Schedule A
(Part – II)

USF Telecommunications Networks and Services Project, "Fiber Optic Connectivity up to Tehsil Level"

Technical Specifications/Rev.1/September 09

A. Optical Fibre Cable Specifications

1. Introduction

This specification covers the minimum standards and requirements for the optical fiber cables to be used in the USF telecommunications networks of Pakistan .The F.O cable shall be direct buried type, aerial cable type or hauled into ducts type as may be determined after survey by the Bidder and its characteristics shall be compatible with the existing F. O cables in the network.

2. Definitions

Definitions applied throughout this specification are as follow: -

i) "Fiber"
The drawn coated optical fiber

ii) "Primary Coating"
The first layer of inert material applied to the fiber immediately after being drawn from a perform and can be readily removed for splicing purpose without damage to the fiber.

iii) "Strength Member"
The component of the assembled cable which is designed to provide sufficient strength to the cable to ensure that the fibers are not strained beyond their permissible limits

iv) "Wrapping"
Non-metallic barrier tape, which surrounds the cable core

v) "Fiber Core"
The central region of the optical fiber through which most of the optical power is transmitted.

vi) "Cladding"
The dielectric material of an optical fiber surrounding the core with a different refractive index from core

vii) "Non-Circularity of the Cladding Surface"
The difference between the maximum cladding surface diameter (Dmax) and minimum cladding surface diameter (Dmin) divided by the nominal cladding diameter (D).

viii) "Core / Cladding Concentricity Error"
The distance between the core centre and the cladding centre divided by the core diameter

ix) "Refractive Index Profile"
The distribution of the refractive index along the diameter of an optical fiber

x) "Attenuation Coefficient"
It is the attenuation of the fiber per unit length. It is expressed in dB/Km.

xi) "Chromatic Dispersion"

The spreading of light pulse per unit source spectrum width in optical fiber caused by the different group velocities of different wavelengths composing the source spectrum

xii) "Cutoff Wavelength"
The cutoff wavelength is the wavelength at which the mode ceases to propagate in the fiber.

xiii) "Chromatic Dispersion Coefficient"
The Chromatic dispersion per unit source spectrum width and unit length of fiber, it is expressed in ps/nm.km.

xiv) "Zero Dispersion Wavelength"
The wavelength at which the chromatic dispersion vanishes

xv) "Zero Dispersion Slope"
The slope of the chromatic dispersion coefficient versus wavelength curve at zero dispersion wavelengths

xvi) "Polarization Mode Dispersion (PMD) "
Dispersion of an optical signal due to the different polarizations of light traveling at different speeds through optical fiber

3. Optical Fiber Cables

a) All optical fibers shall maintain their geometrical properties for the required life, 25 years of the cable.
b) The value of the mode field diameter shall be within 8.6-9.5 um. The mode field diameter deviation shall not exceed ±0.7μm.
c) The mode field concentricity error shall not be more than 1.0 μm.
d) The cladding diameter shall be 125 ± 1μm.
e) The cladding non-circularity shall not exceed 2.0%.
f) Core/clad concentricity error shall not exceed 0.8μm.
g) Macro bending loss shall be measured by forming 100 turns of fiber on a mandrel of 75mm diameter. The attenuation increase shall not exceed 0.5 dB at 1550 nm.
h) The minimum bending radius shall not be less than 10-12 times outer diameter of the cable
i) No jointed fibers are allowed in cable according to this specification.
j) The diameter of the coating shall be 250 ± 15 μm.
k) Fiber optic cable shall be supplied in nominal lengths of four (4) km
l) The splice loss of 0.02dB for SM is desirable however; maximum value of splice loss shall not exceed 0.05 dB for SM fiber.
m) The Optical Fiber Cable shall qualify International test standards for Tensile Test, Temperature Cycling Test, Crush Strength Test, Impact Test ,Repeated Bending Test and Torsion Test

4. Optical Transmission Requirements

i) Optical Attenuation Properties

The attenuation properties of the optical fibers shall conform to the following values specified below.

Design Parameter	Maximum Values at room temperature
Wavelength of Light (nm)	1285-1330 1310 1550
Attenuation for individual Fibers (dB/km)	≤ 0.4 ≤ 0.38 ≤ 0.25
Average attenuation for the Cable (dB/km)	≤ 0.38 ≤ 0.35 ≤ 0.21

ii) Cutoff Wavelength

The F.O Cable cutoff wavelength shall not exceed 1260 nm.

iii) Chromatic Dispersion

Chromatic dispersion shall not exceed 3.5 ps/nm.km between 1285 nm and 1330 nm and 18 ps/nm.km at 1550 nm.

iv) Attenuation Uniformity

The attenuation of the fiber shall be distributed uniformly along the fiber length such that there are no localized discontinuities in excess of 0.1 dB at any of the design wavelengths.

v) Polarization Mode Dispersion

Polarization mode dispersion (PMD) coefficient of cable shall not exceed 0.5ps/√km for an electrical regeneration section of 400 km of installed fiber. Differential Group Delay (DGD) shall not exceed 10ps for a maximum section length of 640 km.

B. Optical Fibre Cable Laying Specifications

1. Introduction

This specifies the technical parameters for laying or installation of Optical Fiber Cable in USF defined areas of Pakistan as stated in Schedule C to SSA.

2. Scope of Work

This covers laying of O.F cable as direct buried or ducted or as aerial installation as the case may be, including all civil works, in different terrains throughout the defined USF areas. The provision of sand, bricks, PVC pipes / HDPE pipes /or equivalent , GI pipes sub ducted with PVC/ HDPE pipes /or equivalent, bridge attachments, cement, slabs, route indicators, Posts, accessories and materials, cable trays, machinery, transport ,Joint enclosures, ROW and test equipment etc shall be the responsibility of the USF Service provider. In city areas the underground duct system shall be built with necessary hand holes for the laying of OFC. In hilly areas or other locations not suitable for direct buried or ducted type F.O cables, aerial fiber optic cable may be used with proper and secure installations. The Fiber optic cable routes have been defined in Schedule C to SSA for implementation.

3. Direct Buried Optical Fiber Cable

a. Cable section lengths must allow for looping the cable at splice closure locations.
b. Care should be taken to ensure that cable attachment systems are specifically designed for optical fiber cable and do not transmit stress to the fiber
c. Care is required to counter cable movement in steep approach sections or vertical sections. This type of movement which can be produced by traffic vibrations could lead to excessive fiber strain and suitable cable restraints should be used
d. Where a trench method is used, back filling materials and practices may require particular consideration so that fiber strain limits are not reached during this operation.

3.1 Excavation of Trench

3.1.1 The trench shall be excavated to a depth of 1.5m except rocky areas; the trench shall be graded to enable the cable to be laid on an even plain. The width of the trench shall be 40cm at the top and 35-40cm at the bed. The depth reference for the trench shall be taken from the road surface or the normal earth surface level which one is lower.

3.1.2 A bed of sand 10 cm deep shall be laid along the bottom of the trench and cable shall be placed at the centre of trench.

3.1.3 A sand bed 10 cm deep shall be provided above the cable.

3.1.4 Bricks shall be placed transversally on the cable with no space between the bricks. See Fig.1

Note: All dimensions are in cm.

Fig.1. Direct Buried Cable

3.2 Standing Water Area

There will be locations where still water ponds fall along the trench alignment. In such area, the following procedure shall be followed.

3.2.1 If the height of water is 1 meter or above and is not seasonal water but permanent then cable shall be laid directly on the surface of the earth and slabs with cement sand ratio 1:8 (100x50x20cm bag size) shall be placed longitudinally. See Fig.2

Fig.2. Sand-Cement Bags

3.3 Rocky Soil

3.3.1 In rocky area, the trench depth shall be 110 cm, width 40 cm at the top and 35-40 cm at the bed with all the sharp edges of rock removed. Sand cushion 20cm thick above and below the cable shall be provided. Bricks shall be placed as in the case of normal soil. See Fig.3

Note: All dimensions are in cm.

Fig.3 Direct Buried Cable in Rocky Area

3.3.2 There will be situations where it is not practical to excavate in extremely hard rock to a depth of 1.1 meter. For such areas, the depth of the trench may be kept as 90 cm including 10 cm concreting at the top.

3.4 GI Pipe sub ducted with PVC/HDPE or equivalent

Throughout the execution of the project GI pipe sub-ducted with PVC pipe / HDPE or equivalent shall be installed on bridges, culverts that require attachments, under rivers, railway lines, highways, canals, rain washable area, and heavy traffic passing area e.g. Petrol pumps etc, In all three cases the minimum separation between the existing service and the Optical fiber Cable shall be 100cm. Under no circumstances the cable shall be installed above an existing service.

3.5 Warning Tape

A suitable yellow PVC tape 0.5 mm thick and 100 mm wide shall be placed 30 cm above the installed optical fiber cable for indication to the excavators of the presence of optical fiber cable with some warning note.

3.6 Route Indicators

Route markers are to be installed along the cable route at locations visible from the previous marker or 100 meters apart and at turning points where cable route changes direction.

3.7 Cable Joint Pit Markers

Cable Joint Pit markers are to be installed at all joint pit locations. It is important that all locations of joint pits are recorded and have a reference location measurement.

3.8 Slabs (50X30X10CM AND 100X30X10CM)

The slab of 50x30x10cm shall be used in a joint pit. The slab of 100x30x10 cm shall be used along the route at small culverts, loops at the bridges and over cable laid along places where there could be damage to the cable.

4. Ducted Optical Fiber Cable

FO cable shall be laid in ducts with two inches diameter, 2 way PVC pipes **/HDPE or equivalent** along with appropriate HHs. Minimum wall thickness shall not be less than 3.5mm.

On completion of the duct line between any two jointing chambers, a cylindrical brush and an iron test mandrel shall be passed once through each way to test the duct and remove any foreign matter which may have entered. Pressure testing for duct ways shall be carried out. After the last joint has been completed in each way, pressure plugs shall be inserted at each end and tightened.

Section 3 to this Technical Specifications report lists direct buried cable laying specifications. Same specifications, except the bricks arrangement, shall be followed for Duct laying. In areas which may be considered as sandy areas, use of sand may not be necessary for laying of ducts. A careful study shall be carried out for the laying of ducts to determine the use of sand & bricks wherever necessary.

5. Aerial Fiber Optic Cable

The fiber optic cable is a high capacity transmission medium which can have its transmission characteristics degraded when subjected to excessive pulling force, sharp bends, and crushing forces. These losses may not be revealed until long after installation is complete. For these reasons extra care must be taken during the entire installation procedure.

The following information shall be used as a basic guideline for the installation of aerial fiber optic cable. It is for the personnel having prior experience in the planning, engineering, or placement of aerial cables as this does not cover all aspects of fiber optic aerial cable placement.

1. A self-supporting fiber optic cable includes messenger and carrier sections and at least one interconnecting web.

2. In order to protect the optical fiber from tensile forces and to facilitate mid-span access, the carrier section can have an over length and includes a strength member.
3. A site survey of the entire route should be performed before cable placement begins. The survey will verify construction methods, special tools required and splice locations. The characteristics of the ground along the route, trees or other obstructions shall be noted. Clearance issues over roadways, driveways, etc. need to be taken into account before cable placement begins. It will also qualify the condition and size of the existing poles to be used, the condition and size of the existing pole's anchors and reveal the need for any new poles before placement operations begins.
4. Safety cones, signs, flags, etc., should be used to channel traffic where required.
5. The fiber optic cables should occupy the uppermost available communications space on a pole, wherever possible, due to having less weight and sag than copper cables.
6. Sufficient clearances must be maintained between fiber optic cables and electrical power cables on joint-use poles, as per Electrical Safety Codes. The minimum clearance shall be one meter.
7. Splice locations shall be chosen to allow for the longest possible continuous cable spans and a minimum number of splices.
8. During cable installation, special care should be taken to not violate the minimum cable bend radius or maximum rated cable tensile load. For standard loose tube cable designs the minimum bend radius under dynamic conditions (during installation) is 15 times the cable outer diameter. The minimum bend radius under static conditions (installed) is 10 times the cable outer diameter.
9. Aerial installation should never be done in wet conditions.
10. Fiber optic cables (including all dielectric cables) shall be properly grounded when installed in the vicinity of high-voltage power cables.
11. Each jelly filled tube may contains 4 -12 fibers. Solid or stranded steel coated with polyethylene may be used as central strength member. Fiber glass reinforced plastics (FRP) may be used as central strength member if non metallic construction is required. Either aramid yarn or fiber glass shall be wound around the tube to provide physical protection and tensile strength.
12. Water blocking materials shall be filled in the interstice of the cable core, core wrapping layer/water blocking tape.
13. The un-armored type of aerial fiber optic cable is given below: The armored type normally have steel armor instead of aluminum tape beneath outer jacket.

Unarmoured Type

14. As fiber optic cables have to be pulled into place through ducts (outdoor) or conduits (indoor), pulling eyes are to be attached to the strength members or cable outer jackets.
15. Cable structures shall protect fibers from moisture (outdoor cables), extreme temperature (aerial cables) and influx of hydrogen into the fiber.
16. The temperature range during installation and operation shall be as follows:
    - Installation: -30°C to +60°C • Operating: -40°C to +70°C
17. The amount of sag is dictated by clearance and tension requirements. The maximum sag shall be as follows:
    - Installation: 1 % of pole to pole distance (span length)
    - Long term installed: 3 % of pole to pole distance (span length)
18. Some extra cable may be left at the beginning and at the end of the cable run. Also, extra cable should be placed at strategic points such as junction boxes, splice cases and cable vaults. Extra cable is useful should cable repair or mid-span entry be required.
19. The cable maximum pulling tension is not to be exceeded during cable installation. In general, most cables designed for outdoor use have a strength rating of at least 600 lbs. After cable placement is complete the residual tension on the cable should be less than this value.
20. Use the method of attachment that pulls most directly on the strength material—without stressing the fiber. With indirect attachment, pulling forces are distributed over the outer portion of the cable structure.
21. The leading end of the cable should be sealed to prevent intrusion of water or other foreign material while pulling.
22. Installation procedures for open placement of fiber optic cables are the same as for electrical cables. Care should be taken to avoid sudden, excessive force so as not to violate tensile load and radius limits. Sharp bending and scraping at entrances and covers should be avoided.
23. Proper installation standards shall be followed.

C. Fibre Optic Line and Multiplexing Equipment

1. General

i. The Fibre Optic Line and Multiplexer Equipment shall comply with all relevant latest ITU-T / ETSI recommendations.

ii. The minimum capacity of the Fibre Optic Line and Multiplexing Equipment for each F.O Link shall be designed as specified in the Schedule A and C to SSA so as

to meet the minimum traffic matrix (bandwidth) requirements specified in the Schedule B to SSA.

iii. All equipment supplied shall be new and the manufacturer's latest generation of production equipment.

iv. The operation and maintenance functions of F.O transmission equipment shall be manageable through LCT and NMS for which all necessary interfaces and features shall be provided.

v. The engineering order wire shall be provided at all ADM and terminal locations

vi. The Fibre Optic equipment shall be upgradeable to higher level with out any major changes .

vii. The Fibre Optic equipment shall be compatible and integrate smoothly with the existing F.O Equipments in the network.

viii. The configuration of F.O system shall be quite flexible as Terminal or ADM.

ix. The protection of equipment level shall be realized by the redundancy hot swap protection for the units such as electrical interface, timing and cross-connection.

x. The synchronization features in equipment shall conform to the ITU latest standards.

xi. The Jitter and Wander characteristics shall conform to ITU latest standards.

xii. The System supplied shall support the Next Generation Features

xiii. It shall operate at a wavelength of either 1310nm or 1550nm and shall be compatible with FO cable of this project.

xiv. An automatic laser shutdown function shall be provided to switch the laser off in case of a break in the optical path.

xv. It shall have capability for direct inter-working with DWDM equipment without intermediate wavelength adapters.

2. Interfaces

Following interfaces shall be supported by the F.O equipment corresponding to the capacities designed for the network and as applicable in compliance to latest ITU recommendations.

i) 2 Mb/s Electrical Interface
ii) 34 Mb/s Electrical Interface
iii) 45 Mb/s Electrical Interface
iv) 140 Mbit/s electrical interfaces
v) 155 Mbit/s electrical interface
vi) Optical Interface, 155.520 Mbit/s.
vii) STM-4 Optical Interface,
viii) STM-16 Optical Interface,

2.1 Ethernet Interface

The offered equipment shall support the Fast Ethernet. It shall also be able to provide related technologies like Gigabit Ethernet, Resilient Packet Ring (RPR), Generic Framing Protocol (GFP), Virtual Concatenation (VCAT) and LCAS (Link Capacity Adjustment).

2.2 Auxiliary Interfaces

Several data interfaces shall be available as follows:

2.2.1 Minimum 1 x 2-wire analogue telephone interface, providing multiplex section order-wire communication at 64 Kb/s co-directional and telephone jack.

2.2.2 Minimum 4 x 64 Kbit/s co-directional data interfaces in compliance with ITU-T Rec. G.703 + 2 x 2 Mbit/s G.703 + 4 x RS-232 + 4 x V11 async.

2.2.3. Synchronization Interface : Clock input / output interface

2.2.4 D1~D3 and D4~D12 for network management.

2.3 Synchronization Interface, 2048 KHz

The electrical characteristics of the input and output of the 2048 kHz clock synchronization interface shall conform to latest ITU-T Rec. with impedance of 75 ohm unbalanced or 120 ohm balanced.

2.4 G.703 64 Kbit/S Data Channel Interface (Auxiliary Channel)

The electrical characteristics of the G.703 64 kbit/s interface shall conform to ITU-T Rec. G.703

2.5 13.8V.11 64 Kbit/S Data Channel Interface (Auxiliary Channel)

The electrical characteristics of the V.11, 64 kbit/s interface shall conform to the specifications given in ITU-T Rec. V.11.

3. Functional Characteristics

a) The aggregate interface unit shall support MSP, BSHR and SNCP configurations.

b) The LINE SYSTEM shall provide 140 Mbit/s, 155 Mbit/s (STM-1) electrical and 622 Mbit/s (STM-4) and 2.5 Gbit/s (STM-16) optical tributary interfaces.

c) The matrix switching shall be non-blocking for all connection types. The maximum tributary capacity can be divided into four separate tributary groups. Full trib-trib connectivity shall be available within the same tributary group. The cross-connect matrix units shall support (1+1) protected configuration.

d) The synchronization interface shall provide 2048 kHz clock input and output at 120 ohms and 75 ohm. The unit shall support 1+1 protected configuration and shall provide the following facilities and functions:

e) The synchronization unit shall enable the Line System to be synchronized from any one of the following sources:

i) 2048 kHz sine or pulse external clock source (e.g. station clock). Any STM-1 (155.520 Mbit/s) tributary signal
ii) Any STM-4 (622.080 Mbit/s) tributary signal
iii) Any STM-16 (2,488.320 Mbit/s) tributary signal
iv) Internal clock oscillator (free-running mode).

f) Access to a 64 kbit/s G.703 or V.11 data channel using byte F1 in the regenerator section overhead (RSOH) shall be available on the Line System.

g) The Line System shall have a controller unit that shall be responsible for the management of the Line System. This unit shall also include the management via the F and Q-interfaces.

h) It shall be possible to perform full remote configuration and control of any Optical Line Equipment connected to the local Optical Line Equipment using the Embedded Control Channel (ECC) of either optical aggregate. Remote operation of the system via a serial link by using a modem, or via an Ethernet link shall also be possible.

4. System Configurations

The following system configurations must be supported by the Line System:

i) Terminal Multiplexer Mode
ii) Add-Drop Multiplexer Mode
iii) Regenerator Mode

5. System Applications

The Line System shall be used in the following applications:

i) Point-To-Point
ii) Chain Topology
iii) Ring Topology

6. Protection Switching

i) Multiplexer section protection switching
ii) Sub-Network Connection Protection (SNC/P
iii) Bi-directional Self Healing Ring (BSHR) Protection

7. Disaster Recovery

The equipment shall have built-in recovery mechanisms to enable it to become operational in as short a time as possible following unforeseen failures, and in particular the following characteristics:

8. Clock Reference

a) The synchronization subsystem should provide the timing reference required by all components in the network element. It should accept synchronization inputs from a number of sources:

(i) STM-N lines
(ii) 2 Mb/s traffic ports
(iii) 2 MHz / 2 Mbit/s external input
(iv) internal oscillator

b) Automatic selection of one of such sources shall be achieved by using priority criteria. Also manual selection shall be possible.

D. Network Management System (NMS).

The NMS shall support management functions according to the latest relevant ITU-T Rec.

a) The NMS shall be able to manage Multiplexes, Line Equipment Terminals and ADM.

b) The NMS shall support ring, multi-ring, chain, point-to-point, mesh and complex topologies.

c) Cross connection management function shall be supported by the NMS.

d) NMS shall support protection criteria/procedure for the port connection and paths in the network.

e) If the USF Service provider has the existing NMS , that can be up graded to manage the F .O equipment of this project.

f) The necessary hard ware , soft ware , data channels for the connectivity and commissioning of NMS with NEs is included.

g) The NMS shall perform the Performance Management, Fault Management, Configuration management and Security management.

h) This management function shall provide reports and evaluation for communication equipment status. The performance management shall have functions like Performance Data Period, Performance Event Selection, Performance Monitoring, Performance Query, Performance Threshold Setting, Performance Analysis, Performance Reporting and Database Management

i) The NMS shall provide the capability to monitor all transmission facilities in real time.

j) The NMS shall provide functions for the remote control and configuration of Fiber Optic equipment according to the latest relevant ITU-T Rec.

k) NMS shall support and provides the functionalities to set up, initialize and modify the Fibre Optic equipment configuration parameters.

l) The NMS shall support the management functions for the configuration and initialization of the F.O equipment and cards in the Network Elements .

m) NMS shall provide the security management function to prevent network resources and equipment from unauthorized user's access

n) The NMS supplied shall be fully compatible with the Central Network Operations Center (NoC) and fully support all the relevant protocols .

E. Key Performance Parameters for Fibre Optic Cable

The USFCo Technical Auditor may perform sample testing of the following tests of Optical Fiber cable and OSP for confirming compliance to the relevant technical specifications.

(i) Insertion Loss Test

Section: _____A-End: _____

B-End: _____

Fibre No:	1310/1550nm		A	1310/1550nm		B	Average Loss (A+B)/2
	TX (dB)	RX (db)	Section Loss (dB)	TX (dB)	RX (dB)	Section Loss (dB)	

Requirements:	1550nm	1310nm
Cable Attenuation per km (dB):	≤0.25	≤0.38
Average Attenuation (dB):	≤0.21	≤0.35
Maximum Splice Loss (dB)	≤0.05	≤ 0.05
Maximum Connector Loss (dB)	≤0.5	≤0.5
Total Number of Connectors:		
Total Section Loss (dB):		

(ii) Fiber Optic Cable Test Data Sheet
(End to End Test with OTDR)

Route:

Total Optic Fiber Length (km):

Wavelength (nm):

Fiber No.	Fiber Color	From	To	Total Loss	Average Loss (db)

CIVIL WORKS

Section Name: _____

The civil works executed for the laying of Optical Fiber Cable shall be inspected for sample testing by the USF Technical Auditor to verify compliance to relevant Technical Specifications.

Cable Length	From:	To:	Remarks

AERIAL WORKS

The works executed for the installation of aerial Optical Fiber Cable shall be inspected for sample testing by the USF Technical Auditor to verify compliance to relevant Technical Specifications.

F. Key Performance Parameters for Fibre Optic Equipment

The USFCo Technical Auditor may conduct sample testing of the tests performed during commissioning in addition but not limited to the following tests to verify the performance of the fiber optic equipment.

S.#	Description of Item	Accepted Standard	Remarks
1	**Protection Switching** (While removing the active Cross switch board, the standby board will take over the service automatically)	Switching time < 50 ms	
2	15-Minute Bit Error Performance for E1 or E3	No bit error is detected	
3	**24 hours BER Test**	<10^-10 bit errors	