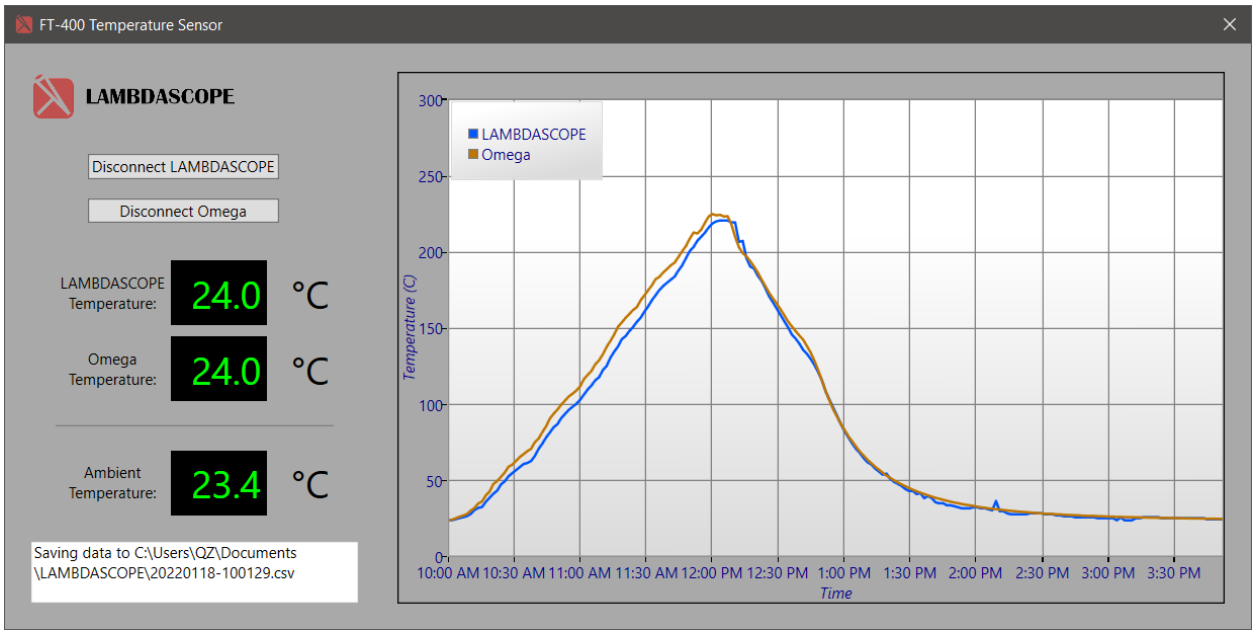
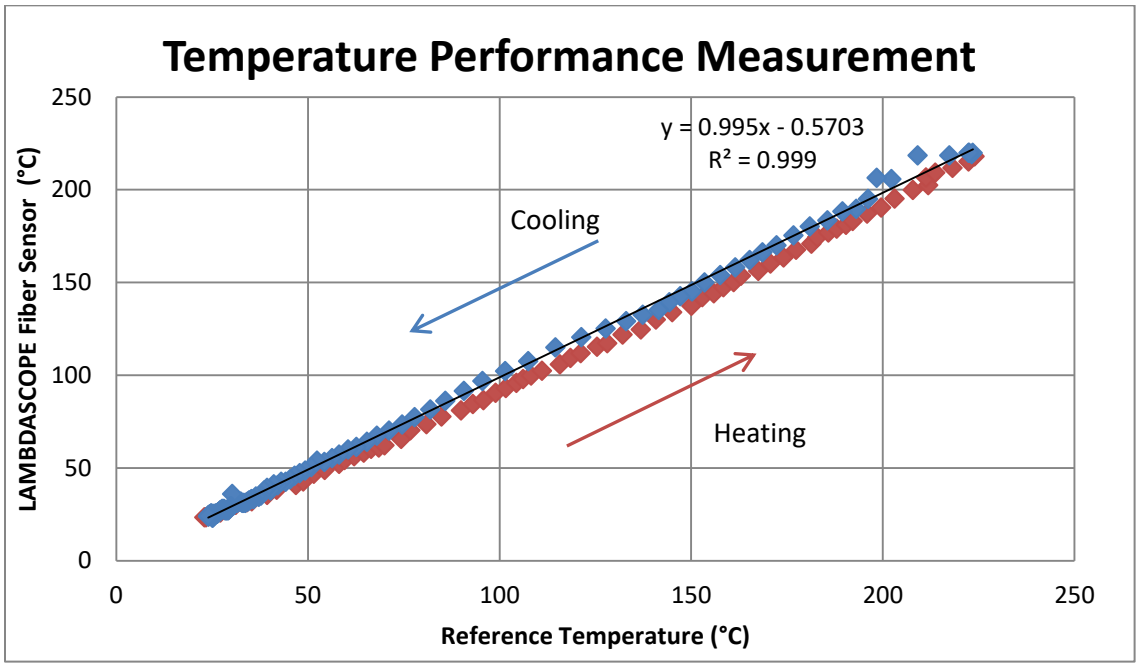


Figure 2. The picture showed the temperature readings captured by GUI from both LAMBDASCOPE FT-400 temperature sensor and Omega HH127 thermometer. The blue line is from FT-400 while the orange line from HH127. It showed on a time scale of 6 hours that, during the heating up stage, the thermometer is more thermally reactive than our fiber probe because of the design differences. However, during the cooling down stage when the oil in more thermally uniform, both data traced each other rather closely.

To analyze the temperature data further, we have regrouped the data and presented them in Figure 3 below.



As shown in Figure 3, we measured the temperature change from room temperature of 22 ^{o}C to 220 ^{o}C. The fiber sensor showed excellent tracking to the Omega thermometer with linear slope equal to 0.995 (99.5%) in almost perfect fit (R^2=0.999). There is a small hysteresis between the heating and cooling temperature tracking due to in part the thermal conductivity of the fiber glass itself. We believe that if the temperature ramping can be further controlled in a slow rate, the hysteresis effect can be greatly reduced. In most industrial applications, the temperature change is expected to be gradual. Our FT-400 has a response time of 2.5 minutes. It should be fast enough to detect any temperature variation in the time interval up to 6 degrees.

In conclusion, we have demonstrated a novel high temperature fiber sensor that is capable of measuring 220 ^{o}C with good accuracy and excellent linearity. The fiber probe exhibited robust endurance when subjected to high temperature in oil. We believe this device is ready for wide range of industrial and medical applications.

If you have any questions about this report, please write to: info@lambdascope.com.