



APPLIED OPTOELECTRONICS CENTRE

Test Equipment and Measurements



Overview

- **Types of instrument**
- **Optical power measurement**
- **Other fibre instruments**
- **Optical time domain reflectometers**



Optical Fibre Test and Measurement Overview



Optical Test and Measurement

Optical measurements takes place at a variety of levels

- **Design & research laboratories**
- **Production and manufacture**
- **Component characterisation**
- **Network test and measurement**
- **Network performance monitoring**
- **Transmission characterisation**



Optical Test and Measurement Equipment

Wide variety of equipment is in use.....

- **Optical source and power meter**
- **Optical test set (source and power meter combined)**
- **Optical Time Domain Reflectometer**
- **Optical spectrum analyser**
- **Optical waveform analyser/optical oscilloscope**
- **Dispersion analyser**
- **Polarization mode dispersion analyser**
- **Optical return loss test sets**
- **Fibre talk sets**
- **Connector inspection microscopes**



Instruments for Optical Fibre Systems

- ***Optical source***
- ***Optical power meter***
- ***Talk-set***
- ***Live fibre detector***
- ***Optical test set (source and power meter combined)***
- ***Optical Time Domain Reflectometer***
- **Optical spectrum analyser/monochromator**
- **Optical waveform analyser/optical oscilloscope**
- **Dispersion analyser**
- **Polarization mode dispersion analyser**
- **Optical return loss test sets**
- **Connector inspection microscopes**

Typically used
in most fibre
systems



APPLIED OPTOELECTRONICS CENTRE

Optical Network T&M Challenges



Endangered Species....

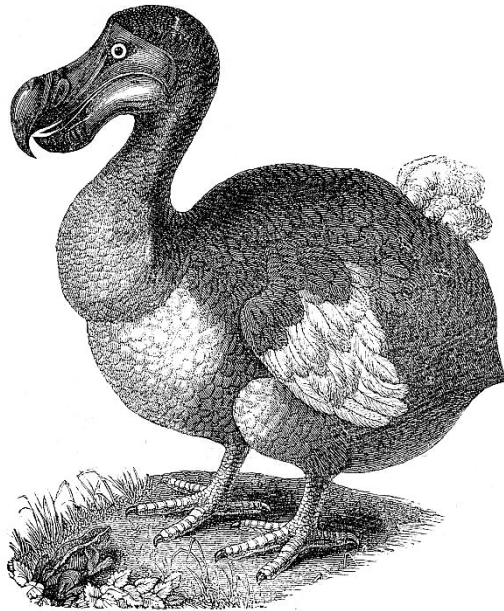


Fig. 1795. — Dodo.

- **Single channel/wavelength measurements...**
- **Attenuation as the main concern...**
- **Responding after faults occur...**
- **Reporting with pen and paper...**



Future Challenges

Optical network measurement challenges:

- **Multiple channels / wavelengths**
- **A variety of new parameters to measure**
- **Must be completed quickly**
- **May need to be carried out remotely**
- **Will require a high degree of automation**
- **High optical power levels > +20 dBm**
- **Extensive data reporting/recording abilities**



LAN Attenuation Test Requirements



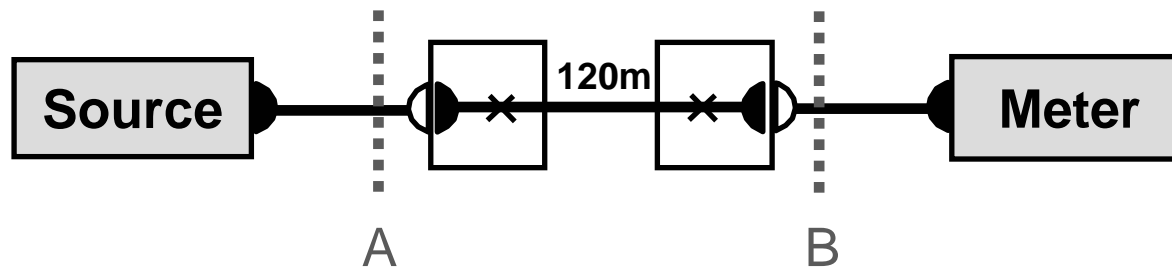
Test Requirements within TIA/EIA-568-A

- **Attenuation testing is the only required test for fibre in TIA/EIA-568-A**
- **Attenuation tests need to be carried out and documented for:**
 - f* **All patchpanel-to-patchpanel fibres in a system**
 - f* **Permanent patchcords**
- **Maximum attenuation limits for measured attenuation should be provided to installers**
- **Maximum limits can be worked out from TIA/EIA-568-A**
- **Testing is carried using:**
 - f* **An optical source/power meter combination**
 - f* **An Optical-Time-Domain-Reflectometer (OTDR)**



Specifying Maximum Limits on Attenuation

120 m patchpanel to patchpanel fibre under test



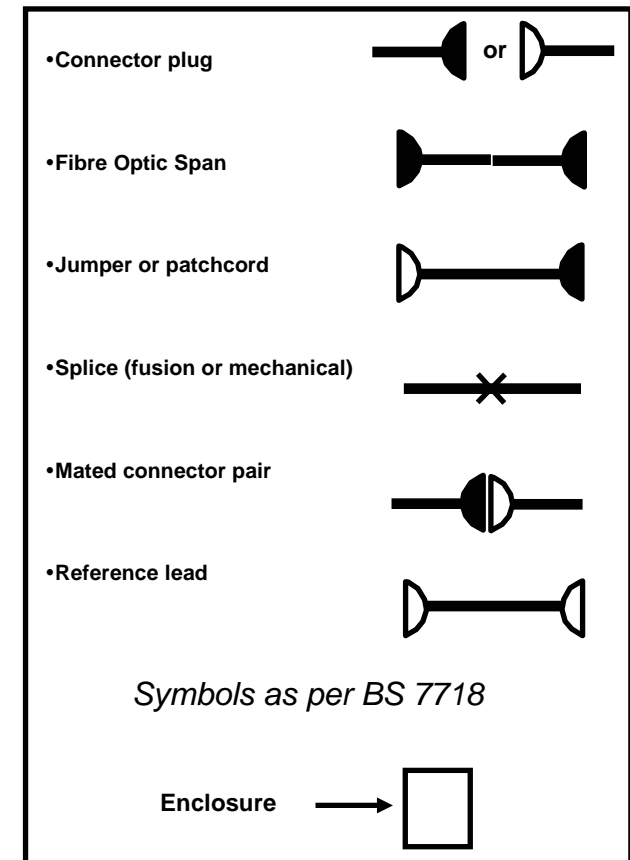
Maximum limit on attenuation between points A and B for multimode fibre at 1320 nm as per TIA/EIA-568-A is:

2 mated connector pairs @ 0.75 dB each = 1.5 dB

2 splices @ 0.3 dB each = 0.6 dB

120 m fibre @ 1.5 dB/km = 0.18 dB

Total = 2.28 dB





Typical Instrumentation for Attenuation Measurements

- Typical power meter and OTDR shown
- Measurements are wavelength specific
- OTDR is more accurate, gives more information and can be used to detect faults and other problems
- OTDR is more expensive and can be more difficult to use



OTDR



Power meter

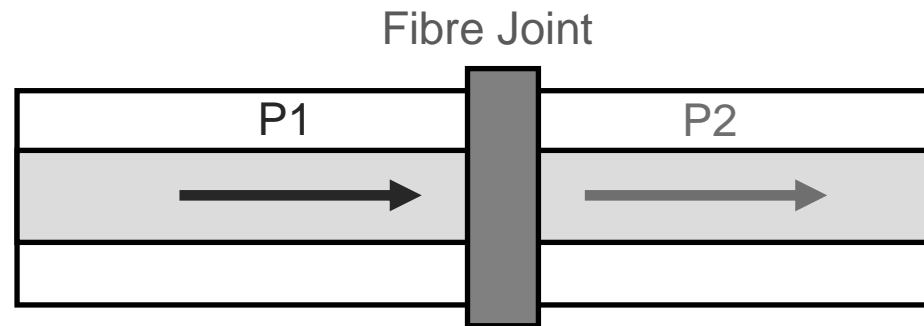


Attenuation / Insertion Loss Measurement



Attenuation (Insertion Loss)

- Most common measurement
- Correctly referred to as "attenuation" but also called "insertion loss"
- Carried out using a source and power meter combination
- Value is in dB
- Typical attenuation for a mated pair of optical connectors is 0.35 dB



$$\text{Insertion Loss in dB} = -10 \log_{10} \left(\frac{P_2}{P_1} \right)$$

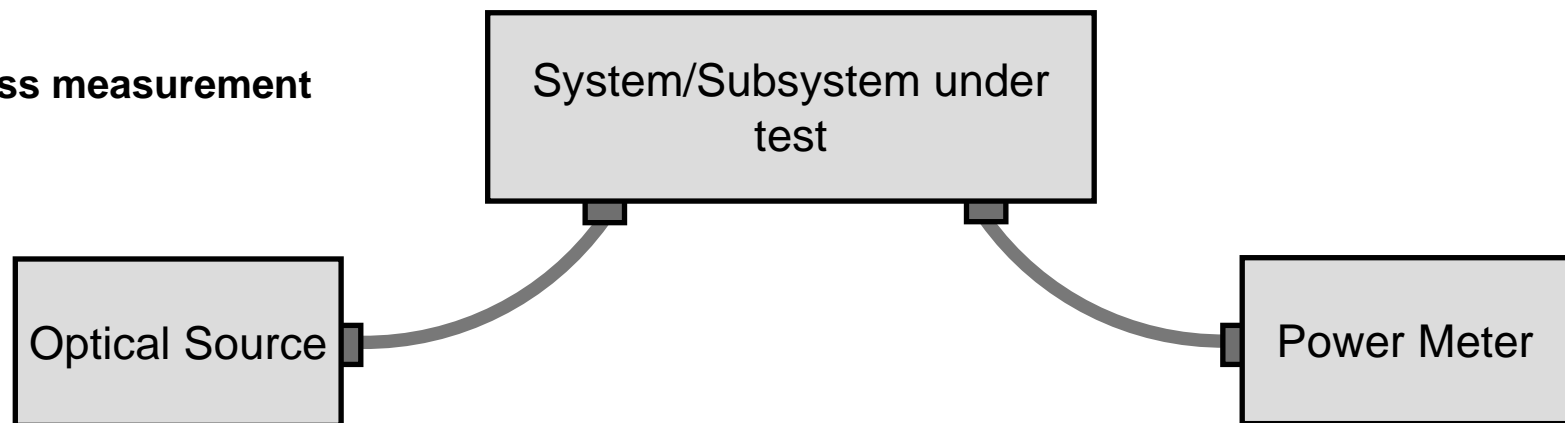


Optical Power and Loss Testing for Systems

Optical power and loss testing is used to:

- Determine if the output power of a transmitter is as specified
 - To measure the output power of a fibre just prior to a receiver
 - To determine the loss in a length of fibre
 - To measure the loss in a device or component
 - To measure the loss between two patchpanels
-

Loss measurement



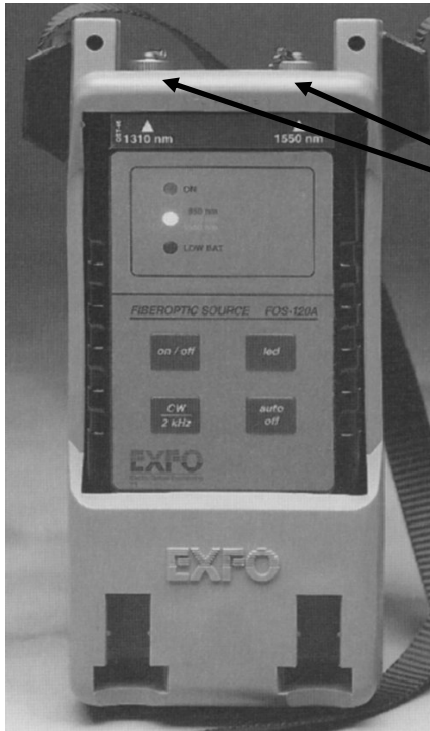


Portable Optical Sources

- Optical sources or light sources are used to provide a stable source of light for loss test purposes.
- Typically handheld devices with common connector adapters (ST, FC/PC, SC etc..)
- LED and Laser based units available
 - f* LED units operate circa 850 nm and 1310 nm with typical power outputs of -20 dBm (50/125 fibre)
 - f* Laser units operate circa 1310 nm and/or 1550 nm with typical power outputs of -7 dBm (9/125 fibre)
 - f* Some LED units can be used with singlemode fibre, very low power though (-36 dBm typ)
- Modulation with a tone (normally 2 kHz) is provided for use with live fibre detectors
- Units available from Megger, Exfo, Laser Precision, Noyes etc..



Typical Portable Optical Sources



Output
connectors



Exfo FOS-120A series LED based

850 or 1310 or 1550 nm

Dual wavelength available (1310/1550 nm)

Output power -20 dBm into 50/125 micron fibre

Stable to within 0.08 dB over 1 hour

Exfo FOS-130A series Laser based

1310 or 1550 nm only

Dual wavelength available (1310/1550 nm)

Output power -7 dBm into all fibre types

Stable to within 0.08 dB over 1 hour



Typical Portable Power Meter

- Calibrated at 850 nm, 1300 nm and 1550 nm
- Measurements in microwatts, dBm and dBr (relative dB)
- Range +3dBm to -50 dBm (0.001 microwatts)
- 0.1 dB resolution
- Wide range of adapters including ST, FC/PC and SC
- 9V battery powered
- More sophisticated units have a larger number of calibrated wavelengths





Typical High-end Production Light Source

- Wavelength options available, with LED and Laser sources
- Output level using laser option is -3 dBm +/- 1 dBm
- Variable attenuation 0-6 dB in 0.01 dB steps
- Short term stability better than 0.02 dB
- Wide range of adapters including ST, FC/PC and SC

Anritsu
MG9001A
Stabilised
Optical Light
Source





Typical Production Power Meter

- Wavelength range options available as different "sensor heads"
- Measurements in microwatts, dBm and dBr (relative dB)
- Range +10 dBm to -70 dBm
- 0.01 dB resolution
- Wide range of adapters including ST, FC/PC and SC

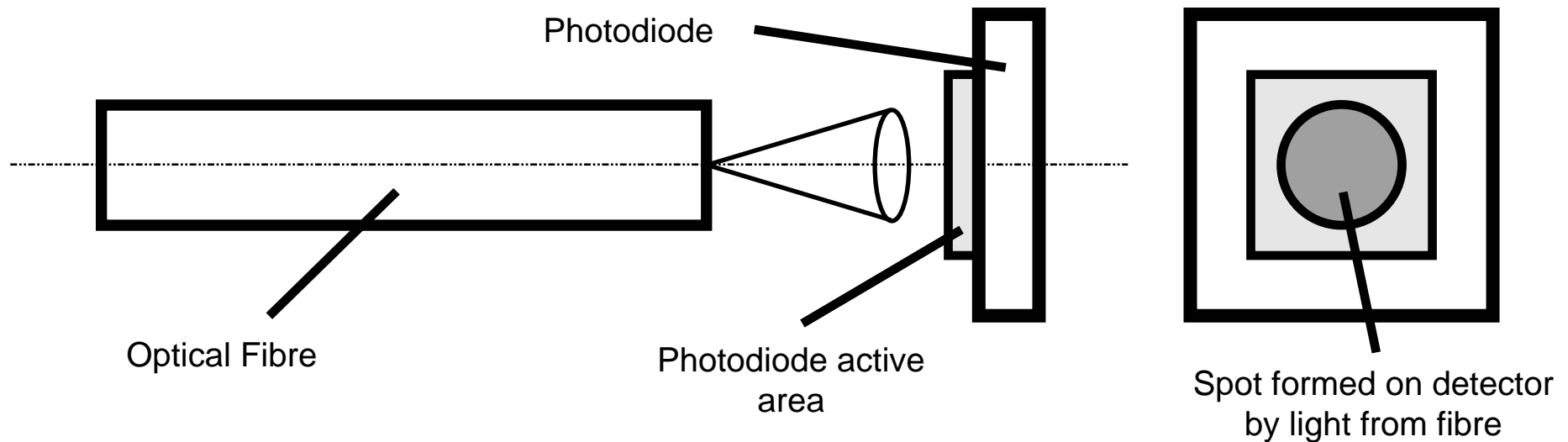
Anritsu
ML9001A
GPIB Optical
Power





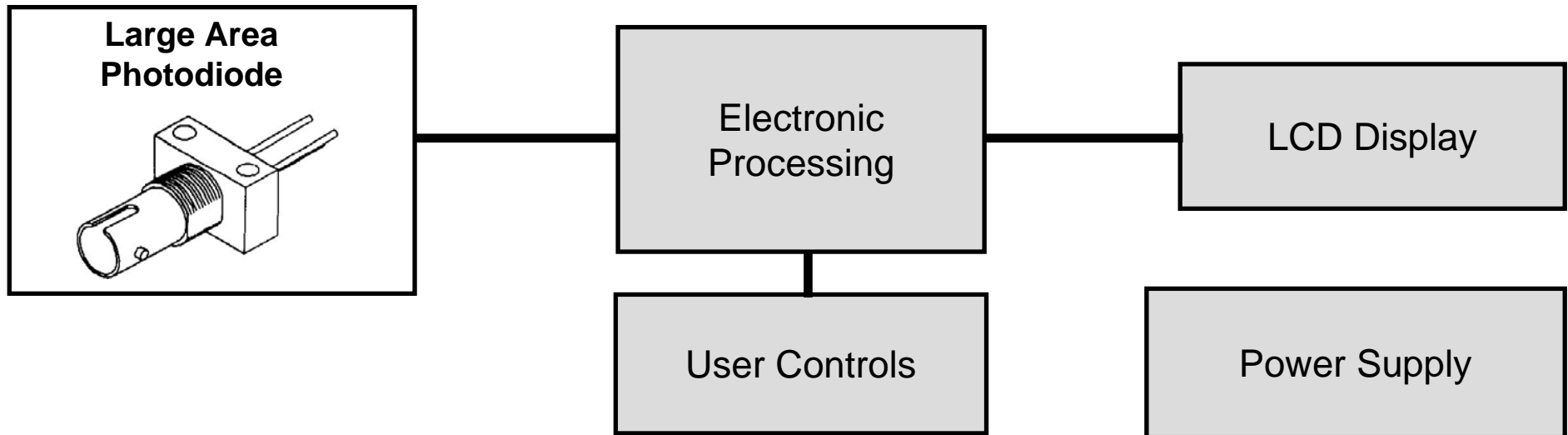
Optical Power Meter Fundamentals

- **Measurement of Optical Power is of fundamental importance in optical systems**
 - **Photodiode detectors are normally used in power meters for optical fibre systems.**
 - **Large-surface area preferred to ensure detection of all of the light from the fibre.**
-





Power Meter Block Diagram

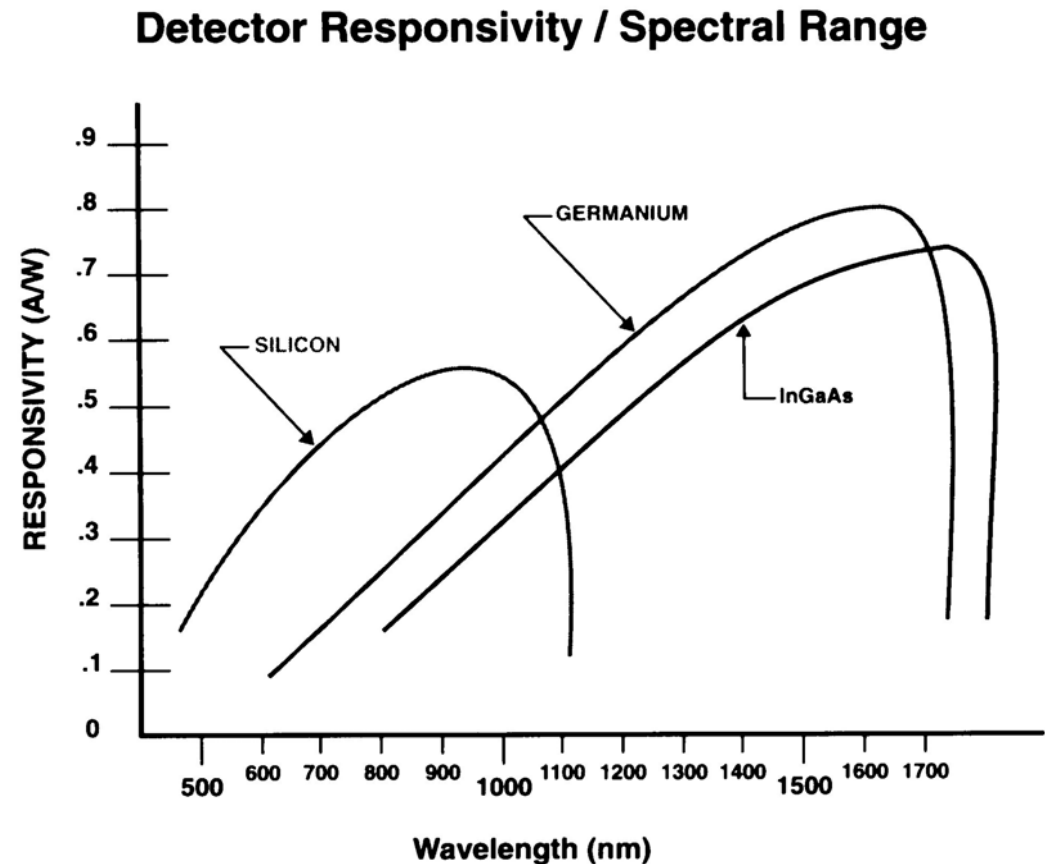


- **Three type of photodiode are used: Silicon, Germanium and InGaAs (Indium Gallium Arsenide)**
- **Different photodiodes are sensitive to different wavelength ranges**



Photodiode Wavelength Ranges

- Silicon photodiodes work only in the first window circa 850 nm
- InGaAs is only suitable for windows circa 1300 and 1550 nm
- Germanium photodiodes are the only type suitable for all windows





Photodiodes Types

Silicon Photodiodes:

- Used from 400 nm to 1000 nm
- Typical dynamic range from 1 pW to 1 mW
- Typical area 1 cm squared

Germanium Photodiodes:

- Used from 500 nm to 1800 nm
- Typical dynamic range from 1 pW to 1 mW
- Typical area 1 cm squared

InGaAs Photodiodes:

- Used from 1000 nm to 1600 nm
- Higher cost
- Typical area is small, 0.5 mm diameter, 0.007 cm squared



Attenuation/Loss Measurement Practice



Production Attenuation Measurement Tips

- Measured loss values for say connectors are small (0.1 dB to 0.5 dB)
- Any fluctuations in the source and/or leads will directly affect attenuation measurement
- Source:
 - f* Ideally use a source with a stability ten times better than lowest attenuation to be measured
 - f* Eg. to measure down to 0.1 dB use a source with a stability better than 0.01 dB
 - f* Perform a periodic reference check every 1-2 hours to eliminate long term drift
 - f* For very high stability use a splitter and power meter to monitor reference continuously
- Leads
 - f* Use high quality test leads
 - f* Keep leads clean and perform periodic checks
 - f* Consider fixing leads in place to eliminate random bend fluctuations
 - f* Consider using a fixing jig for test lead adapters



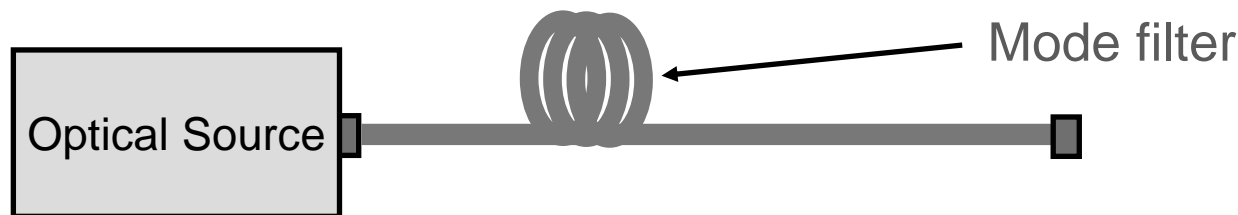
Launch Conditions (Multimode)

- In use in real systems patchcords, connectors etc. are normally distant from the transmitter.
- At a distance the mode distribution reaches a steady state or equilibrium distribution
- When measurements are undertaken with launch leads devices under test will be close to the source.
- Mode distribution is not at equilibrium: misleading results
- Standards such as IEC 60874-1 insist on equilibrium mode distribution
- Using long leads to achieve equilibrium is difficult
- Better to use some form of Equilibrium Mode Simulator
 - Also known as a Optical Mode Conditioner



Launch Conditions (Singlemode)

- In use in real systems patchcords, connectors etc. are normally distant from the transmitter
- When measurements are undertaken with launch leads devices under test will be close to the source.
- Multiple modes may exist close to the source, inaccurate results
- Using long singlemode leads to achieve equilibrium is difficult
- A mode filter consisting of two or more 40-50 mm diameter loops in the source lead should ensure that the DUT sees a true singlemode signal

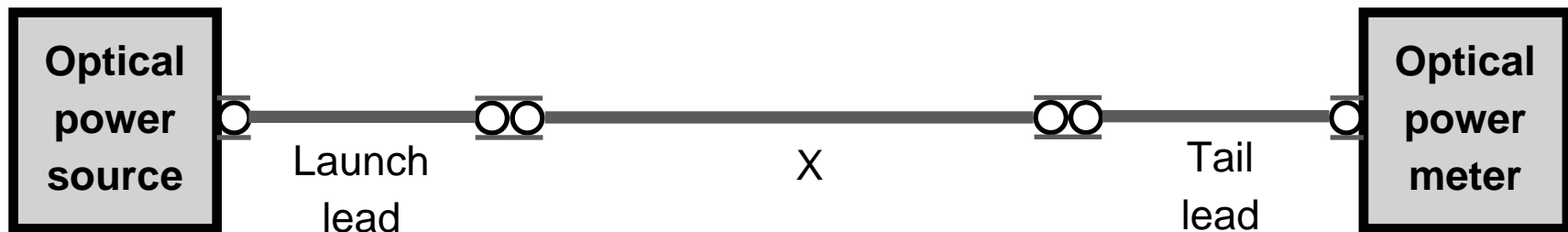




Loss Measurement

Length of fibre only

Attenuation for a length of fibre only (connectors not included)



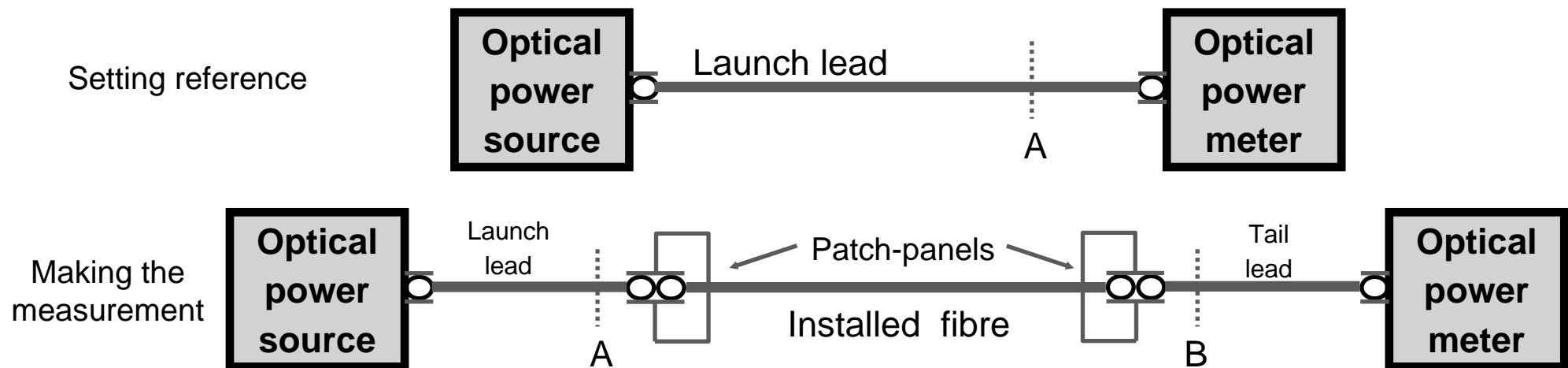
- A short reference lead is used for X and the received power P_1 is recorded
- The lead X is replaced by the length of fibre and received power P_2 is recorded
- Attenuation in the fibre length is $P_1 - P_2$
- Fibre length under test and the reference lead must have the same geometry and connectors from the same manufacturer
- Most power meters incorporate a dBr (dB relative) function to assist in measurements

 = Mated pair of optical connectors



Loss Measurement

Patch-panel to Patch-panel

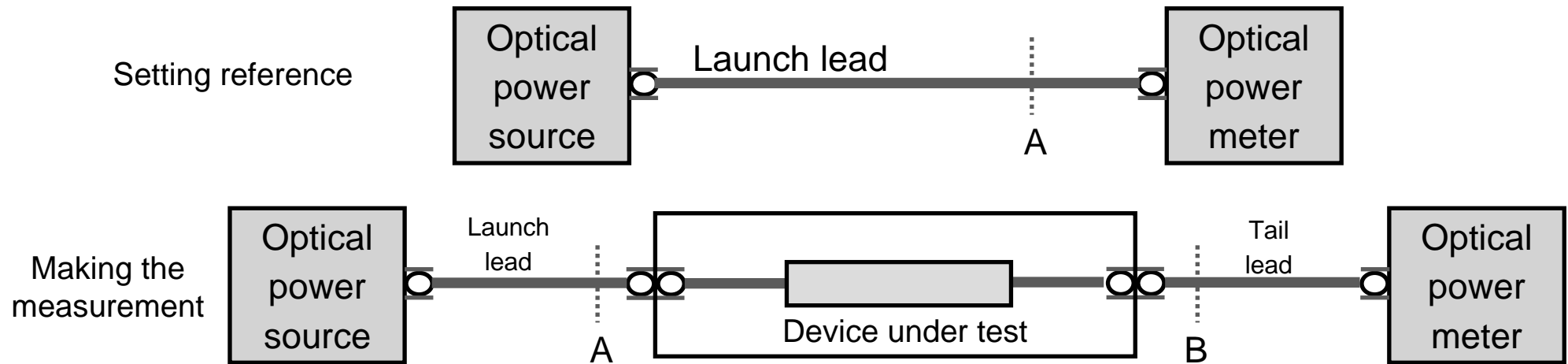


- A launch reference lead is connected as shown and the optical power P_1 is recorded
- The power P_1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the local patch panel
- The power meter is taken to the remote patch panel and connected by a reference tail lead
- The power level P_2 is then measured and the loss between A and B is $P_1 - P_2$
- Fibre under test and the reference lead must have the same geometry and connectors from the same manufacturer

 = Mated pair of optical connectors



Total Loss Measurement: Connectorised Device

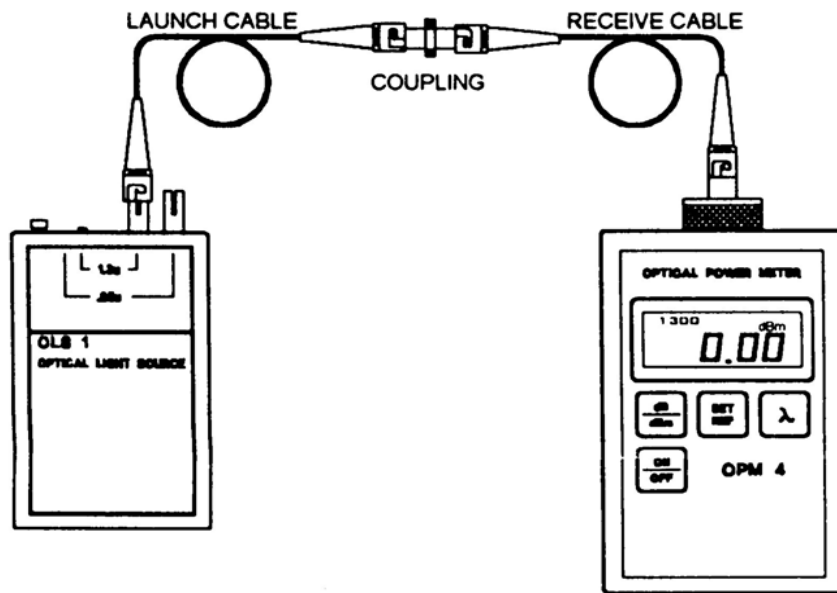


- A launch reference lead is connected between the source and meter as shown
- The optical power P_1 is recorded
- The power P_1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the device input
- The power meter connected to the device output by a reference tail lead
- The power level P_2 is then measured and the loss between A and B is found as $P_1 - P_2$
- Fibre under test and the reference lead must have the same geometry and connectors

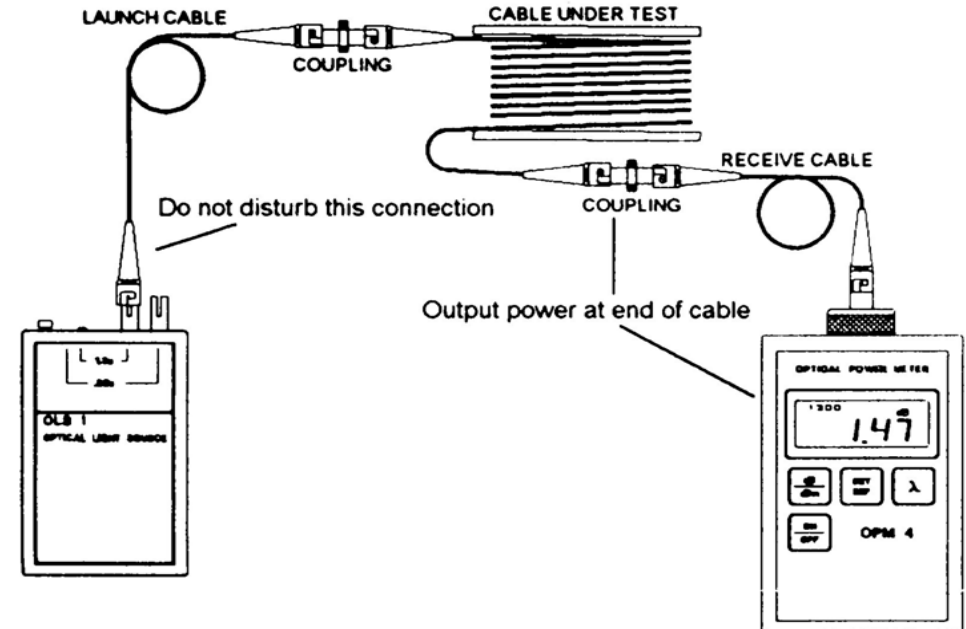


Alternative Method of Measuring Patchpanel-Patchpanel Atten.

Setup Reference



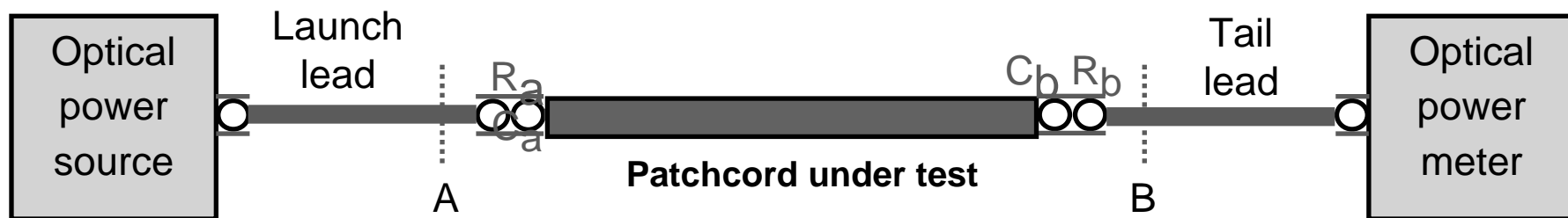
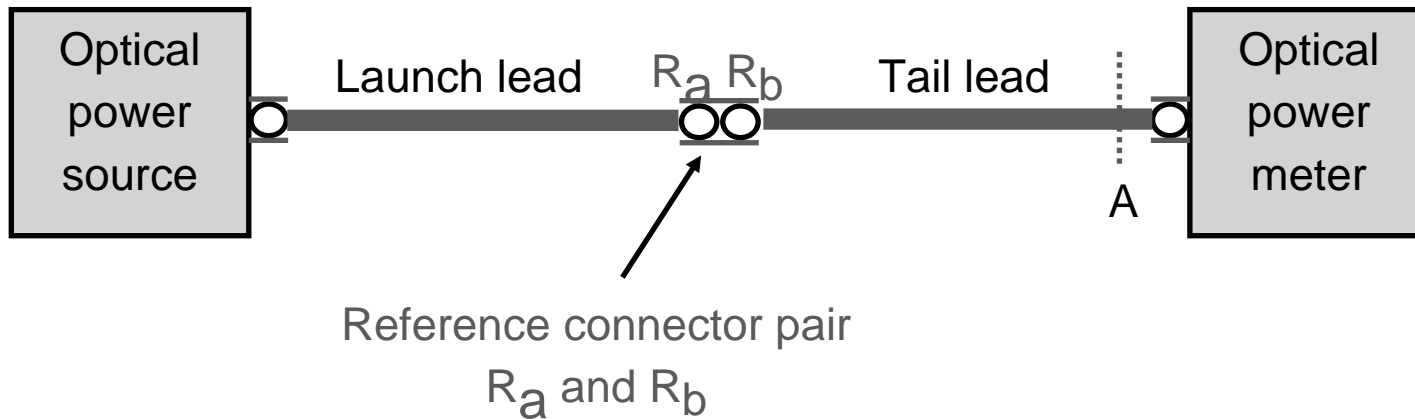
Measure Attenuation



- Diagrams from the instruction sheet of manufacturer for attenuation test on cable ONLY
- Measurement is for cable and a SINGLE mated pair of connectors



Loss Measurement (I): Patchcord as per IEC 60874-1



Assumes equilibrium mode conditions reached in launch lead

 = Mated pair of optical connectors

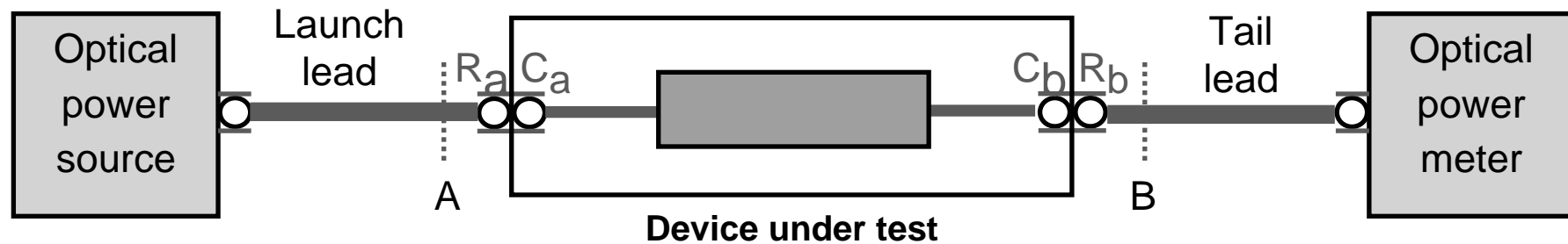
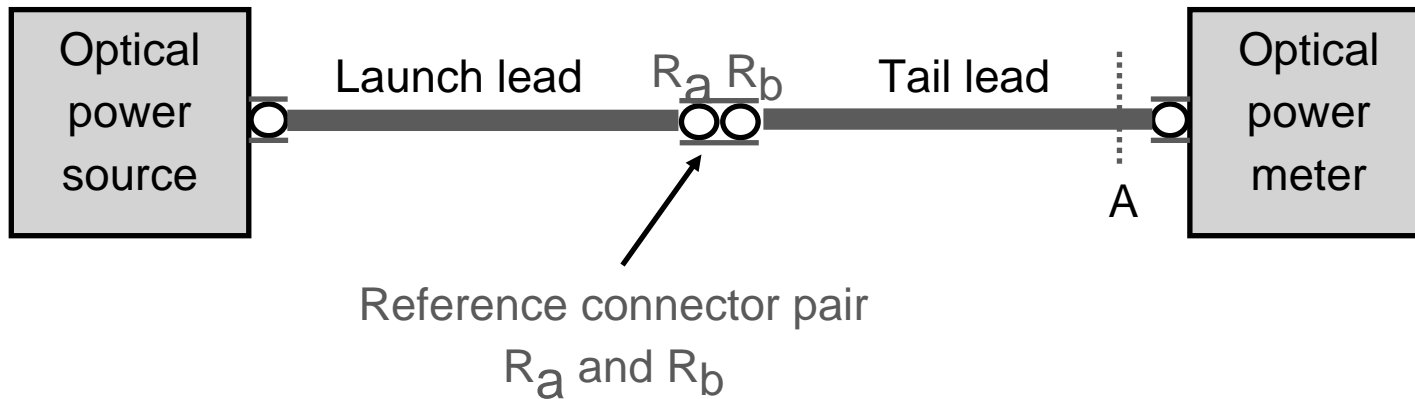


Loss Measurement (II): Patchcord as per IEC 60874-1

- Non-destructive method as per IEC 60874-1
- A launch and tail reference leads are connected between the source and meter
- The reference connectors R_a and R_b are used connect the launch and tail leads
- The optical power $P1$ is recorded in dBm
- The power $P1$ represents the power in the tail lead at point A
- The launch lead from the source is connected to the patchcord input connector C_a
- The power meter connected to the patchcord output by the tail lead using C_b
- The power level $P2$ in dBm is then measured
- The patchcord loss/attenuation is found as $P1 - P2$ (dB)
- Fibre under test and the reference lead must have the same geometry and connectors



Loss Measurement (I): Device as per IEC 60874-1



Assumes equilibrium mode conditions reached in launch lead



= Mated pair of optical connectors



Loss Measurement (II): Device as per IEC 60874-1

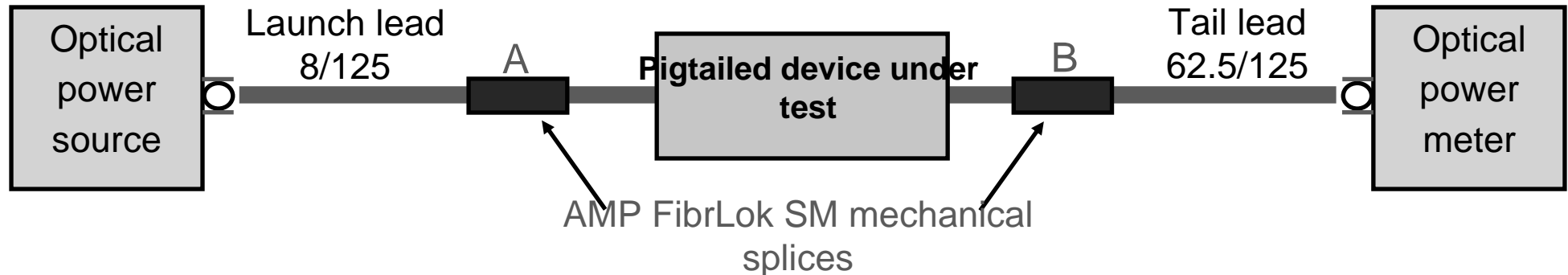
- Non-destructive method as per IEC 60874-1
- A launch and tail reference leads are connected between the source and meter
- The reference connectors R_a and R_b are used to connect the launch and tail leads
- The optical power P_1 is recorded in dBm
- The power P_1 represents the power in the tail lead at point A
- The launch lead from the source is connected to the DUT input connector C_a
- The power meter is connected to the DUT output by the tail lead using C_b
- The power level P_2 in dBm is then measured
- The DUT loss/attenuation is found as $P_1 - P_2$ (dB)
- All fibres in the test must have the same geometry and connectors



Loss Measurement: Unterminated Device



Step 1: setting reference



Step 2: measurement

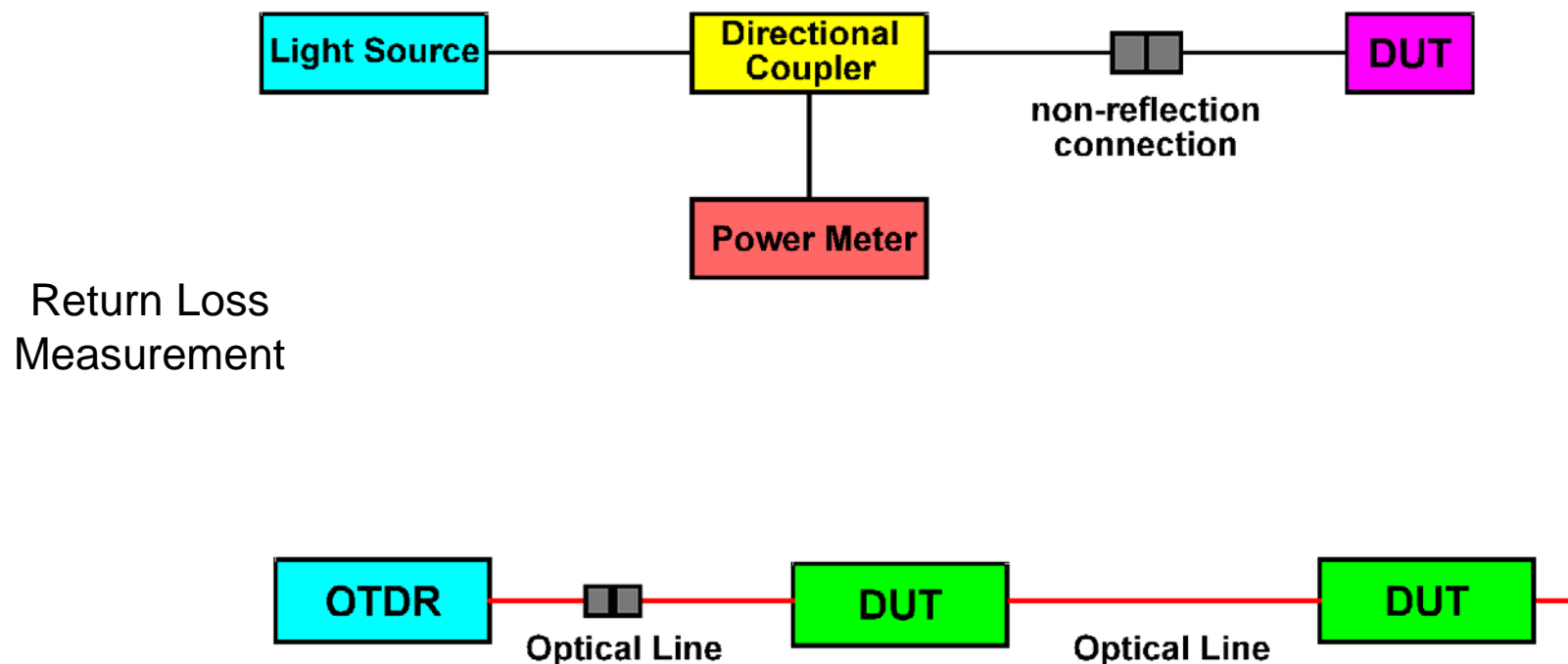


Return Loss Measurement



Recent Instrumentation

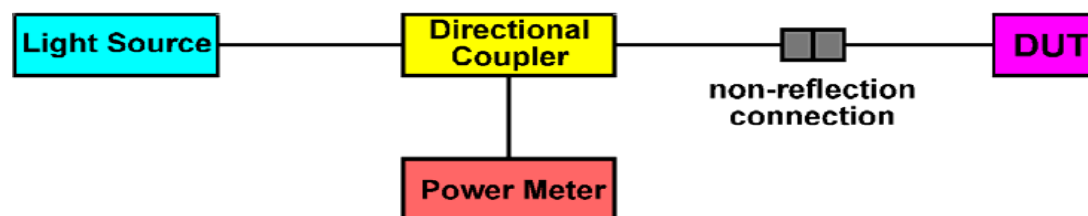
- Polarization analysers
- Return loss Test Sets
- Fibre Amplifiers designed for test and measurement environments





Return Loss Measurement

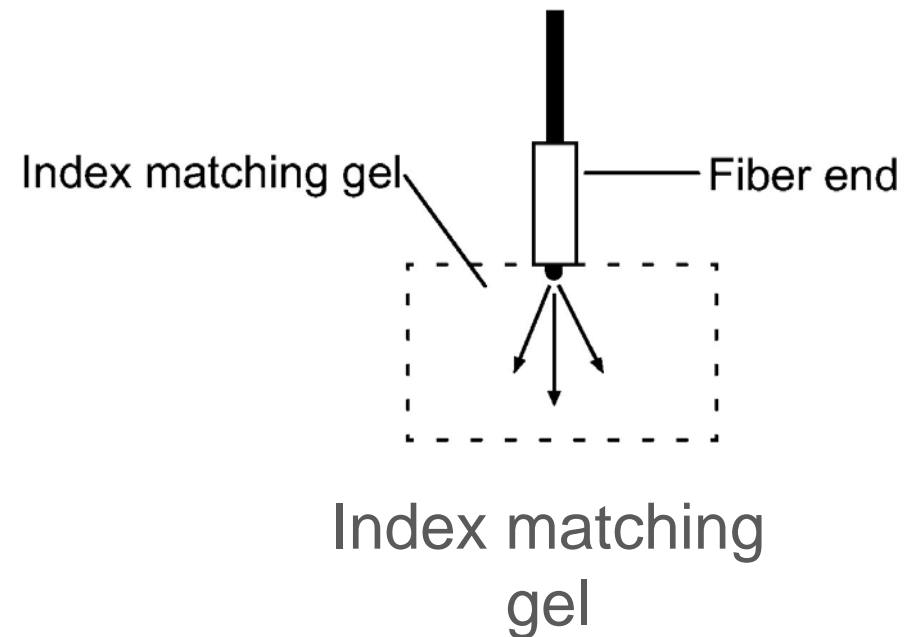
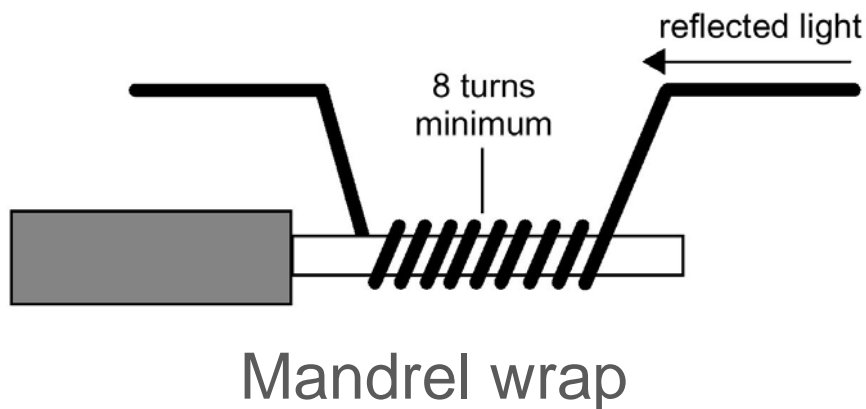
- Measured with dedicated return loss (RL) test set or an Optical time domain reflectometer (OTDR)
- OTDR has a deadzone and is too coarse for accurate measurements
- Dedicated test sets can measure RL to 60 dB and better
- Inherent RL of the test set needs to be 15-20 better than the best RL to be measured.
- Thus to measure a RL down to -55 dB, the test set must have an inherent RL of -70 dB or better





Non-Reflective Terminations for Return Loss

- When measuring RL non-reflective terminations are needed for calibration, RL measurement etc..
- The common techniques are
 - f* Mandrel wrap
 - f* Termination connector
 - f* Gel block
 - f* Index matching gel or fluid



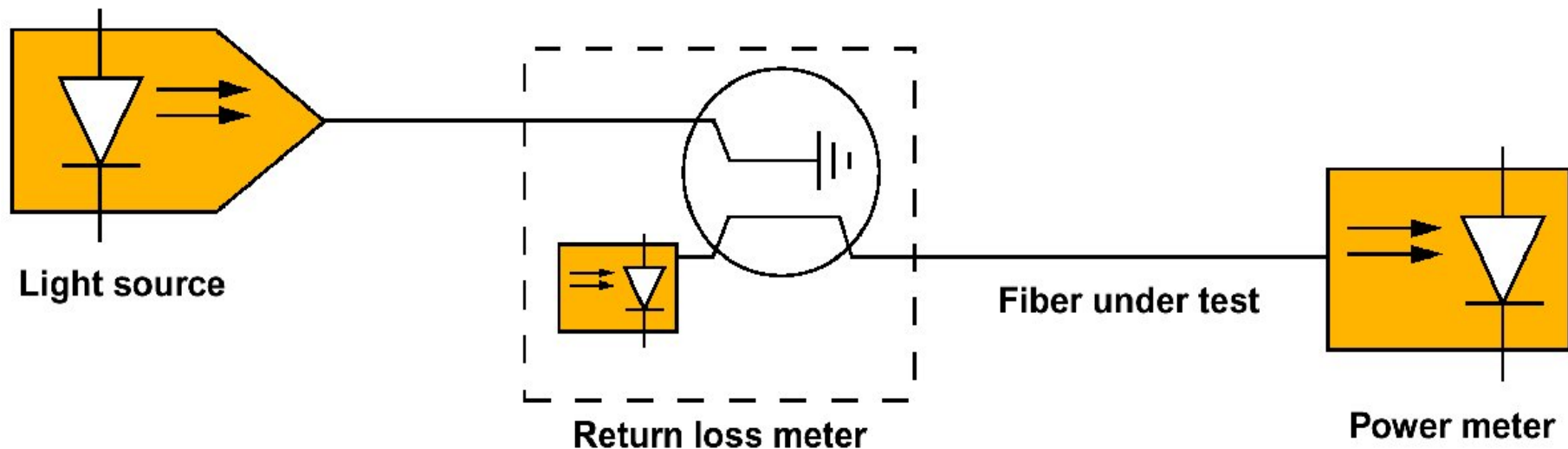


Integrated Attenuation and Return Loss Measurement



Integrated Measurement

- Combines attenuation and return loss measurements
- Combines a variety of features for a production environment
- Can be used as the basis of tracking and recording data
- Products from EXFO, JDS-Fitel etc..





Typical Integrated Measurement Features

- Automatic batch counter
- Detailed DUT identification
- Database browser
- Test and DUT type specified at the touch of a button
- Automatic label printing when a device passes all predetermined tests
- Label and report configuration using the various data fields
- Pass/fail limit and threshold warning assigned to various connector types
- Foot switch operation



Standards for Test for Atten and RL



Measurement Standards for Patchcords/Connectors

- FOTP-34A (TIA/EIA-455-34A): *Interconnection Device Insertion Loss Test*
- FOTP-107 (TIA/EIA-455-107): *Determination of Component Reflectance or Link/System Return Loss Using a Loss Test Set*
- FOTP-171 (TIA/EIA -455-171): *Attenuation by Substitution Measurement for Short-length Multimode Graded Index and Singlemode Optical Fiber Cable Assemblies*
- IEC Publication 60874-1: *Connectors for Optical Fibres and Cables*

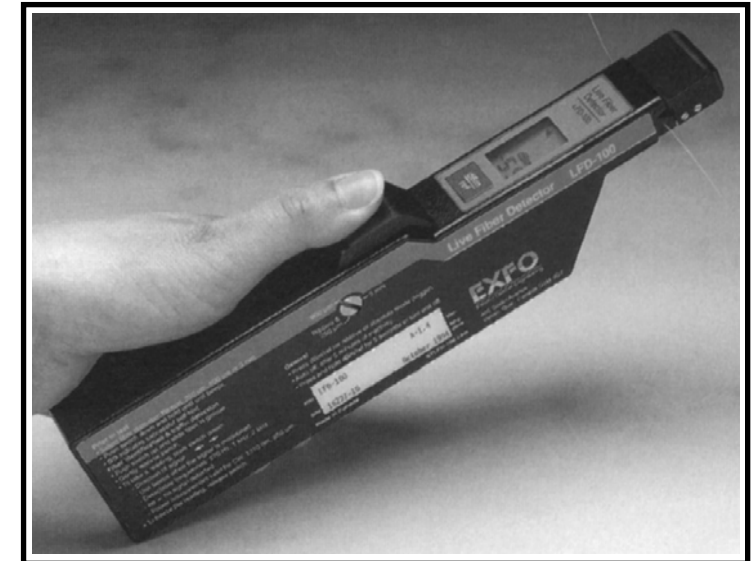


Other Fibre Test Equipment



Live Fibre Detectors

- **Determines if a fibre is "live" or not**
- **Applications include:**
 - f* Verifying fibre colour coding during installation
 - f* Identifying active and inactive fibre prior to rerouting or maintenance
 - f* Continuity testing during repair
- **Clamps onto fibre using a low-loss macrobending technique**
 - f* Insertion loss typically < 0.4 dB at 1310 nm
 - f* Works with 250 and 900 micron fibres
- **Can detect:**
 - f* Data traffic down to -35 dBm or lower
 - f* Modulated test tones from optical sources (2 kHz typically)
- **Some units provide a display of an approximate optical power**
- **Units available from BIT, Laser Precision, Exfo, Noyes**

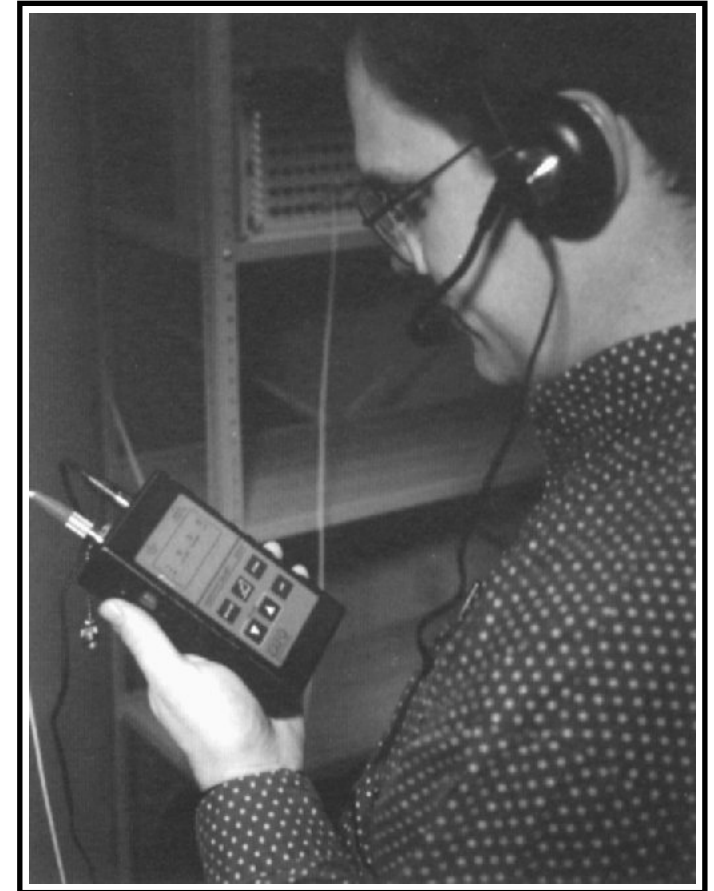


Exfo LFD-100 Live Fibre Detector



Talk-Sets

- A Talk-set is used to provide communication between personnel during installation/repair where no other means is available
- Operates over fibre
- Simple designs are half-duplex
 - f* Only one user can talk at one time
 - f* Voice activated systems are available
- More sophisticated digital systems provide simultaneous communication in both directions
- LED and Laser based systems available
 - f* LED at 1310 nm gives 45 km on 62.5 micron fibre
 - f* Laser at 1310 gives 62 km on singlemode fibre
- Units available from FiberFone, Ixian, Exfo



Exfo VCS-10 Talk-set



Optical Time Domain Reflectometer

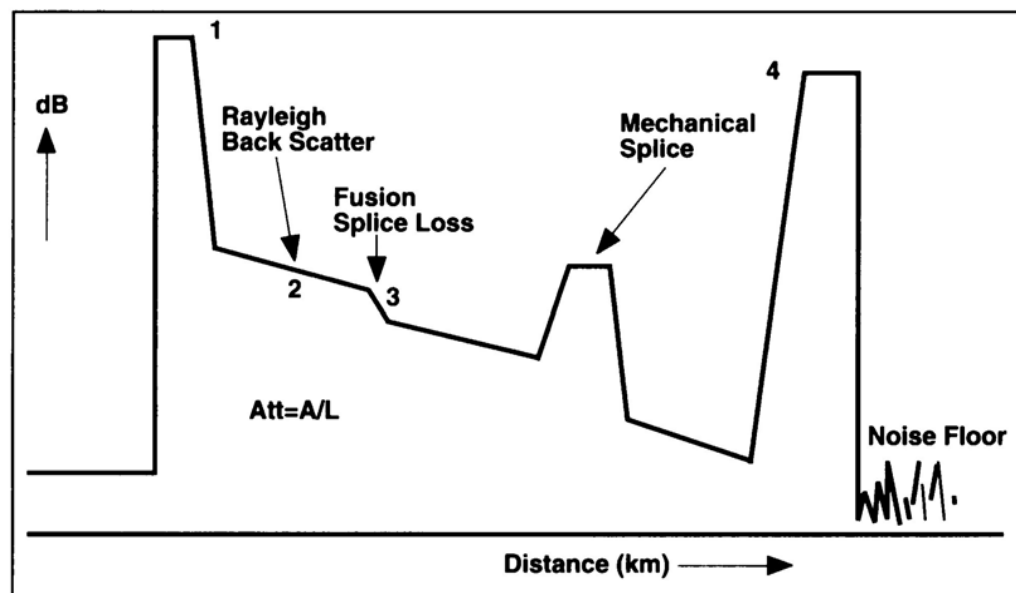


Understanding an OTDR Display

- Light is reflected back to the OTDR from along the fibre because of Rayleigh scattering in the fibre
- Much larger reflections occur at joints with small airgaps and at the fibre end or at a break
- Light reflected back from joints, breaks etc.. produces a spike on the display that looks like "gain". Indicates joints between fibres with different backscatters

Key to diagram:

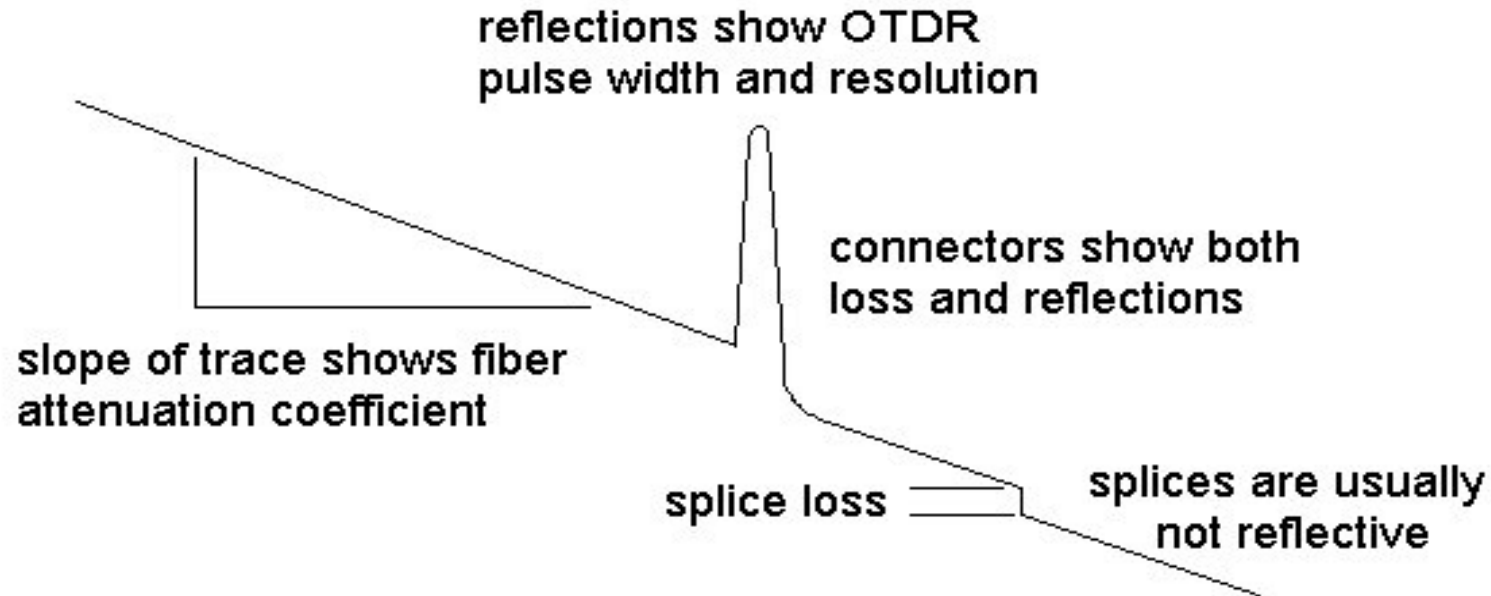
1. Fresnel reflection from first connector
2. Back scattered light from fibre
3. Increase in loss at fusion splice
4. Fresnel reflection from fibre end





Understanding an OTDR Display

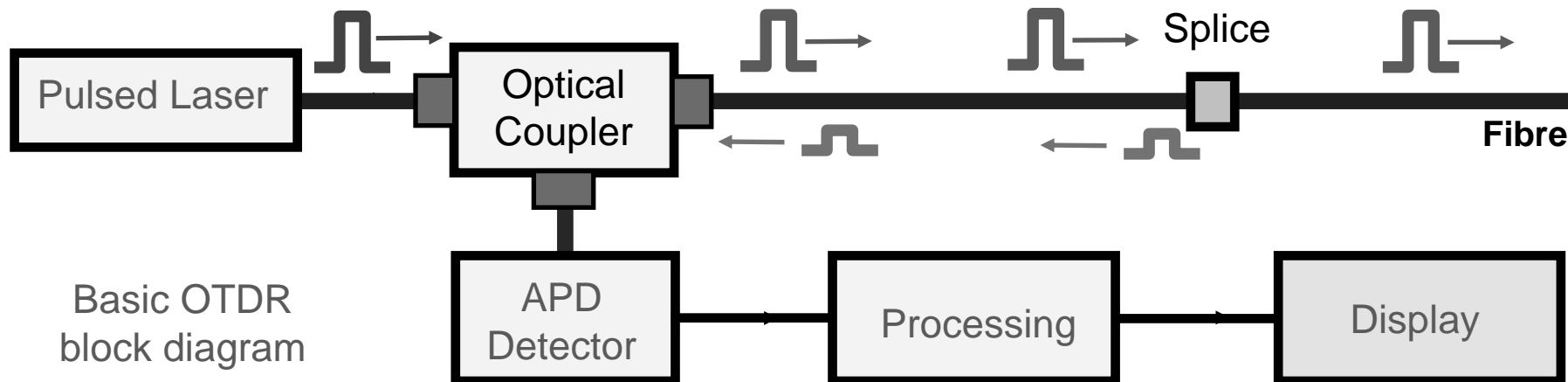
- Light is reflected back to the OTDR from along the fibre because of Rayleigh scattering in the fibre
- Much larger reflections occur at joints with small airgaps and at the fibre end or at a break
- Light reflected back from joints, breaks etc.. produces a spike on the display that looks like "gain". Indicates strong reflection from joint





Optical Time Domain Reflectometry

- An Optical Time Domain Reflectometer (OTDR) displays loss in a fibre link as a function of distance.
- Works by transmitting laser light pulses down an optical fibre and by measuring the reflected light coming back to the OTDR as a function of time and level.
- The OTDR converts time to distance and from the returned levels the loss at various distances is estimated
- The result is a display of loss versus distance for the fibre.





What can an OTDR provide?

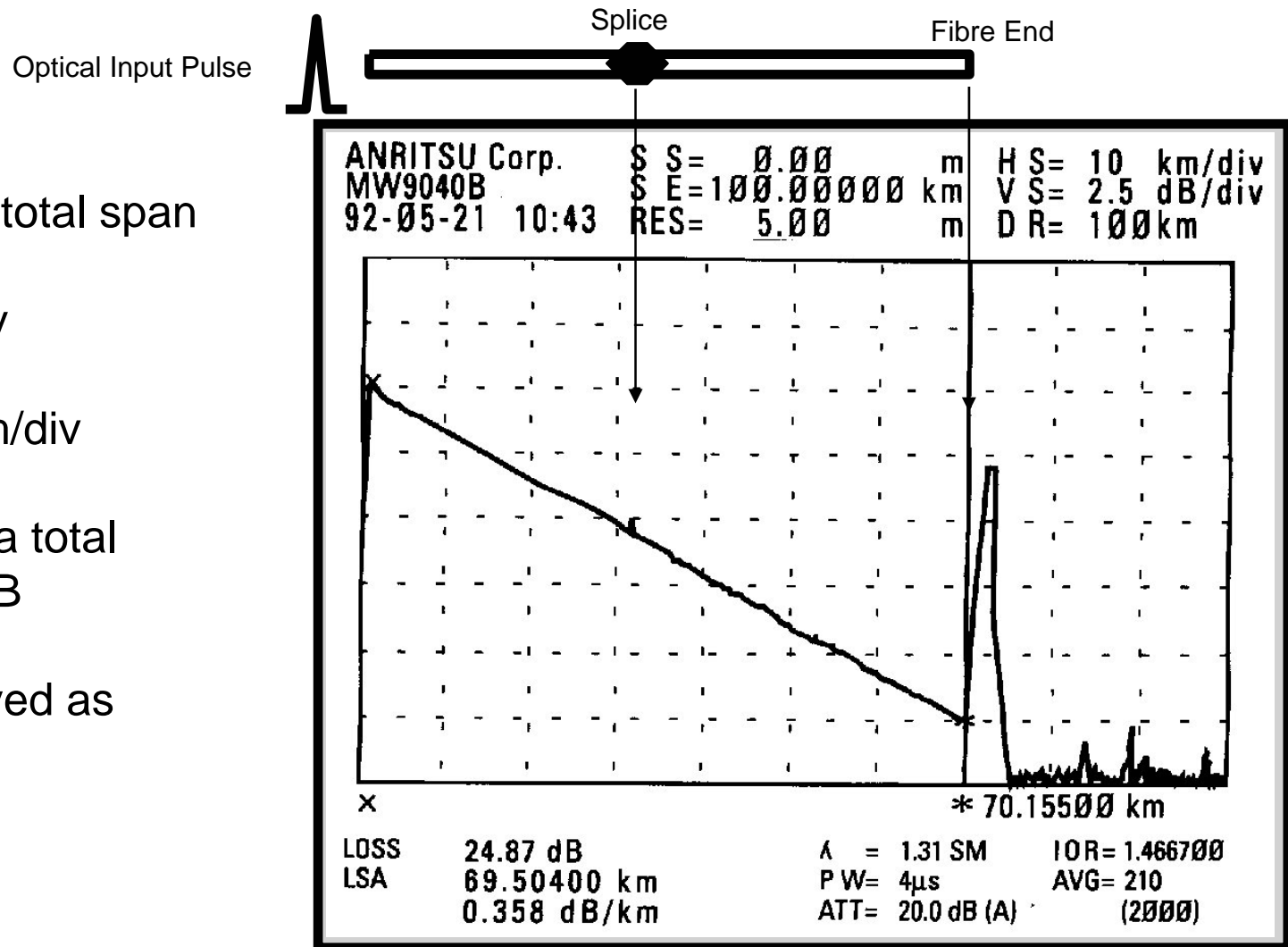
An OTDR can typically provide the following information:

- **total fibre loss**
- **loss per unit length**
- **connector insertion loss**
- **connector return loss (reflection)**
- **splice loss**
- **inter-splice loss**
- **absolute fibre length**
- **evidence of macro/micro bending**
- **position of cable defects or breaks**



Sample OTDR Display

- Display shows total span
- Loss 2.5 dB/div
- Distance 10 km/div
- Markers show a total loss of 24.87 dB
- Span is displayed as 70.155 km



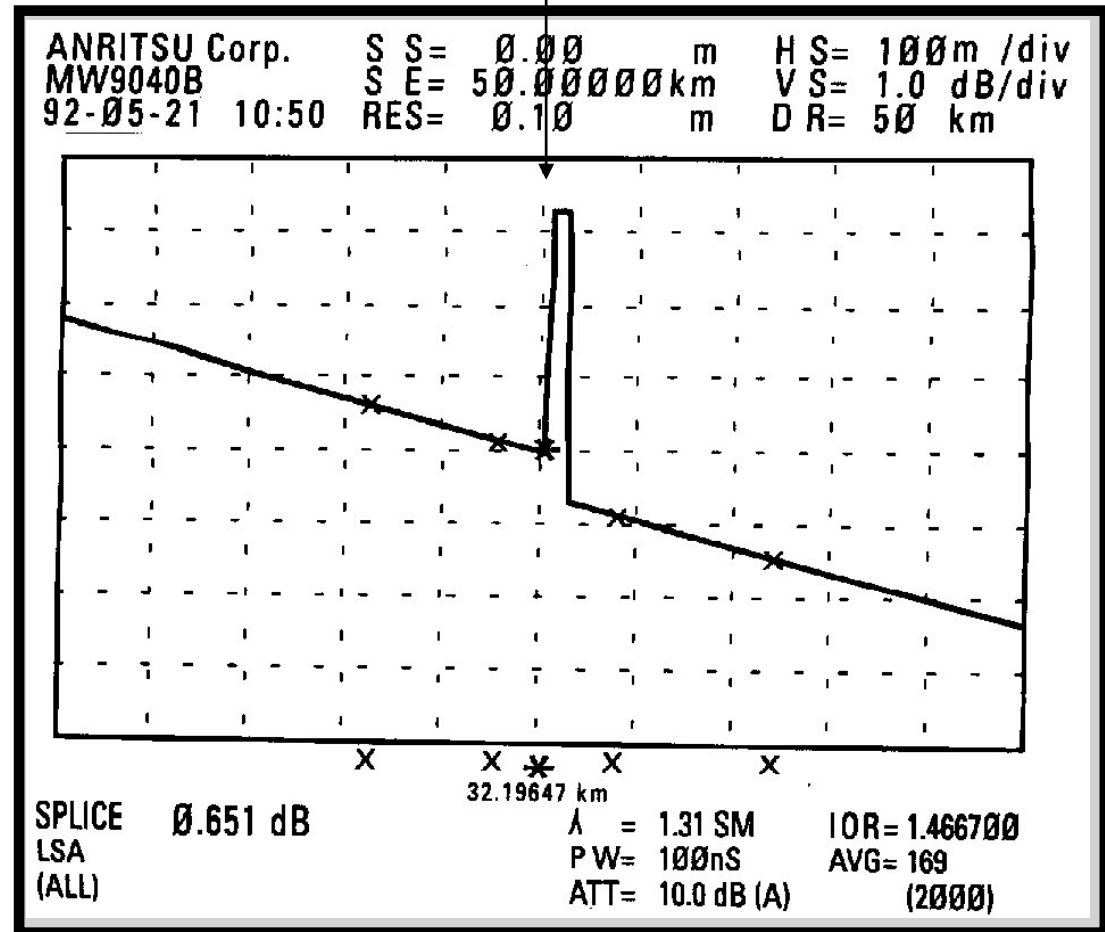


Zoomed OTDR Display

Optical Input Pulse



Splice



- Display shows zoomed span
- Loss 1 dB/div
- Distance 100 m/div
- Markers show a total connector loss of 0.651 dB
- Distance to connector is displayed as 32.196 km



OTDR Characteristics

- Distance range: Maximum distance at which the OTDR can detect a reflection
- Two point resolution: Defined as the minimum distance between two reflection points, such as splices, which can be accurately distinguished
- Resolution depends on a number of factors, for example using a shorter pulse width improves the resolution.
- Accuracy: Distance accuracy depends on a number of factors, including the refractive index (IOR) value used:

Table shows effect of using incorrect IOR Correct IOR is 1.468		1.477	2 % error
	2 km	13 m	39.6 m
	20 km	138m	387m
	40 km	271m	775 m

- All OTDRs have a so called Dead Zone. This is the distance from the OTDR in which the ODTR is unable to provide accurate measurements. Typically this is 20 m for many modern OTDRs



Typical OTDR

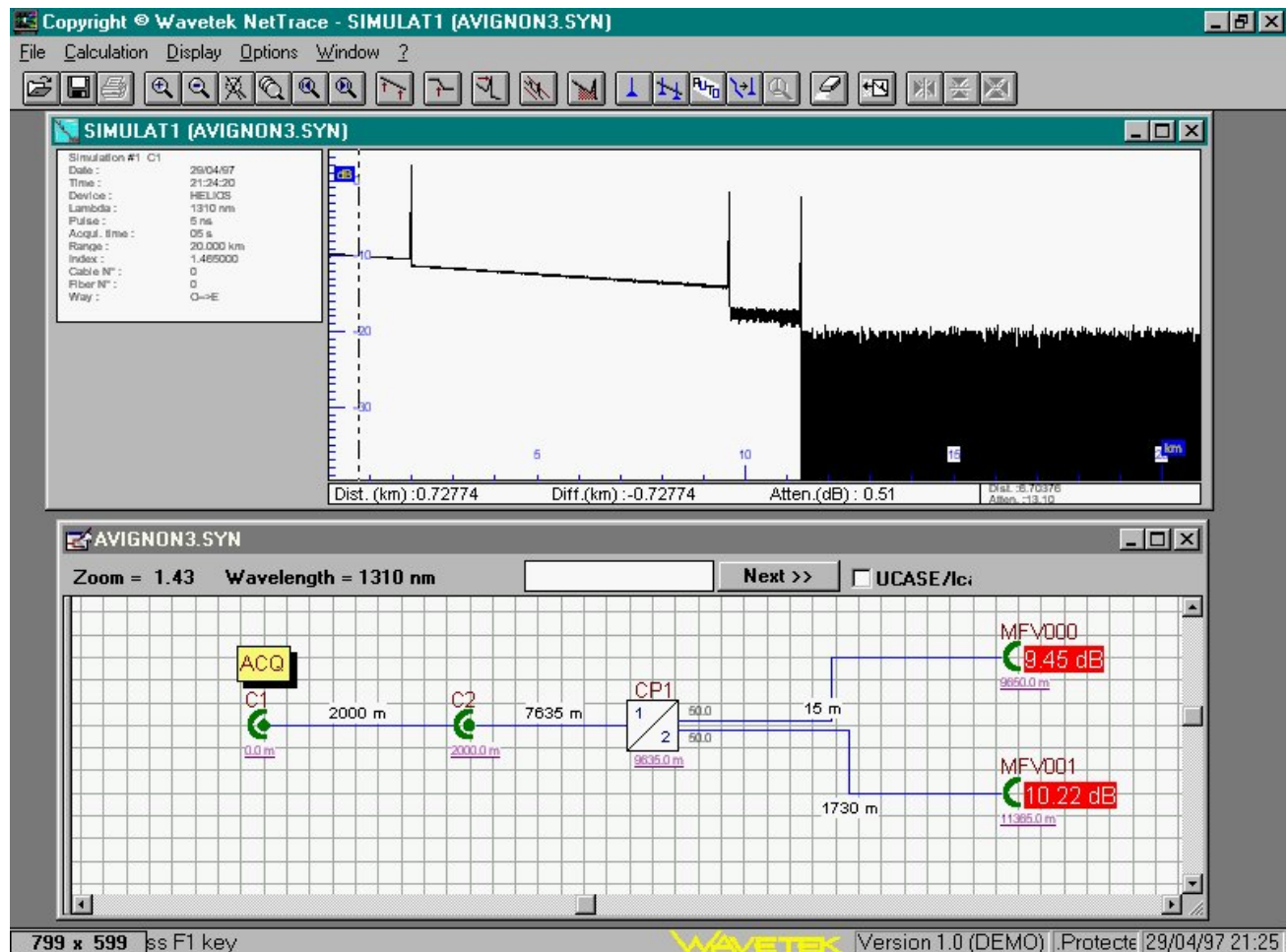
- Wide variety of benchtop, handheld and PC based OTDRs available
 - Ranges from single km to 100's of km, resolutions from <1 m to 50 m
 - Cost is still high relative to other instrumentation IR£ 10K and higher
-
- Exfo FTB-300 OTDR
 - Available at 850, 1310 and 1550 nm
 - Can be configured with different modules for LAN to long range distances
 - Multimode ranges from 0.1 km to 40 km
 - Singlemode ranges from 625 m to 160 km
 - Dead zone < than 25 m, Accurate to +/- 1m
 - Class 1 laser source (eye safe)





Software Prediction of OTDR Traces

- Wavetek and other companies have produced software which allows the system designer to predict the OTDR trace in advance.
- Predicted trace can then be compared to actual during installation to determine if problems exist



Screen from NetTrace Software (from Wavetek)



Network maintenance and fault location



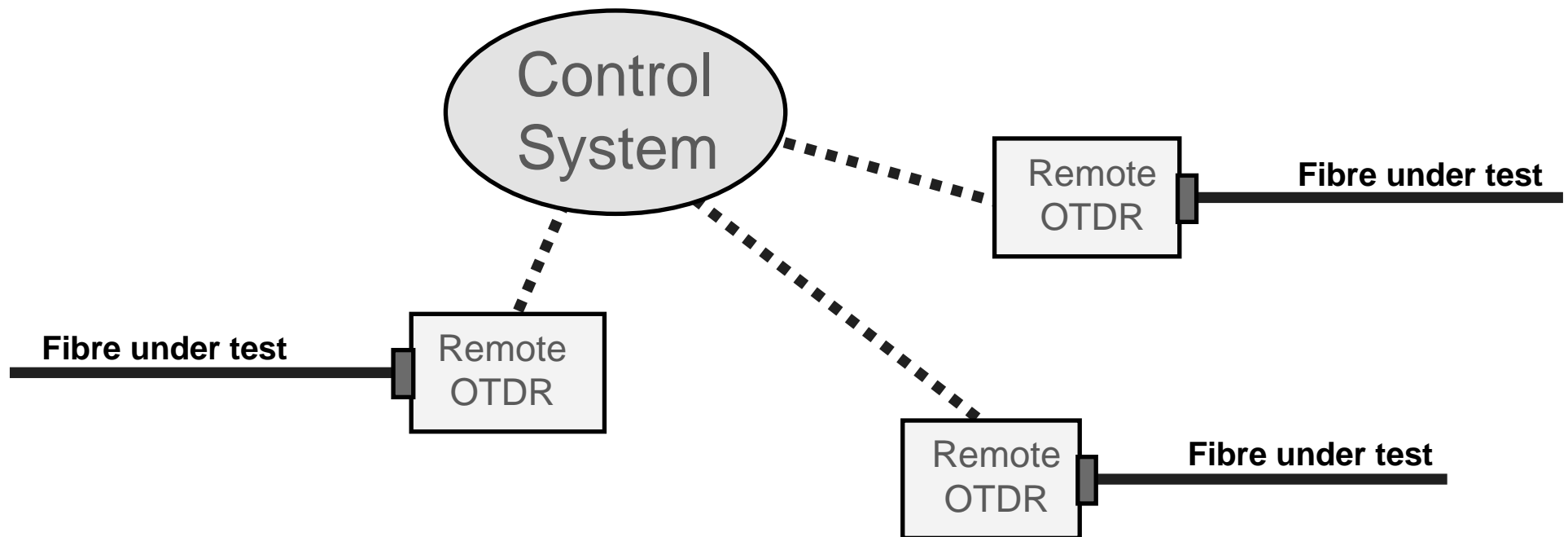
Overview

- **Network maintenance is critical, given the value of traffic**
- **Key instrument is an Optical Time Domain Reflectometer**
- **Optical power measurement still required**
- **Connector inspection and maintenance vital for DWDM**



Remote Fibre Test Systems (RFTS)

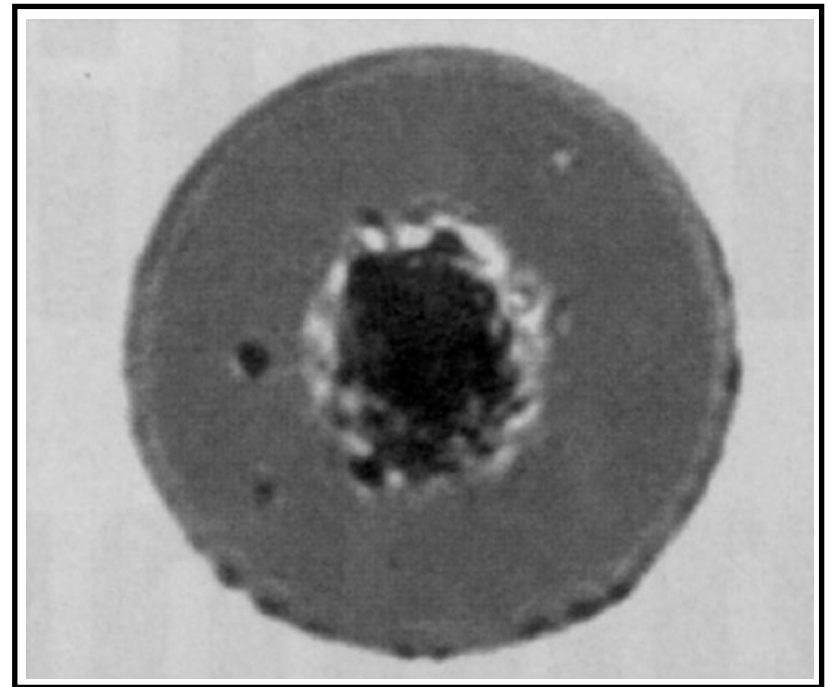
- Allows many faults/weaknesses to be identified prior to failure
- Uses plug-in OTDR modules
- OTDR communicates directly with a control system
- Can be part of an integrated fault location and maintenance system





Inspecting High Power System Connectors

- Aggregate power in many DWDM systems is now close to 1W
- Dirt on fibre end absorbs power and heating results
- Photo shows permanent damage caused by heating
- 1W over 1 minute with a dirty connector may cause permanent
- Cleaning/inspection is critical in DWDM systems





Dispersion measurement



Why Measure Dispersion?

- Dispersion is a critical factor in telecoms systems
- Dispersion management needed
- For DWDM dispersion influences crosstalk
- Dispersion specs are now a key differentiator for SM fibre
- Precise compensation for chromatic dispersion needs measurement
- Can measure chromatic and polarisation mode dispersion



Measuring PMD

- **PMD varies randomly with time,**
- **Makes measurement difficult, successive measurements can differ by up to 20%**
- **Key instrument specifications:**
 - f* **0.05 to 80 ps range**
 - f* **Short measurement time, < 30 s**
 - f* **Accurate to 1% and High dynamic range, 50 dB**

PMD values for various bit rates for a 1 dB penalty

	Bit rate	Maximum PMD	PMD coefficient for 400 km link (ps/km ^{1/2})
STM-16	2.5 Gbits/s	40	< 2
STM-64	10 Gbits/s	10	< 0.5
STM-256	40 Gbits/s	2.5	< 0.125



Measuring PMD

- **PMD varies randomly with time, temperature.**
- **Makes measurement difficult, successive measurements can differ by up to 20%**
- **Table shows maximum expected PMD coefficient values at various bit rate to ensure maximum 1 dB power budget penalty**

	Bit rate	Maximum PMD	PMD coefficient for 400 km link (ps/km ^{1/2})
STM-16	2.5 Gbits/s	40	< 2
STM-64	10 Gbits/s	10	< 0.5
STM-256	40 Gbits/s	2.5	< 0.125

PMD values for various bit rates for a 1 dB penalty



Measuring PMD

- **Specialist and thus expensive instrumentation**
- **Key instrument specifications:**
 - f* **0.05 to 80 ps range**
 - f* **Short measurement time, < 30 s**
 - f* **Accurate to 1%**
 - f* **High dynamic range, 50 dB**

NetTest PMD 440
PMD Analyser



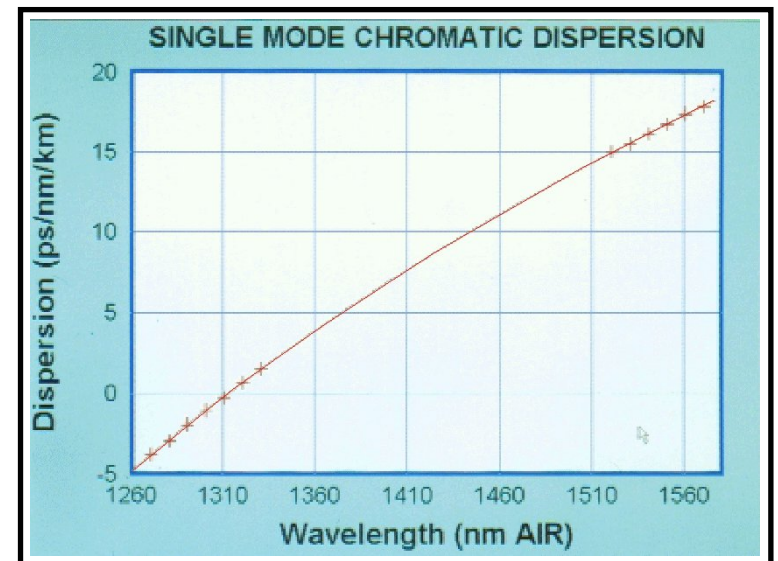


Measuring Chromatic Dispersion

- Number of different techniques, phase shift method is one of the best
- Very important for DWDM systems,
- Impact of chromatic dispersion rises with bit rate and channel count
- Key instrument specifications:

- f* 1310 nm and C & L band operation
 - f* Separate T/X and R/X units for field testing
 - f* Better than 1 nm accuracy
 - f* λ_0 is estimated by curve fitting

Measured chromatic dispersion





Summary

- **Power/Loss measurements are among the simplest yet the most important in fibre systems**
- **Live fibre detectors and talk-sets are valuable aids in installation, maintenance and repair**
- **An OTDR has multiple uses, such as loss measurement and fault finding**
- **Software prediction of an OTDR trace is a recent useful development**

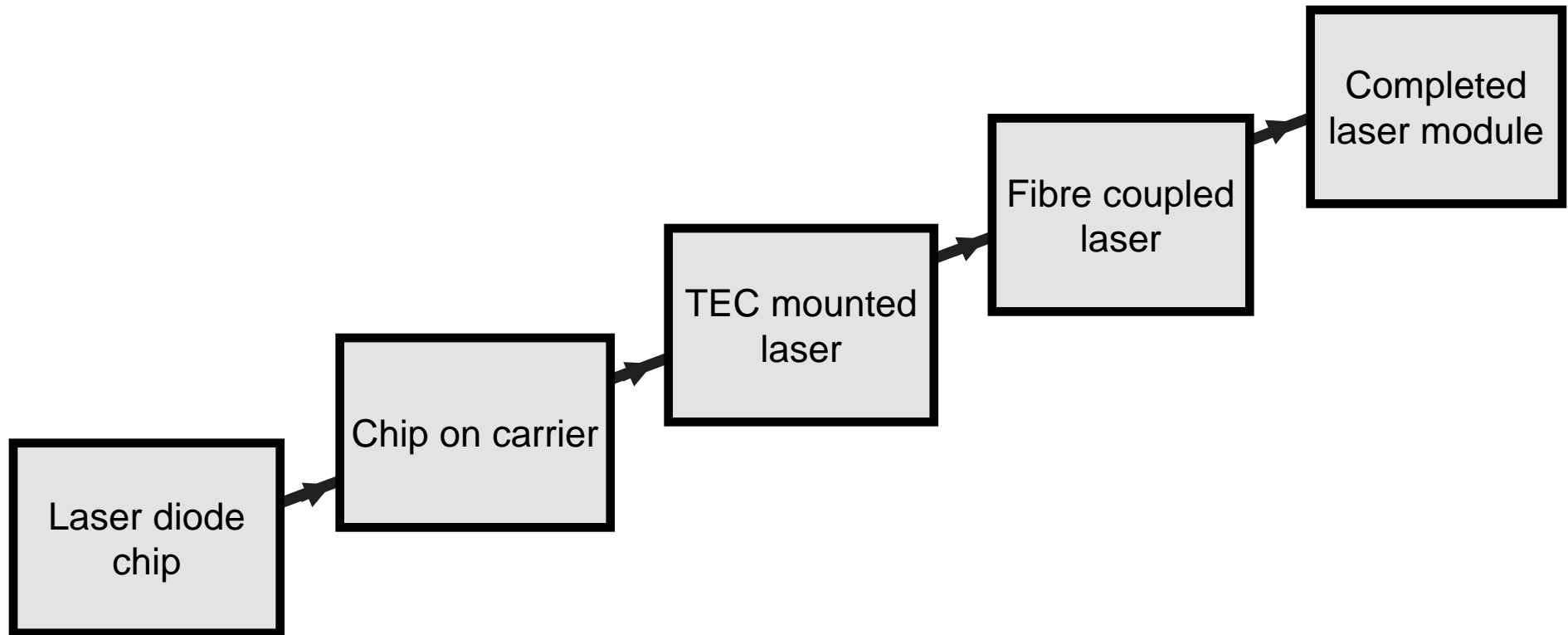


APPLIED OPTOELECTRONICS CENTRE

Laser Diode Test

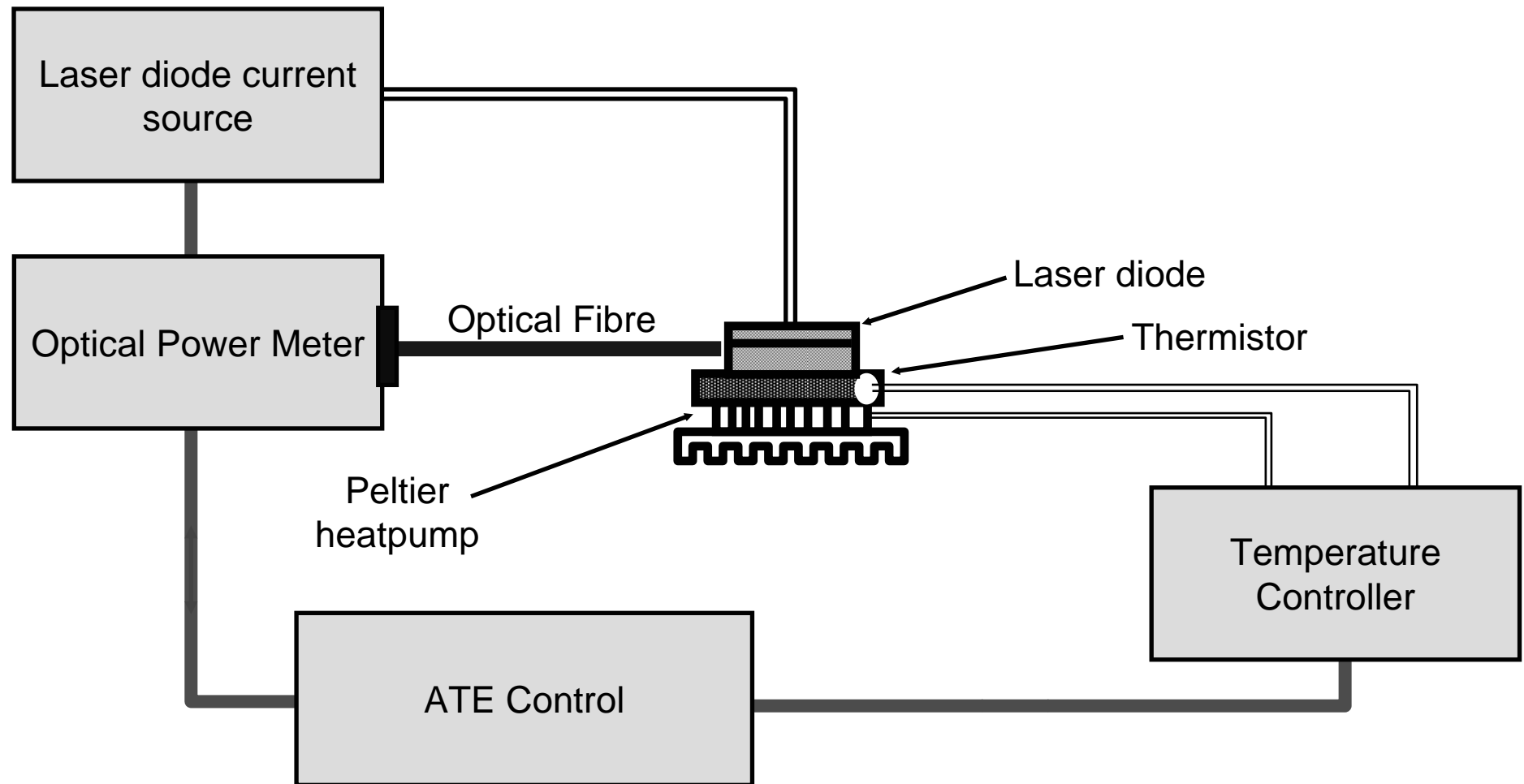


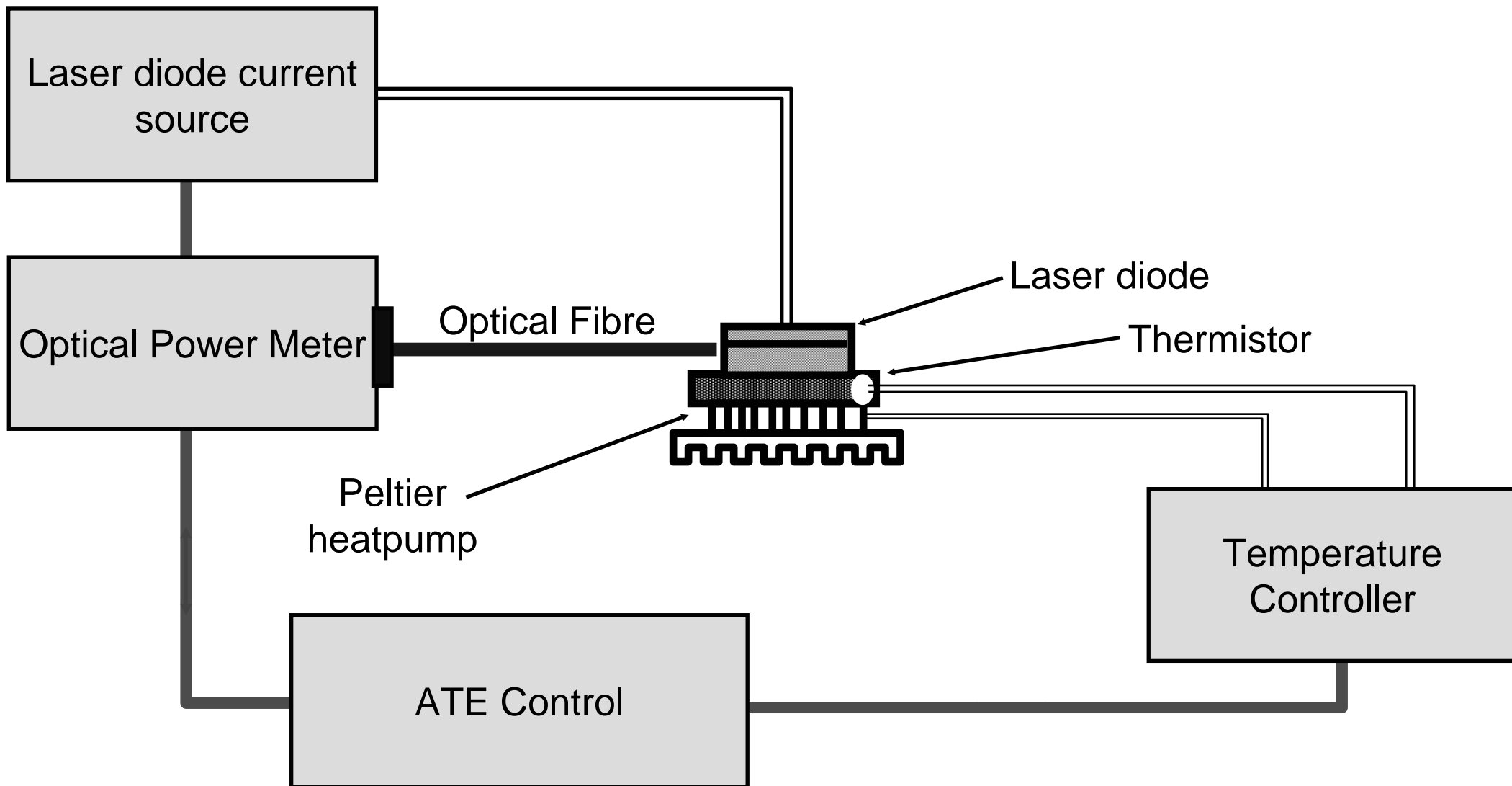
Laser Diode Test Stages

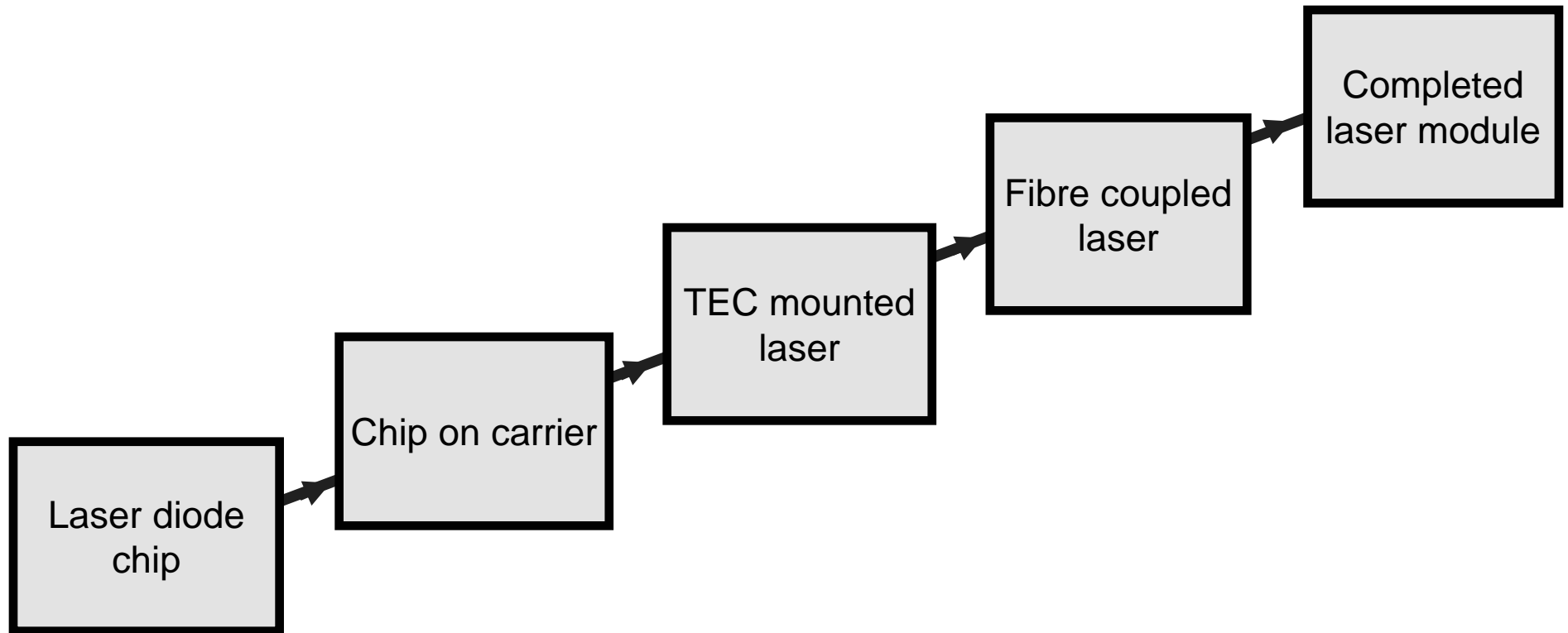




Laser Diode Test Setup for Volume Manufacture







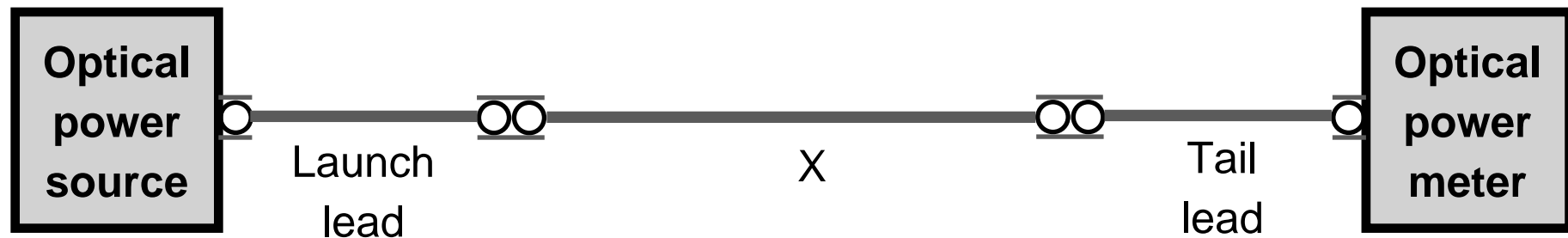



APPLIED OPTOELECTRONICS CENTRE

Various Handouts

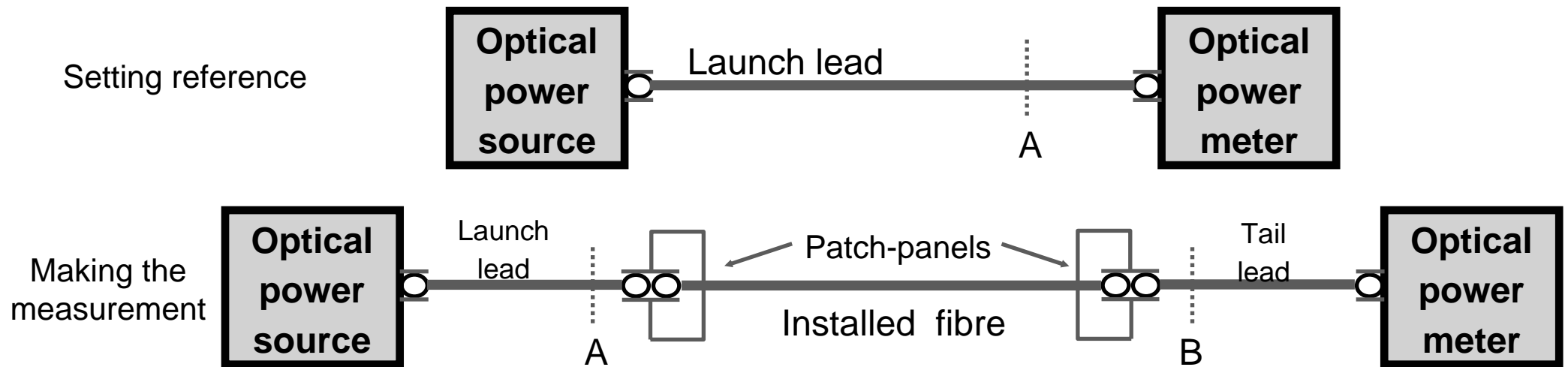
Loss Measurement: Length of fibre only

Attenuation for a length of fibre only (connectors not included)



- A short reference lead is used for X and the received power P_1 is recorded
 - The lead X is replaced by the length of fibre and received power P_2 is recorded
 - Attenuation in the fibre length is $P_1 - P_2$
 - Fibre length under test and the reference lead must have the same geometry and connectors for the same manufacturer
 - Most power meters incorporate a dBr (dB relative) function to assist in measurements
-  Optical connector

Loss Measurement: Patch-panel to Patch-panel



- A launch reference lead is connected as shown and the optical power P_1 is recorded
- The power P_1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the local patch panel
- The power meter is taken to the remote patch panel and connected by a reference tail lead
- The power level P_2 is then measured and the loss between A and B is $P_1 - P_2$
- Fibre under test and the reference lead must have the same geometry and connectors for the same manufacturer

Appendix A:

Loss Measurement Technique

(Adapted from BS7718)

Figure 1

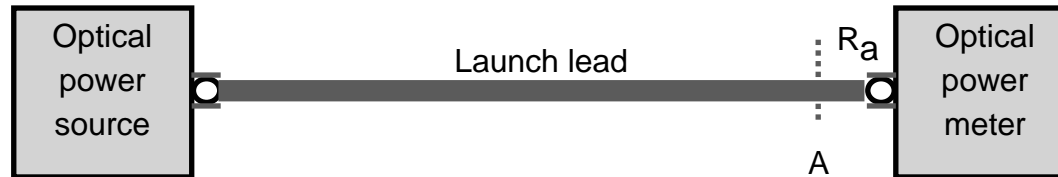
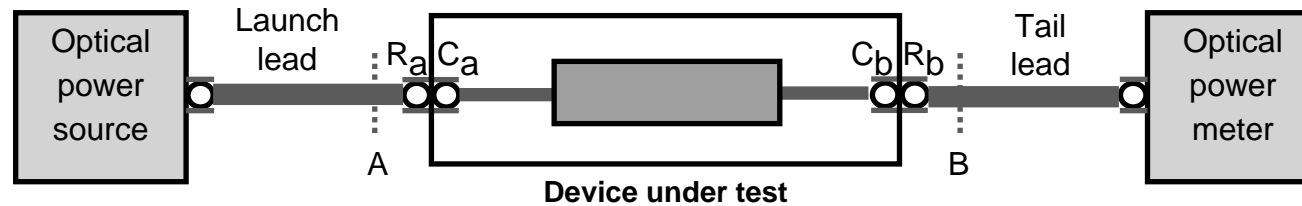



Figure 2



Assumes equilibrium mode conditions reached in launch lead

 = Mated pair of optical connectors

- A launch lead is connected between the source and meter (Figure 1)
- The optical power P_1 is recorded in dB
- The power P_1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the DUT input connector C_a (Figure 2)
- The power meter connected to the DUT output by the tail lead using C_b
- The power level P_2 in dB is then measured
- The DUT loss/attenuation is found as $P_1 - P_2$ (dB)

Loss Measurement (II):

- A launch lead is connected between the source and meter
- The optical power P_1 is recorded in dB
- The power P_1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the DUT input connector C_a
- The power meter connected to the DUT output by the tail lead using C_b
- The power level P_2 in dB is then measured
- The DUT loss/attenuation is found as $P_1 - P_2$ (dB)