Atacama
Large
Millimeter
Array

# APP Optical Fiber Link system prototype test report

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# Change Record

| Version | Date | Affected Section(s) | Change Request # | Reason/Initiation/Remarks |
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# 1 Introduction

## 1.1 Purpose

This document describes the details of prototype production and test results of the OFL system prototype.

## 1.2 Reference Documents

[RD 1] ALMA Phasing Project Plan
[RD 2] APP Optical Fiber Link system design

## 1.3 Abbreviations and Acronyms

| | |
|---|---|
| **APP** | ALMA Phasing Project |
| **AOS** | Array Operations Site |
| **DWDM** | Dense Wavelength Division Multiplexing |
| **OFL** | Optical Fiber Link |
| **OSF** | Operations Support Facility |
| **NAOJ** | National Astronomical Observatory of Japan |
| **VLBI** | Very Long Baseline Interferometry |
| **VSI** | VLBI Standard Interface |

# 2 Prototype production

The purpose of the OFL system is to transmit the antenna sum data from the AOS to the OSF while using minimal fiber resources [RD01]. Based on the detailed design is summarized in the OFL system design document [RD02], prototype production was conducted in early 2013. Prototype manufacturer and model number are:

**Manufacturer:** Elecs Engineering
**Model Number:** XW-100 (both the Multiplexer and Demultiplexer)

Front and rear views of XW-100 are shown below. Nine slots on the front panel are attached with 10GBASE-SR XFP modules to constitute nine local ports including one spare. The DWDM remote port is located at the bottom-right corner of the front panel. On the rear panel, three cooling fans are attached. The power on-off switch is located at the bottom-left corner on the rear.

**Figure 1:** Front view of XW-100

**Figure 2:** Rear view of XW-100

# 3 Prototype test

In order to evaluate the performance the OFL system prototype XW-100, we have conducted various tests at the manufacturer as well as at NAOJ Mitaka, and below we report details of the test results.

## 3.1 Full-data-rate transmission test

**Specification:** The OFL system has to be capable of sending data at a total rate of 8 Gbps x 8 = 64 Gbps.

**Test description:** The test data from a 10GbE analyzer was sent to OFL system in a daisy chain mode so that one 10GbE stream is copied to all the nine ports (including the spare port) of Multiplexer and sent to Demultiplexer through a single fiber at the same time with DWDM technique. See figure 1 for the experiment setup. Note that an optical attenuator was inserted to emulate the fiber loss between AOS and OSF.

**Result:** Maximum data rate of 9.8Gbps x 9 (=88.2 Gbps) was achieved without any packet loss or any other error. Note that 9.8 Gbps is the maximum throughput of one 10GbE stream, and so XW-100 achieved the maximum transmission rate based on 10GbE.

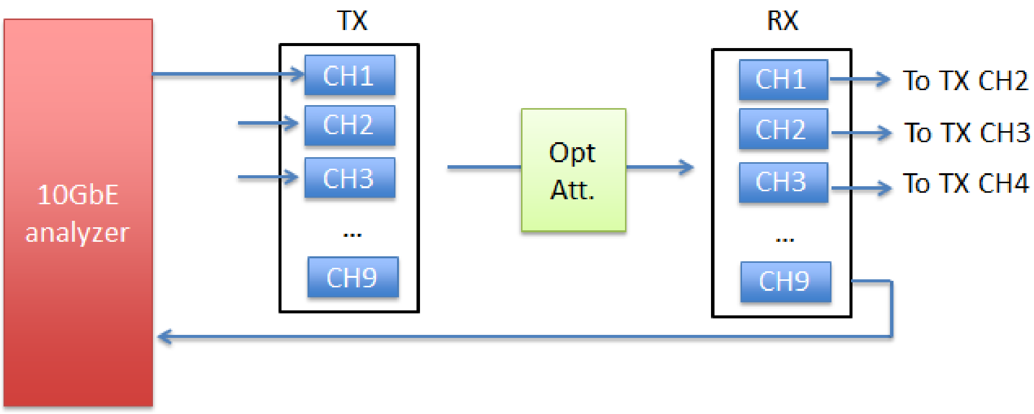


**Figure 3:** Schematic diagram for data transmission test at the full rate

**Figure 4:** Picture of the two sets of XW-100 under testing

### 3.2 Attenuation tolerance test

**Specification:** The optical fiber between AOS and OSF has an optical attenuation of about 7.5 dB. The OFL has to be able to establish a link between AOS and OSF with this attenuation.

**Test descripition:** An optical attenuator is inserted in the DWDMed stream between the Multiplexer and Demultiplexer, and attenuation tolerance level is measured.

**Result:** It is confirmed that the data can be correctly transmitted with an attenuation level less than 20 dB. Figure 5 shows an example of error rate measured against the attenuation level.

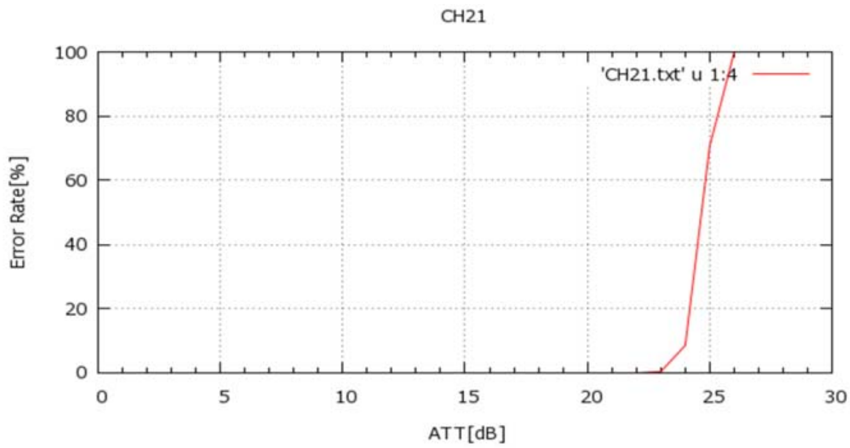


**Figure 5:** Example result of attenuation tolerance test

### 3.3 Long-term running test

**Specification:** The OFL system can be operated without any significant trouble for a period longer than normal VLBI observations (at least ~10 hours).

**Test description:** Long-term running test of the OFL system was conducted at the full data rate.

**Result:** No packet loss or data error occurred through the test run for three weeks.

### 3.4 Power consumption

**Specification:** Power consumption is less than 150 W.
**Result:** Power consumption in regular operation is measured to be ~68 W.

### 3.5 Acceptable input voltage

**Specification:** Input AC voltage of 100/230 V must be accepted.
**Result:** Operation is confirmed with input AC voltages of 90, 100, 110, 200, 230, 240 V.

### 3.6 Power supply

**Specification:** Operation with one power supply unit is possible.
**Result:** Operation with one power supply unit is confirmed.

### 3.7 Cooling capability

**Specification:** The OFL system must have cooling capability enough for operation at the high site. Cooling with two fans (out of the three fans attached) should be OK for redundancy.

**Test description:** Surface temperature of XFP module was measured with varying the number of fans in operation (decreasing from three to one). The experiments were done under room temperature and sea-level atmospheric pressure. Temperature increase with respect to the outside air temperature was measured as a function of the number of fans in operation.

**Result:** The temperature increase is summarized below. Maximum temperature increase was 9.5 C deg in case of one fan in operation. This corresponds to the XFP module surface temperature of ~35 C deg (using the room temperature of ~25 C deg), which is far below the maximum operation temperature of 75 C deg. Note that at the high site (AOS) the air density is roughly half of the sea-level atmosphere, and thus operation with one fan at the sea level roughly emulates operation with two fans at the high site.

| Number of fans in use | Temperature increase 1) | note |
|---|---|---|
| 3 | 2.5 C deg | |
| 2 | 5 C deg | |
| 1 | 9 C deg | Roughly corresponds to operation with two fans at AOS |

1) Surface temperature increase of XFP module with respect to the room temperature

### 3.8 Software interface test

**Specification:** The OFL system is connected through LAN with telnet / VSI-S protocol.

**Result:** Connection with telnet / VSI-S is confirmed. Commands are properly sent to Multiplexer and Demultiplexer and also statuses are properly retuned from Multiplexer and Demultiplexer. Figure 6 is a screen shot of the software interface test.

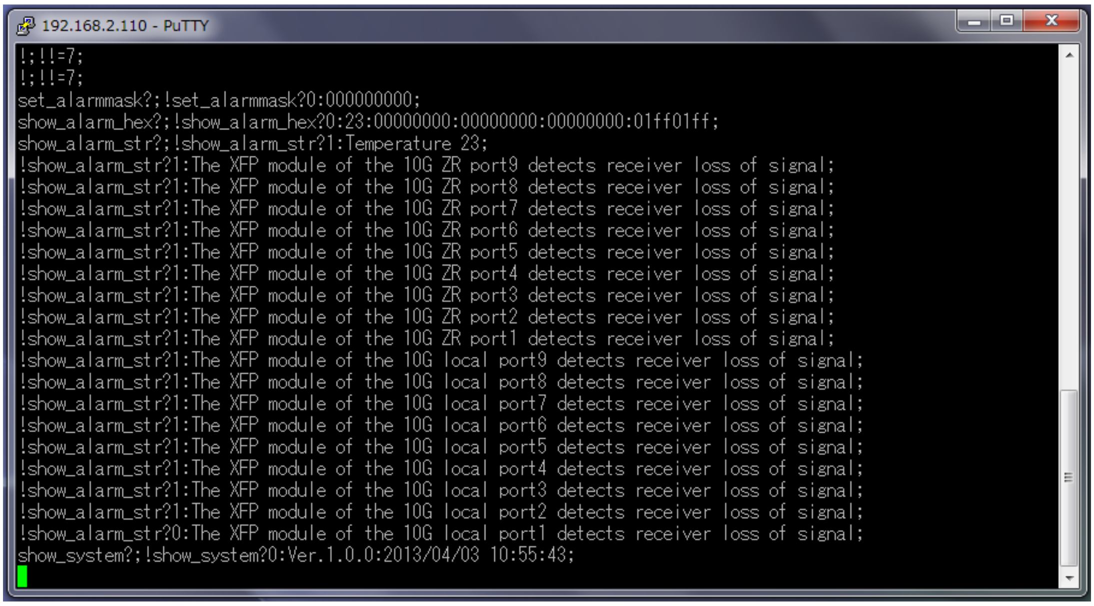


**Figure 6:** Screen shot of telnet /VSI-S connection to the OFL system.