O-03 Submarine Cable & Data Reach Test

ENGINEER: __Sonnichsen / Lerner_____

DATE: 09/07/2004 - 09/10/2004

COMMENTS:

Testing done on MARS fiber at the Ile De Re

Condition and Attenuation Values for Optical Test just Prior to shipment to Ile De Re

Preamp EDFA	**in=0 out=0**
Booster EDFA	**in=10 out=0**
Sea xpndr 1555.75	**in=5 out=0**
Shore xpndr 1558.98	**in=5 out=0**
Sea DeMux	**in=.5**
BERT rate 1555.75	**7 errors in 18 hours**
BERT rate 1558.98	**0 errors in 18 hours**

MARS
Org: WHOI
Engr: Fritz Sonnichsen
Date: 07/06/04

O-03 Submarine Cable & Data Reach Test- Summary of Results

CONCLUSIONS AT END OF TEST:

Testing completed on MARS fiber at the Ile De Re 09/10/2004

The MARS/ALCATEL cable has optical characteristics of ~0.21 dB/km loss and -1.7ps/km.ns dispersion. Overall length per ODTR was 76.023 km.

The use of such cable is clearly viable for transporting Gigabit Ethernet DWDM signals using the Network Electronics suite of optical products in conjunction with Bookham EDFAs.

BIT error rates below the required 1 / 10^{12} were maintained throughout the tests.

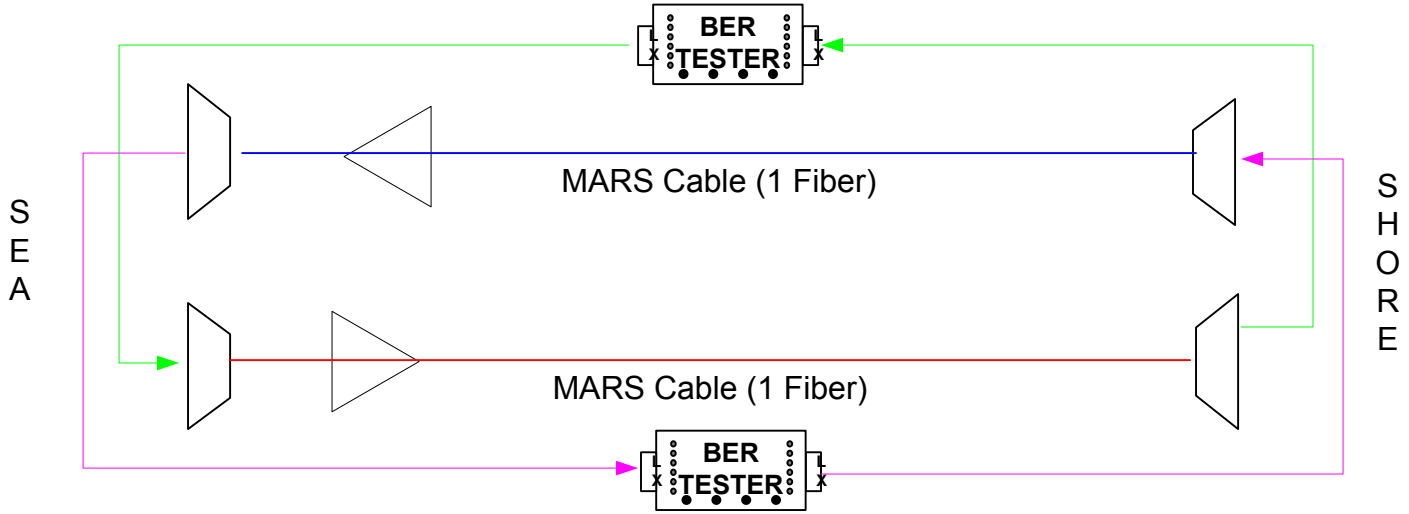
Using a pre-amp and line-amp configuration in series distances of at least 217km are possible.

Using either EDFA singly permits distances of at least 140km.

O-03 Submarine Cable & Data Reach Test (overview)

Prior to laying the MARS shielded cable the ability to transfer data at the proper Bit Error Rate is to be tested. This will represent the first complete end-to-end test of the MARS data communications system. This test is comprised of a physical layer and link layer (ISO-0,1) BER test to insure that the optical and electrical media are capable of conducting gigabit ethernet frames with an error rate of less than 1 error in 10^{12}. Also a Layer4 Data Rate test will be performed.

1) The test will be performed with both pre-amp and booster EDFAs in single and back to back configurations.
2) An additional test will be performed to determine the maximum optical reach of the equipment over the MARS type cable
3) Tests are done separately for the East then the West paths of the node
4) This complete test will be run prior to atttending the ship, using a 100km length of SMF28E test fiber in the lab. This will:
    a) Insure that the test procedure that follows is accurate
    b) Provide future information for the NEPTUNE project
5) For Gigabit Ethernet, a test of at least 100 minutes is recommended to insure confidence in the Bit Error Results.
6) Shown below is the basic concept for the tests. A bit error tester sends a determinite bit stream into the optical transponders. These pass through the MARS cable and are collected at the other end, where the BER tester compares them for accuracy. Various variations will be tried using cable lengths coupled in series and other amplifier configurations.



BASIC IDEA OF BERT SETUP

O-03 Submarine Cable & Data Reach Test (BER)

A note on Bit Error Rate Testers

The BER tester chosen for the MARS test was the ANCOT Netminer. This device is capable of accepting 2 SFPs or GBICs which provide the signal transmitter and receiver for the test. The device allows 3 possible bit patterns per the IEEE P802.3z/D3.0 document:

CRPAT - This pattern provides a broad spectral pattern with few peaks.
CJTPAT- Alternate low and high transition patterns. This test emphasizes jitter tolerance testing.
CSPAT - Simulates power supply noise introduced by the transceiver.

We should use all three patterns during final testing with emphasis on the CJTPAT since jitter will be an important issue for the MARS system later when sending timing signals.

For Gigabit Ethernet the probability of running error free for N bits is given by:

$$P=(p-1)^N / P^N$$

where p is 10^{12} , the accepted Bit Error Rate for Gigabit Ethernet. After 16.66 minutes, exactly this many bits have been transferred. Plotting the above equation (P w.r.t. N) yields the result that we need to run roughly 6 times this number of bits, or about 100 minutes to insure that we are within the BER spec with over 99% confidence.

In order to expedite testing, a second test option was chosen. This was the use of CISCO proprietary Stardust software, which implements a high speed Ethernet data test using a CISCO switch. The vendor description of the software was somewhat limited w.r.t bit patterns, so this method was only used as an ancillary test.

O-03 Submarine Cable & Data Reach Test-portable chassis and travel tools list

Required equipment for this test is:

1) Suiitable gigabit ethernet BER optical test set
2) Rack Mounted MARS subsea node assembly completely fibered including Switches, NE optical assemblies, and EDFAs. (See next page)
3) Uncut MARS cable (72km).
4) Rack Mounted MARS shore station completely fibered including Switches, NE optical assemblies, and EDFAs. (same rack as subsea node)
5) Optical Power Meter
6) Optical attenuators - around 10 each of 3dB 5dB 10dB and 15 dB
7) Optical Laser Source or Loss Test Set
8) LANforge Test Set or comparable IP test software
9) Long (12') jumpers suitable for connecting to MARS fiber on spool

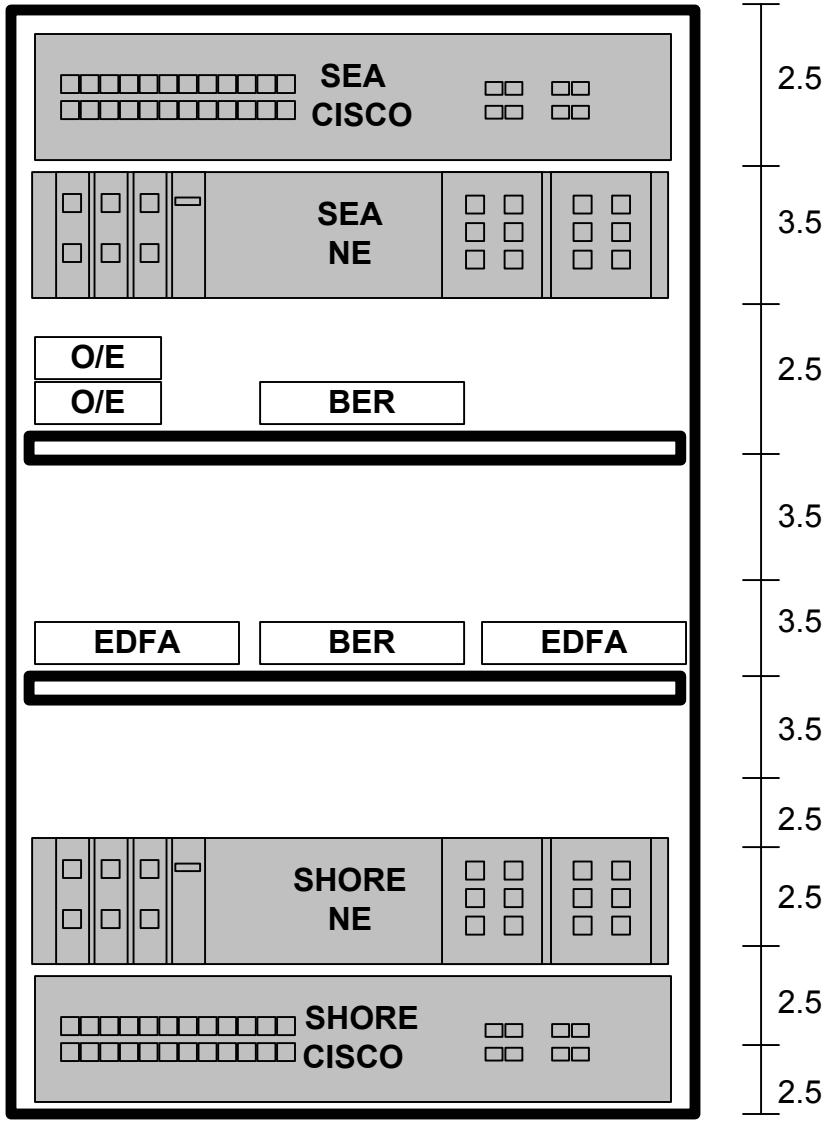
Possible Additional Tools:

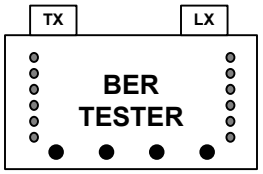
1) Fusion splicer for connnecting jumpers to MARS cable
2) Spare FC and SC connectors
3) FC/SC and SC/SC couplers

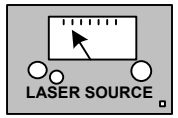
Issues to confirm with Alcatel

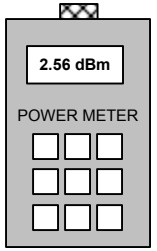
1) What connector types will be available at the 2 ends of each fiber in the bundle
2) Will the cable be pre-cut to the actual length that it will occupy in the ocean

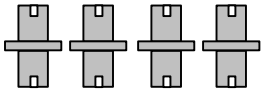
O-03 Submarine Cable & Data Reach Test-portable chassis and travel tools list



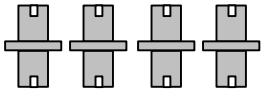




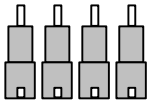




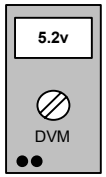
15 SC/SC Couplers

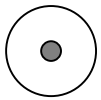


15 FC/FC Couplers

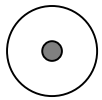


SET OPTICAL ATTENUATORS





STARDUST SOFTWARE



LAPTOP BASED ETHERNET TEST

Laptop computer

O-03 Submarine Cable & Data Reach Test-Procedure

Each of the 3 sea to shore channels will be tested concurrently. Tests will include:

a) Testing the optical components alone
b) Testing the optical components in conjucntion with the OE Gigabit Ethernet converers
c) Testing the complete system with IP traffic including the switches
d) Testing the optical reach of the system on the MARS cable
e) Testing the function of dual amplifier systems

1) Proper fiber handling and saftey techniques are assumed throughout and not further mentioned.

2) Use SM fiber for all loopbacks

3) ***CAUTION!*** We cannot discuss the optical test set configuration since this will vary with the unit procured for the test. However, be sure to insert an appropriate attenuator or you may damage the receiving MRTR transponder. Using a power meter insure that the output of the test set measured *after* the attenuator is at -6dBm or slightly less.

4) If 2 BERT testers are available, both the East and the West paths can be tested concurrently. A CISCO Startdust setup may be used as a secondary BERT test, however a commercial BERT tester will provide more wave patterns and better diagnostics.

5) Since Optical Return Loss can be a problem, test O-05 will be used to give the minimum/maximum injection values for the MRTRs and SFPs. Record the outcome of this test on the datasheets the end of *this* document for choosing attenuators as needed.

6) Each test is shown on one fiber pair. Repeat all tests on each of the 4 fiber pairs.

7) All tests should run for at least 100 minutes which will insure a 99% level of confidence in the test.

FIBER SELECTION-

Each of the 8 fibers in the MARS cable should be permanently labled. Pairs should be selected and labeled as follows:

PAIR1: Data East Transmit - Data East Receive PAIR2: Data West Transmit - Data Weast Receive
PAIR3: OBC East A - OBC East B PAIR4: OBC West A - OBC West B

O-03 Submarine Cable & Data Reach Test

OPTICAL BER TEST- Setup 0

1) This test will verify basic setup of the BER tester and Cable and will excercise all optical components
2) Using the following two diagrams (Setup 0), set up SM fiber jumpers to complete the optical circuit
3) Insert attenuators per the O-05 test at the MRTR inputs,
4) At the line (1AEC28) EDFA input insert an attenuator to maintain input levels below-6 dBm. If the Preamp is driving a large output add an attenuator to the output to the demux such that the demux outputs are less than the -3dBm limit into the SFPs.
5) At the BERT tester SFPs, insert attenuators to prevent overdriving the SPFs past thier -3dBm level.s
6) Run the BER test per the test-set vendor for at least 100 minutes, 24 hours if possible.
7) No more than 1 error should be detected in a 15 minute period.
8) If errors are detected chase the optical path with a power meter to insure proper connections. Also check return loss. All MRTRs and SFP should be injected at levels determined by the O-05 tranceiver characterization test.
9) Record the results in the data tables at the end of this document

OPTICAL LOOPBACK TEST - Setup 1

1) This test is described here for those cases where both cable ends cannot be accessed at the same physical point, and must be looped back. If the previous test can be performed omit this test as it is redundant. One advantage of this test is that all channels can be tested at once. The disadvantage is that is BER errors are detected it is not easy to localize them to a particular channel.
2) Using the following two diagrams (Setup 1), set up SM fiber jumpers to complete the optical circuit
3) Insert attenuators per the O-05 test at the MRTR inputs,
4) At the line (1AEC28) EDFA input insert an attenuator to maintain input levels below-6 dBm. If the Preamp is driving a large output add an attenuator to the output to the demux such that the demux outputs are less than the -3dBm limit into the SFPs.
5) At the BERT tester SFPs, insert attenuators to prevent overdriving the SPFs past thier -3dBm level.s
6) Run the BER test per the test-set vendor for at least 100 minutes, 24 hours if possible.
7) No more than 1 error should be detected in a 15 minute period.
8) If errors are detected chase the optical path with a power meter to insure proper connections. Also check return loss. All MRTRs and SFP should be injected at levels determined by the O-05 tranceiver characterization test.
9) Record the results in the data tables at the end of this document

O-03 Submarine Cable & Data Reach Test

ELECTRICAL BER TEST- Setup 2

1) This test will verify the inclusion of OE converters into the SEA side of the system
2) Using the diagrams (Setup 2), set up SM fiber jumpers to complete the optical circuit. Add the CAT5E cables as shown. Note the special treatment of the 3rd 1549.32 channel as a pass-thru only.
3) Insert attenuators per the O-05 test at the MRTR inputs,
4) At the line (1AEC28) EDFA input insert an attenuator to maintain input levels below-6 dBm. If the Preamp is driving a large output add an attenuator to the output to the demux such that the demux outputs are less than the -3dBm limit into the SFPs.
5) At the BERT tester SFPs, insert attenuators to prevent overdriving the SPFs past thier -3dBm levels. Note the TX SFPs used here for the CAT5
6) Run the BER test per the test-set vendor for at least 100 minutes, 24 hours if possible.
7) No more than 1 error should be detected in a 15 minute period.
8) If errors are detected chase the optical path with a power meter to insure proper connections. Also check return loss. All MRTRs and SFP should be injected at levels determined by the O-05 tranceiver characterization test.
9) Record the results in the data tables at the end of this document

SWITCHED DATA TRANSPORT TEST- Setup 3

1) This test will verify the inclusion of CISCO switches into the system. BER testing will be replaced by a data througput test. Etherchannel is not used here and each optical channel may be connected one at a time to test it. A suitable routing configuration need be added per CISCO to complete interconnection bewteen the 2 computers. Each computer should run and appropriate IP test such as LANFORGE.
2) Using the diagrams (Setup 3), set up SM fiber jumpers to complete the optical circuit. Add the CAT5E cables as shown. Note the special treatment of the 3rd 1549.32 channel as a pass-thru only.
3) Insert attenuators per the O-05 test at the MRTR inputs,
4) At the line (1AEC28) EDFA input insert an attenuator to maintain input levels below-6 dBm. If the Preamp is driving a large output add an attenuator to the output to the demux such that the demux outputs are less than the -3dBm limit into the SFPs.
5) At the CISCO tester SFPs, insert attenuators to prevent overdriving the SPFs past thier -3dBm level.s
6) Run the data test per the test-set vendor for at least 100 minutes, 24 hours if possible.
7) No client-client errors should be seen.
8) If errors are detected chase the optical path with a power meter to insure proper connections. Also check return loss. All MRTRs and SFP should be injected at levels determined by the O-05 tranceiver characterization test.
9) Record the results in the data tables at the end of this document

O-03 Submarine Cable & Data Reach Test

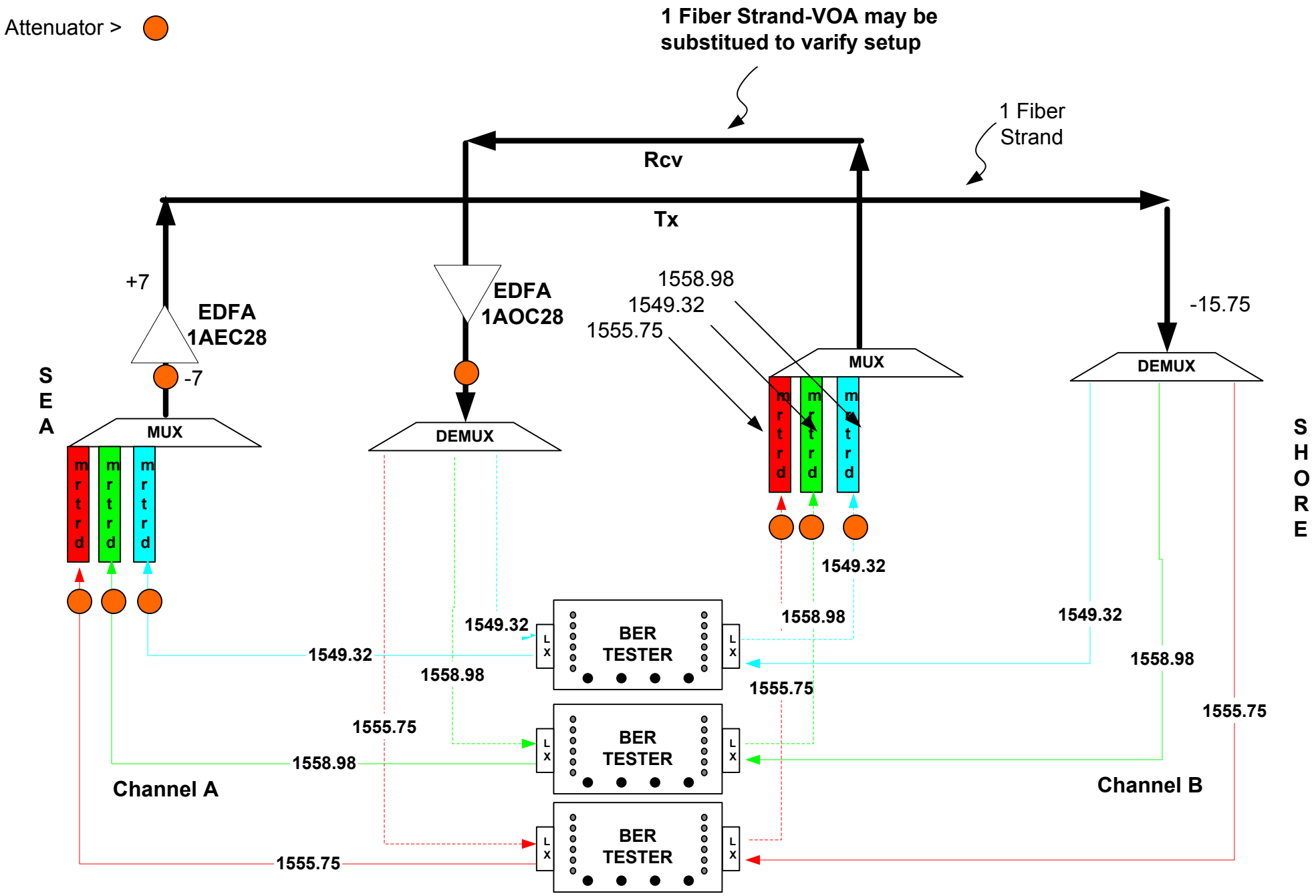
OPTICAL REACH - Setup 4

1) This test will determine the maximum reach of the optical assemblies over the MARS type cable.
2) Using the following diagram (Setup 4), set up SM fiber jumpers to complete the optical circuit. Use only one fiber pair as a verification of setup. Then immediately extend this fiber pair with a second pair, using fiber coupler/connectors.
3) Determine the optical loss of the extended fibers and record the result in the data sheets.
4) Insert attenuators per the O-05 test at the MRTR inputs,
5) At the line (1AEC28) EDFA input insert an attenuator to maintain input levels below-6 dBm. If the Preamp is driving a large output add an attenuator to the output to the demux such that the demux outputs are less than the -3dBm limit into the SFPs.
6) At the BERT tester SFPs, insert attenuators to prevent overdriving the SPFs past thier -3dBm level.s
7) Run the BER test per the test-set vendor for at least 100 minutes, 24 hours if possible.
8) No more than 1 error should be detected in a 15 minute period.
9) If errors are detected chase the optical path with a power meter to insure proper connections. Also check return loss. All MRTRs and SFP should be injected at levels determined by the O-05 tranceiver characterization test.
10) Record the results in the data tables at the end of this document
11) Repeat the above test extending with yet another fiber pair. Continue in this fashion until the system can no longer operate.

FIFTH TEST - DUAL AMPLIFIER

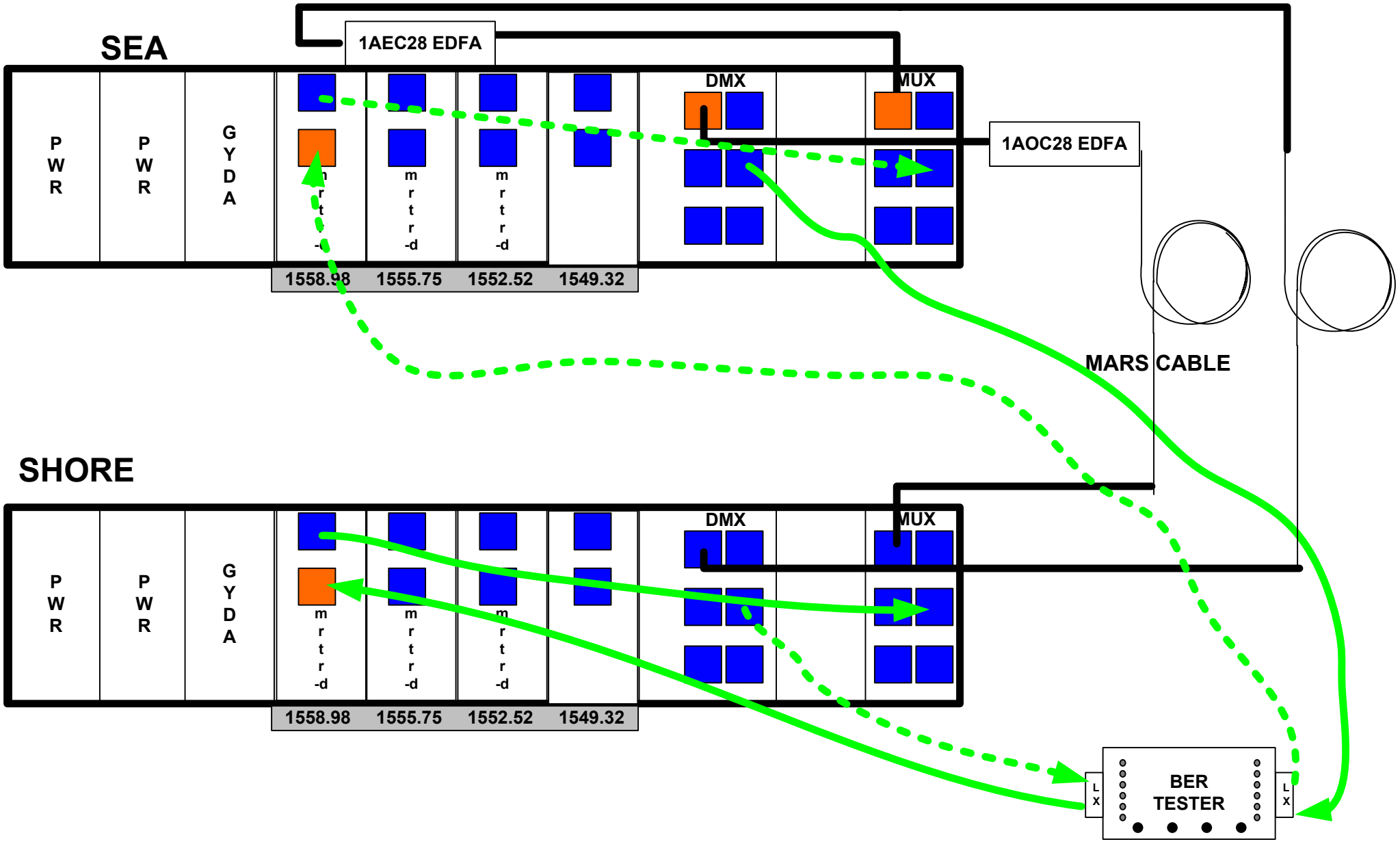
1) Start with 1 fiber strand to verify setup. Build the test shown on setup 5. Note the rearrangement of the EDFAs in push-pull fashion. Be sure to attenuate input into the booster 1AEC28 EDFA as required to limit input below -6dBm. Attenuate the pre-amp 1AOC28 to prevent overdrive of the receive side of theSFPs.
2) Note that only one fiber strand can be tested since there are only 2 EDFAs.
3) When setup is verified, begin testing by extending the fiber by adding a second strand in series using SC/SC couplers.
4) Record the above results in the results table

O-03 Submarine Cable & Data Reach Test (schematic)
Setup 0: Optical Test

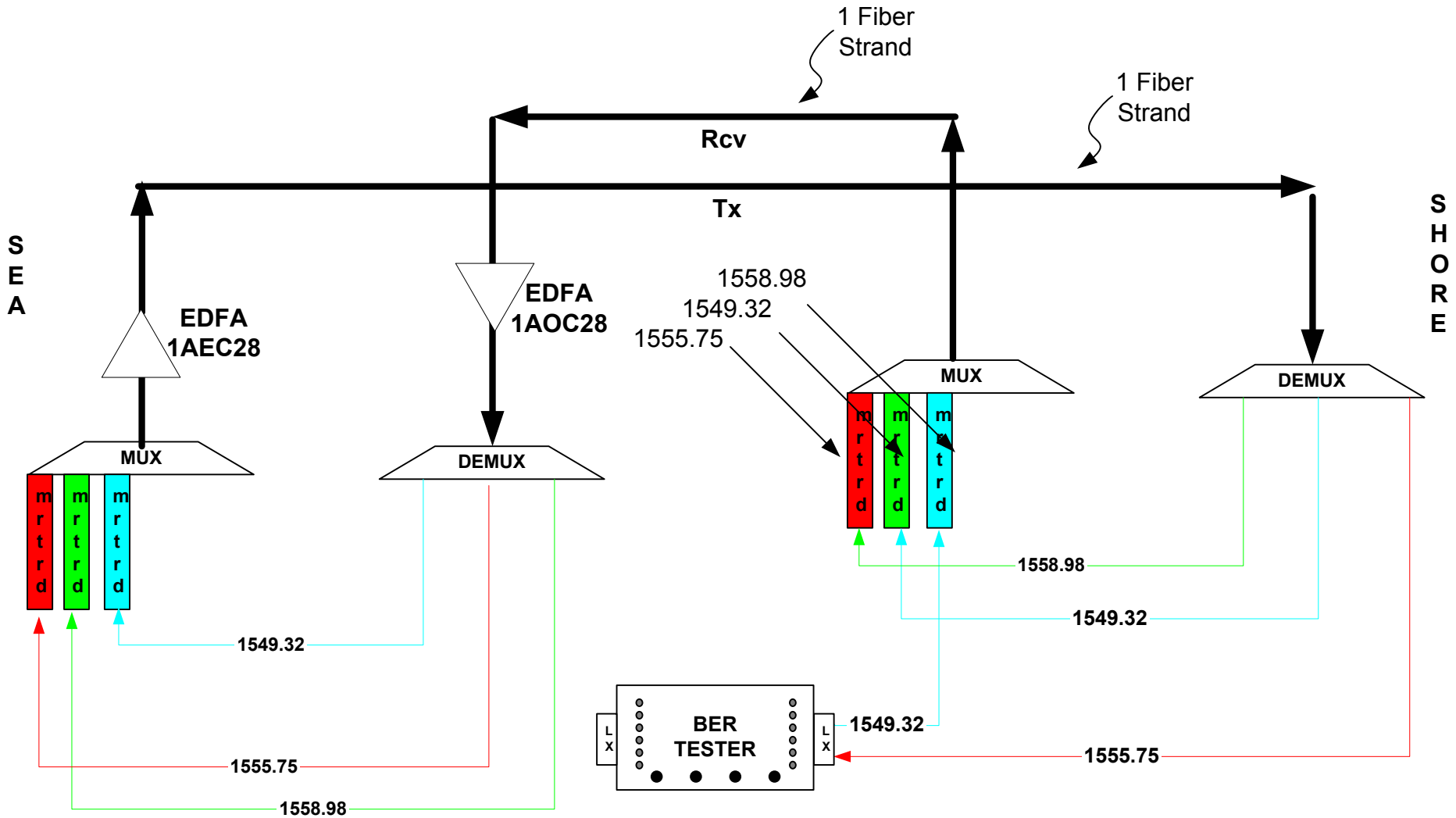


O-03 Submarine Cable & Data Reach Test
Setup 0: Physical Diagram Optical Test (1558.98 shown only)

USE SM FIBER FOR LOOPBACKS ORANGE REPERSENTS ATTENUATORS >

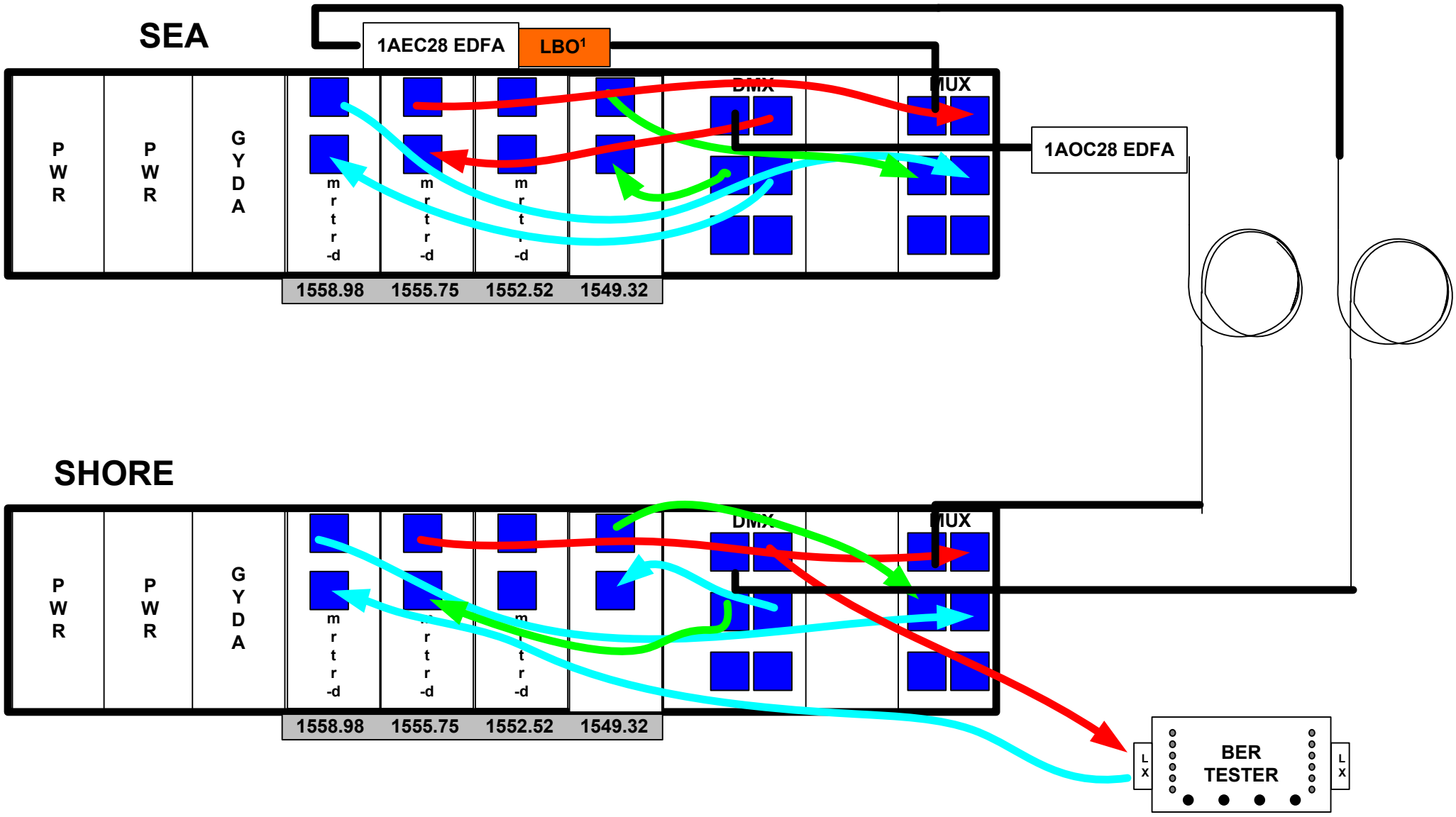


O-03 Submarine Cable & Data Reach Test (schematic)
Setup 1: Optical Loopback

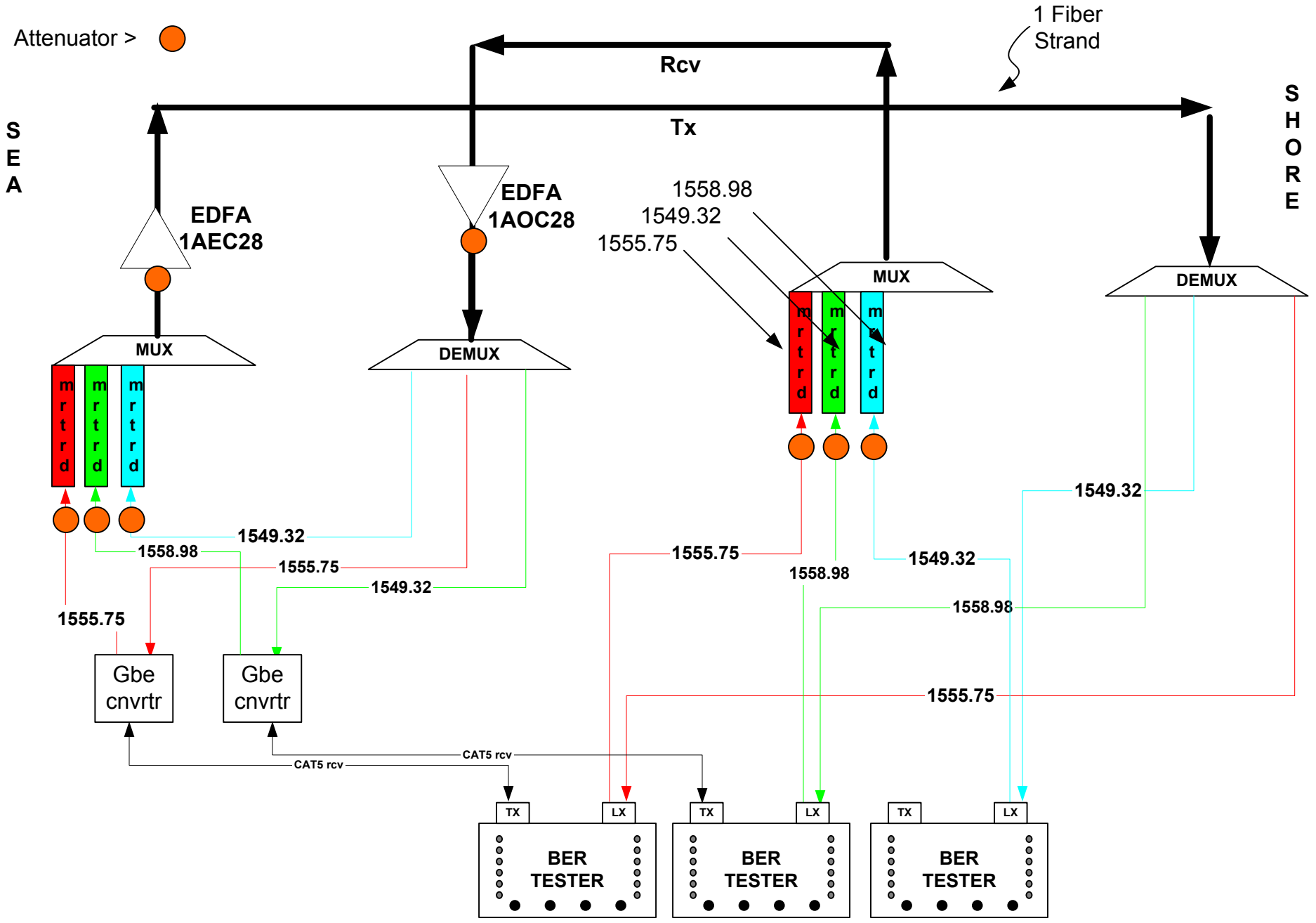


O-03 Submarine Cable & Data Reach Test
Setup 1: Physical Diagram for Optical Loopback test

USE SM FIBER FOR LOOPBACKS **ORANGE REPERSENTS ATTENUATORS**

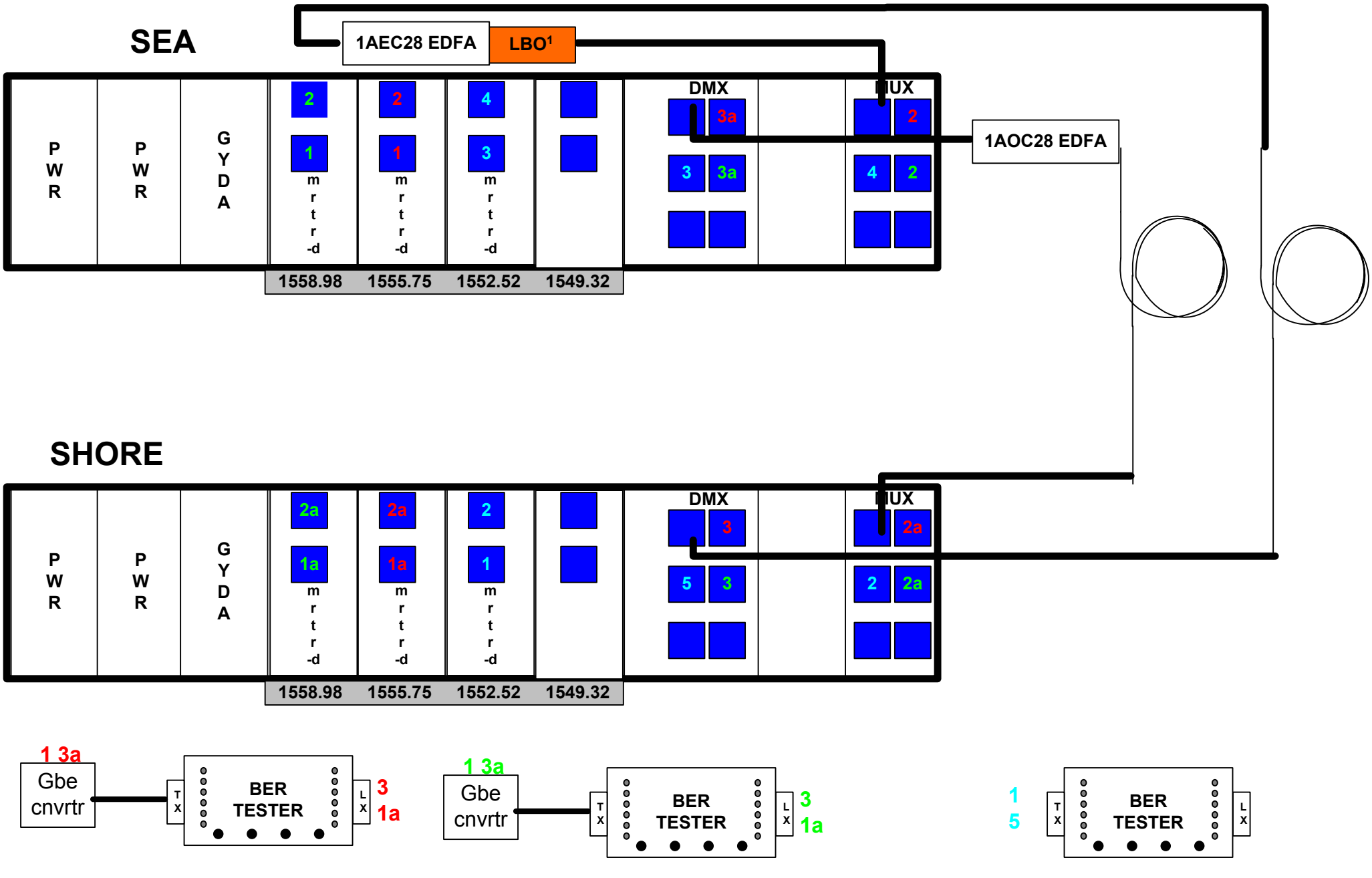


O-03 Submarine Cable & Data Electrical Test (schematic)
Setup 2: Electrical BER Test

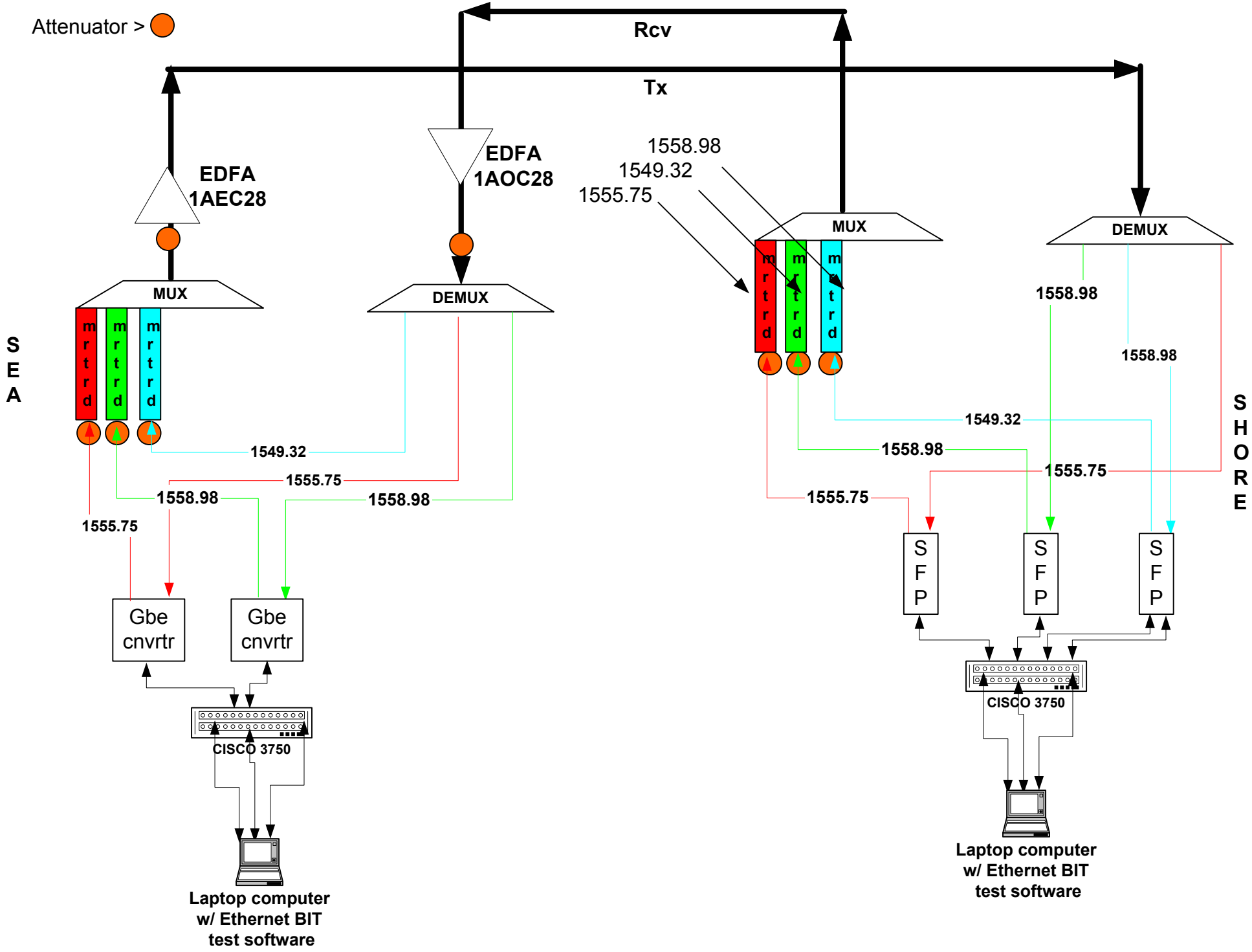


O-03 Submarine Cable & Data Reach Test
Setup 2: Physical Diagram for ElectricalTest

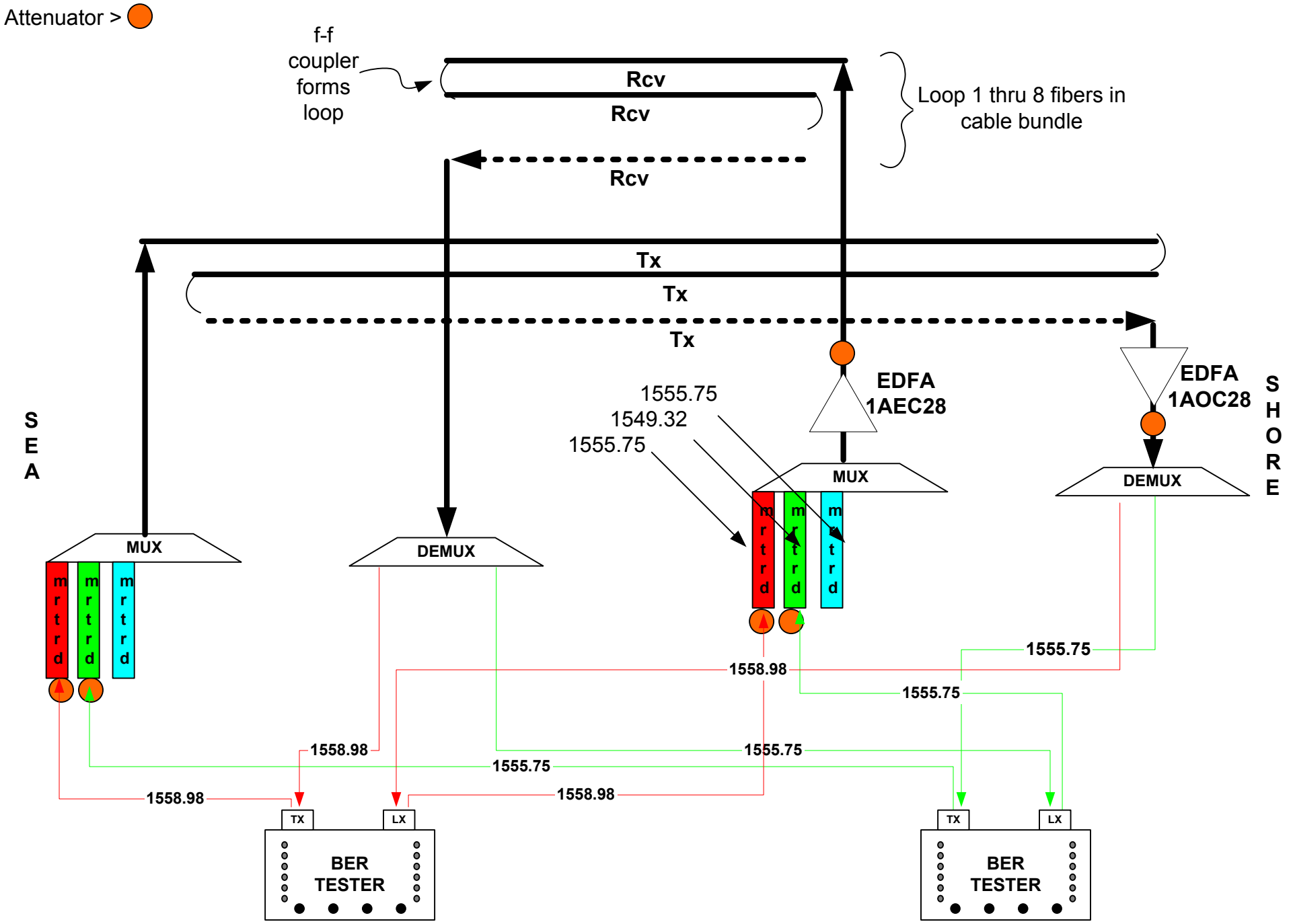
USE SM FIBER FOR LOOPBACKS **ORANGE REPERSENTS ATTENUATORS**



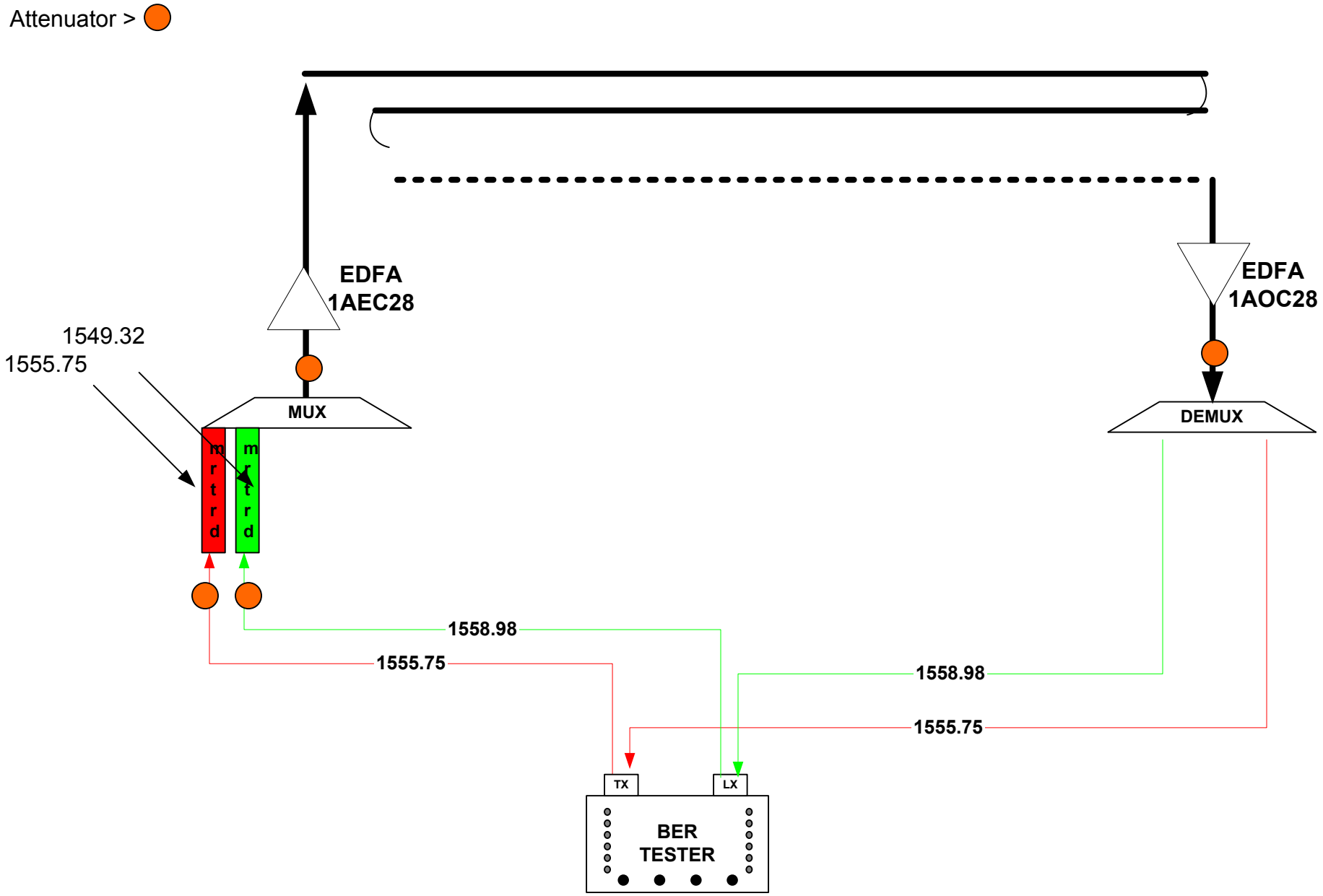
O-03 Submarine Cable & Data Reach Test (schematic) Setup 3: Switched Data Throughput



O-03 Submarine Cable & Data Reach Test (schematic)
Setup 4: Reach Test Setup



O-03 Submarine Cable & Data Reach Test (schematic)
Setup 5: Dual EDFA Test



Some Useful Details about Optical Components

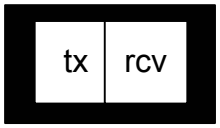
com-mon	1555.75
1549.32	1558.98
1552.52	upgrade

NE Mux and DeMux port layouts

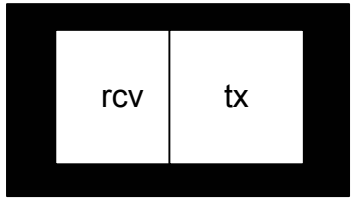
	Tx
	Rcv

NE MR-TR-D15xx Port Layout

DIP settings for MRTRD in gB ether mode



CISCO SFP GBIC Paths



CISCO GBIC Paths

GYDA CONNECTION PROCEDURE

Set up a 10 network on the PC.
Give the PC and ethernet address of 10.0.0.49
Connect Ethernet Crossover cable from PC to GYDA Ethernet 10BaseT
arp -s 10.0.0.50 00-01-C0-00-7A-0D
Turn off the GYDA
Turn on the GYDA
ping 10.0.0.50
WEB browser to 10.0.0.50

EDFA SERIAL COMMUNICATIONS CONNECTION PROCEDURE

The PC need only be placed in a minicom or hyperterm mode with an RS232 connection to the EDFA "evaluation" card, per Bookham's instructions.

Setup Parms are:

8N1 flowcontrol off 9600b.

To login type:

AD FFFF 1234

Some Important Optical Specs

Device	Sensitivity dBm	Overload dBm	Damage dBm	Output dBm	Loss /Gain dB
NE MRTRD	-20	-3	-1	-0 (1mW)	
NE MRTR	-25			-7.5	
NE MRTR enhancd	-3 to -19			6 (4mW)	
LX SFP [1]	-3 to -19			-3 to -9.5	
GbE Converter	-3 to -21			-3 to -9.5	
1AEC28 EDFA		-6			+23
1AOC28 EDFA		-10			+23
NE Mux/Demux					-3 per side
MARS Cable					-15

1 - SFP is same spec as a GBIC

NE Channels		
Channel	Wavelength	frequency Ghz
493	1549.32	193500
557	1555.75	192700
589	1558.98	192300

O-03 Submarine Cable & Data Reach Test - Results Sheet- GENERAL

GENERAL	
Date	09/06/2004
RUN	01
Cable Length	72.026 km
Ambient Temp.	not avialable ~72
COMMENTS	no cable/ test run only

SERIAL NUMBERS		
Shore	1558.98	00161 4-5
Shore	1555,75	00161 4-5
Shore	1549.32	00208 5-8
Sea	1558.98	173 5-5
Sea	1555,75	172 5-5
Sea	1549.32	209 5-8
sfp lx	cisco	p11uhes 03-20
spf lx	cisco	p4b0jfs 03-37
sfp lx	fiberxon	2w2040308084
spf lx	fiberxon	2w2040308085
sfp tx	n/a	dm7041 d/c04016
spf tx	n/a	hbcu5710r a00008505

FIBER PAIR ASSIGMENTS and Optical Loss Measurements						
	Xmit	**In**	**Out**	**Recv**	**In**	**Out**
DCS EAST	blue	-5.11	-20.3	red	-5.11	-20.3
DCS WEST	green	-5.2	-20.5	yellow	-5.2	-20.3
OBC EAST	pink			brown		
OBC WEST						

COMMENTS:

O-03 Submarine Cable & Data Reach Test - Results Sheet- Optical Test

OPTICAL TEST-Channel A				
fiber color		blue		
Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
1558.98	1h20m	10dB	0	-14.9
1555.75				
1549.32				
Attenuator on Line EDFA input			10dB	
Input into EDFA from Mux			-11.4	
Input into Cable from EDFA			+6.7	
Output returned from Cable			-14.8	

OPTICAL TEST-Channel B				
fiber color		red		
Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
1558.98	1h20m	10	0	-13.5
1555.75				
1549.32				
Attenuator on preamp EDFA output			10dB	
Input into EDFA from Cable			-17.8	
Input into Cable from Mux			-2.7	
Output from preamp EDFA+atten			-20.9	

OPTICAL TEST-Channel A				
fiber color		blue		
Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
1558.98	15h34m	10dB	0	-14.9
1555.75	15h36m	10dB	0	-6.55
1549.32	1h19m	10dB	0	-13.4
Attenuator on Line EDFA input			10dB	
Input into EDFA from Mux			-8.2	
Input into Cable from EDFA			+7.44	
Output returned from Cable			-10.6	

OPTICAL TEST-Channel B				
fiber color		red		
Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
1558.98	15h34m	10dB	0	-13.5
1555.75	15h36m	10dB	45	-14.07
1549.32	1h19m	10dB	0	-15.4
Attenuator on preamp EDFA output			10dB	
Input into EDFA from Cable			-14.2	
Input into Cable from Mux			+1.0	
Output from preamp EDFA+atten			+8.6	

COMMENTS:
First 2 tests run to verify setup only using one channel.

O-03 Submarine Cable & Data Reach Test - Results Sheet-
Electrical Test Using Converters

ELECTRICAL TEST NUMBER: 1

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
SEA	1558.98	4h32m	10	0	-15.2
	1555.75	4h29m	10	0	-16.3
	1549.32	4h29m	10	0	-13.28
SHORE	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
	1558.98	4h32m	10	0	-15.8
	1555.75	4h29m	10	0	-16.8
	1549.32	4h29m	10	0	-15.9

pre	fiber color	blue
	Attenuator on preamp EDFA output	10dB
	Input into EDFA from Cable	-14.2
	Input into Cable from Mux	+1.0
	Output from preamp EDFA+atten	+8.6
line	fiber color	red
	Attenuator on Line EDFA input	10dB
	Input into EDFA from Mux	-8.2
	Input into Cable from EDFA	+7.44
	Output returned from Cable	-10.6

ELECTRICAL TEST NUMBER: 2

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
SEA	1558.98	13h36m	10	1	-15.2
	1555.75	13h47m	10	0	-16.3
	1549.32	13h47m	10	0	-13.28
SHORE	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
	1558.98	13h36m	10	0	-15.8
	1555.75	13h47m	10	0	-16.8
	1549.32	13h47m	10	0	-15.9

pre	fiber color	yellow
	Attenuator on preamp EDFA output	0
	Input into EDFA from Cable	-12.4
	Input into Cable from Mux	+3.1
	Output from preamp EDFA	-2.9
line	fiber color	green
	Attenuator on Line EDFA input	10dB
	Input into EDFA from Mux	-8.3
	Input into Cable from EDFA	+13.7
	Output returned from Cable	-1.6

COMMENTS:
Test 2 used software to cut output of preamp:
"SA 1 O -2"
resulting in listed output of -2.3 and measured output of -2.9. Attenuator was removed
All tests were done with Ancot BER tester on channels 1555.75 and 1549.32 and CISCO Stardust on 1558.98

O-03 Submarine Cable & Data Reach Test - Results Sheet-
Electrical Test Using Converters

ELECTRICAL TEST NUMBER: 3

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
SEA	1558.98	30m	10	1	-15.2
	1555.75	30m	10	0	-16.3
	1549.32	30m	10	0	-13.28
SHORE	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
	1558.98	30m	10	0	-15.8
	1555.75	30m	10	0	-16.8
	1549.32	30m	10	0	-15.9

pre	fiber color	pink
	Attenuator on preamp EDFA output	0
	Input into EDFA from Cable	-12.24
	Input into Cable from Mux	+3.0
	Output from preamp EDFA+atten	-3.0
line	fiber color	brown
	Attenuator on Line EDFA input	10
	Input into EDFA from Mux	-8.3
	Input into Cable from EDFA	+13.6
	Output returned from Cable	-1.95

ELECTRICAL TEST NUMBER: 4

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
SEA	1558.98	30m	10	0	-15.2
	1555.75	30m	10	0	-16.3
	1549.32	30m	10	0	-13.28
SHORE	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr
	1558.98	30m	10	0	-15.8
	1555.75	30m	10	0	-16.8
	1549.32	30m	10	0	-15.9

pre	fiber color	orange
	Attenuator on preamp EDFA output	0
	Input into EDFA from Cable	-11.8
	Input into Cable from Mux	+3.0
	Output from preamp EDFA	-2.94
line	fiber color	black
	Attenuator on Line EDFA input	10
	Input into EDFA from Mux	-8.3
	Input into Cable from EDFA	+13.5
	Output returned from Cable	-1.2

COMMENTS:
Tests used software to cut output of preamp:
"SA 1 O -2"
resulting in listed output of -2.3 and measured output of -2.9. Attenuator was removed
All tests were done with Ancot BER tester on channels 1555.75 and 1549.32 and CISCO Stardust on 1558.98.
These 2 tests were done to check the 3rd and 4th pairs in the cable

O-03 Submarine Cable & Data Reach Test - Reach Tests

FOURTH TEST - OPTICAL REACH - loss -line EDFA		
1 length	Input Signal	
	Measured Output	
2 lengths	Input Signal	
	Measured Output	
3 lengths	Input Signal	
	Measured Output	
4 lengths	Input Signal	
	Measured Output	

FOURTH TEST - OPTICAL REACH - loss-pre-amp EDFA		
1 length	Input Signal	
	Measured Output	
2 lengths	Input Signal	
	Measured Output	
3 lengths	Input Signal	
	Measured Output	
4 lengths	Input Signal	
	Measured Output	

COMMENTS:
See OTDR listing from ALCATEL for optical loss measurements of fibers connected in series

O-03 Submarine Cable & Data Reach Test - Reach Tests

Reach Test Number: 1

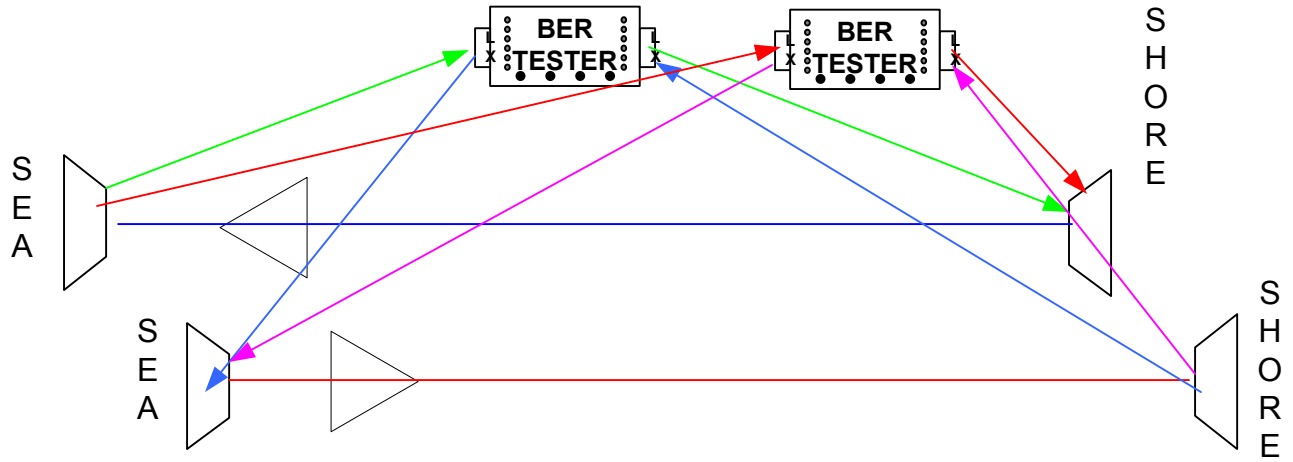
	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr	from dmx
SEA	1558.98	2h 39m	10	1	-15.2	
	1555.75		10	0	-16.3	
	1549.32		10	0	-13.28	
	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr	power into mrtr
SHORE	1558.98	2h39m	10	0	-15.8	
	1555.75		10	0	-16.8	
	1549.32		10	0	-15.9	

pre	fiber color	orange + red
	Attenuator on preamp EDFA output	0
	Input into EDFA from Cable	-27.0
	Input into Cable from Mux	3.29
	Output from preamp EDFA+atten	-2.97
line	fiber color	black + blue
	Attenuator on Line EDFA input	10
	Input into EDFA from Mux	-9.2
	Input into Cable from EDFA	13.7
	Output returned from Cable	-16.8

Reach Test Number: 1a

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr	from dmx
SEA	1558.98	18m	10	1	-15.2	-12.5
	1555.75	18m	10	0	-16.3	-12.2
	1549.32	18m	10	0	-13.28	-11.6
	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr	power into mrtr
SHORE	1558.98	18m	10	0	-15.8	-23.26
	1555.75	18m	10	0	-16.8	-24.7
	1549.32	18m	10	0	-15.9	-24.3

pre	fiber color	orange + red
	Attenuator on preamp EDFA output	0
	Input into EDFA from Cable	-27.0
	Input into Cable from Mux	3.29
	Output from preamp EDFA+atten	-2.97
line	fiber color	black + blue
	Attenuator on Line EDFA input	10
	Input into EDFA from Mux	-9.2
	Input into Cable from EDFA	13.7
	Output returned from Cable	-16.8



O-03 Submarine Cable & Data Reach Test - Reach Tests

Reach Test Number: **2**

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr	from dmx
SEA	1558.98		10		-15.2	
	1555.75		10		-16.3	
	1549.32		10		-13.28	

	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	power into mrtr	power into mrtr
SHORE	1558.98		10		-15.8	
	1555.75		10		-16.8	
	1549.32		10		-15.9	

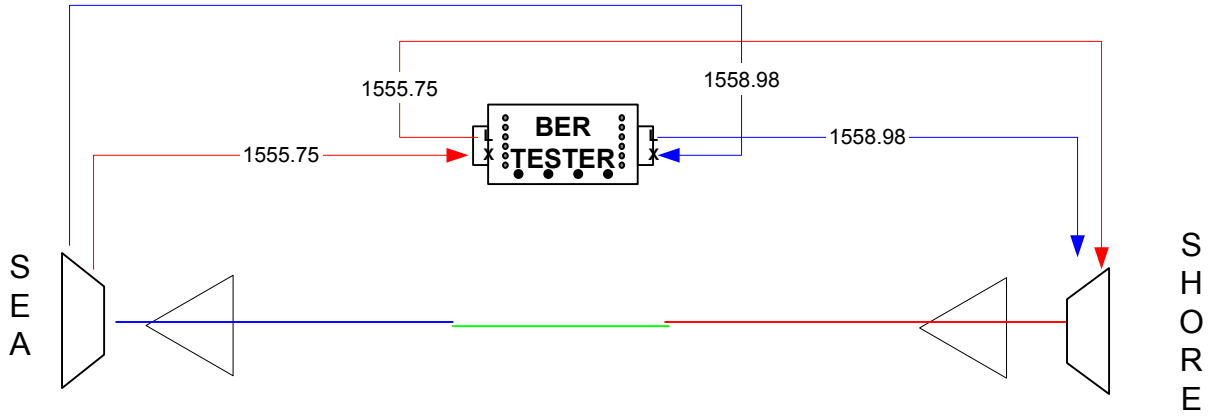
pre	fiber color	orange + red + yellow
	Attenuator on preamp EDFA output	0
	Input into EDFA from Cable	-41.8
	Input into Cable from Mux	3.18
	Output from preamp EDFA+atten	-3.06
line	fiber color	**black + blue + green**
	Attenuator on Line EDFA input	10
	Input into EDFA from Mux	-8.98
	Input into Cable from EDFA	13.6
	Output returned from Cable	-32.4

COMMENTS:
All Channels Failed - neither EDFA could reach the 200+ km distance of this (single EDFA) setup

O-03 Submarine Cable & Data Reach Test - Reach Tests with DUAL EDFA

	Dual EDFA Test Number:	1			
SEA	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	from dmx
	1558.98	15m	n/a	0	-8.8
	1555.75	15m	n/a	0	-8.4
pre	fiber color				orange + red
	Attenuator on preamp EDFA output				0
	Input into EDFA from Cable				-17.83
	Output from preamp EDFA+atten				-2.9
line	Attenuator on Line EDFA input				10
	Input into EDFA from Mux				-11.27
	Input into Cable from EDFA				+13.6

	Dual EDFA Test Number:	2			
SEA	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	from dmx
	1558.98	11h14m	n/a	1	-8.8
	1555.75	11h14m	n/a	0	-8.4
pre	fiber color				orange + red + black
	Attenuator on preamp EDFA output				0
	Input into EDFA from Cable				-32.5
	Output from preamp EDFA+atten				-2.9
line	Attenuator on Line EDFA input				10
	Input into EDFA from Mux				-11.27
	Input into Cable from EDFA				+13.6

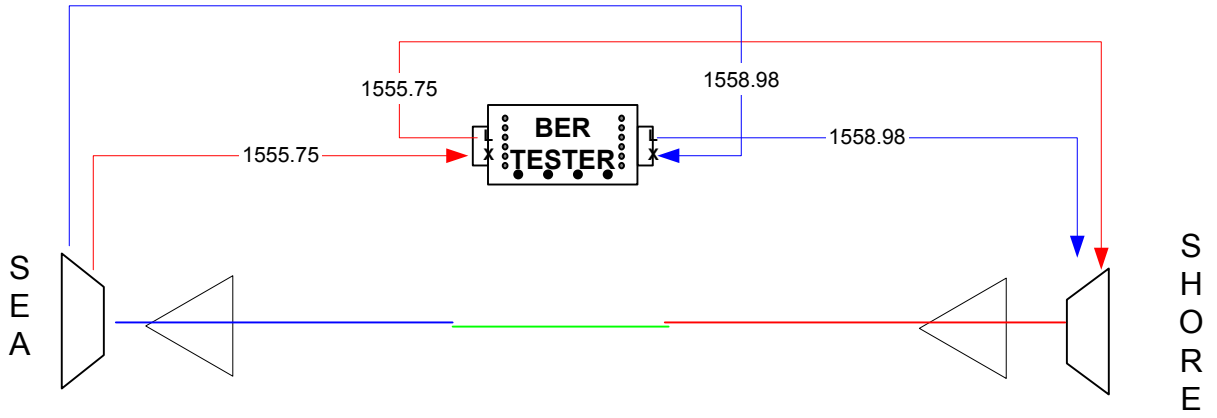


COMMENTS:
Tests were performed with the following SFPs: 2W2040308085 and P4BDJFS03-37
BER tests were ANCOT type CJT for shore wavelength bit patterns.

O-03 Submarine Cable & Data Reach Test - Reach Tests with DUAL EDFA

	Dual EDFA Test Number:	3			
SEA	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	from dmx
	1558.98	15m	n/a	0	-8.8
	1555.75	15m	n/a	0	-8.4
pre	fiber color				orange + red
	Attenuator on preamp EDFA output				0
	Input into EDFA from Cable				-17.83
	Output from preamp EDFA+atten				-2.9
line	Attenuator on Line EDFA input				10
	Input into EDFA from Mux				-11.27
	Input into Cable from EDFA				+13.6

	Dual EDFA Test Number:	4			
SEA	Xpondr	Duration	MRTR Rcv Attenuation	# Errrors	from dmx
	1558.98	15m	n/a	0	-8.8
	1555.75	15m	n/a	0	-8.4
pre	fiber color				orange + red + black
	Attenuator on preamp EDFA output				0
	Input into EDFA from Cable				-32.5
	Output from preamp EDFA+atten				-2.9
line	Attenuator on Line EDFA input				10
	Input into EDFA from Mux				-11.27
	Input into Cable from EDFA				+13.6



COMMENTS:
Repeat of prior test with different BIT patterns as follows:
Test 3 - ANCOT CD patterm for long wavelength BIT pattern
Test 4 - ANCOT CS patterm for mid wavelength BIT pattern simulating power supply noise