FIBRE-OPTICS POWER METER

INSTRUCTION MANUAL

ELLMAX
ELECTRONICS

FIBRE-OPTICS POWER METER

ELLMAX ELECTRONICS LTD.
Unit 29, Leyton Business Centre, Etloe Road,
Leyton, London E10 7BT, England
Tel: 020-8539 0136 Fax: 020-8539 7746
Email: ellmaxelec@aol.com Web: www.ellmaxelec.com

 Version 2.1

CONTENTS

Page

Introduction

The Ellmax Fibre-Optics Power Meter measures the mean optical power emanating from an SMA* terminated cable, and has a measurement range of below 1nW to 1mW, and -60dBm to 0dBm. A meter pointer indicates the received optical power level, and this meter has both linear and dBm scales. Examples of the type of optical measurements that may be made with the meter are:

a) transmitted power levels
b) minimum and actual received power levels
c) attenuation measurements of cable routes
d) long-term monitoring of route attenuation, using the meter output socket.

A pointer scale has been incorporated into the equipment in favour of a digital readout, since a scale has a number of advantages:

1. it is easier to read at a glance
2. changing optical levels are easily interpreted on a pointer scale
3. dBm and linear scales can be combined on the one meter face.

The main advantage of a digital readout over a pointer scale is that the reading accuracy is higher. This advantage can also be obtained with the Ellmax meter by connecting a DVM, set to d.c., to the output socket of the meter, where the linear full scale reading = 1.00V.

The meter is calibrated at a wavelength of 820nm, and the response is relatively flat between 800nm and 850nm, varying less than 4% between these wavelengths.

** SMA or other connector option.*

The Fibre-Optics Power Meter contains the following items:

METER
2.5mm FREE CONNECTOR
CABLE WITH 3.5mm CONNECTOR TO CROC. CLIPS
BATTERY
INSTRUCTION MANUAL (THIS BOOK)
CARRYING CASE

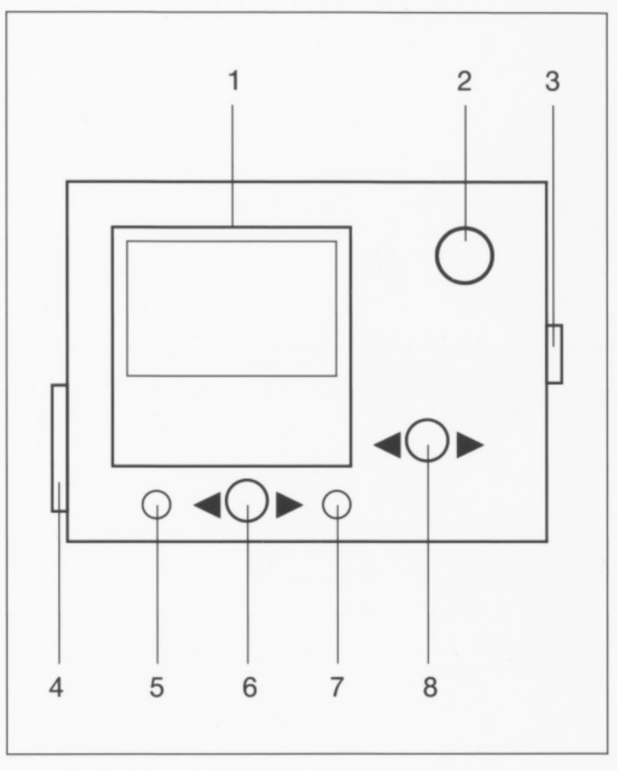
FIBRE-OPTICS POWER METER

1. Analogue meter showing received optical power level, with dBm and linear power scales. Also gives battery check indication.
2. Rotary range switch with following six dial settings:

   dBm: —50, —40, —30, —20, —10, 0
   Watts, linear full scale: 10nW, 100nW, 1µW, 10µW, 100µW, 1mW.

   For dBm reading, add switch setting to dBm scale of meter reading.
   For Watts reading, switch setting is linear full scale meter reading.
3. Large area Si receive diode housing with SMA* (Standard 9mm) connector, for optical input.
4. Battery holder for 9V 'radio' battery. Typical life for alkaline battery is 500 hours.
5. Output socket, 3.5mm, 5kΩ output impedance. Linear full scale = 1.00V. Maximum signal without overload = 2V. Output is for long-term monitoring applications, or high accuracy of reading using a DVM set to d.c.
6. ON/OFF/BATTERY CHECK switch for battery. Does not control optional external supply.
7. 2.5 mm socket for optional external supply of +7V to +15V d.c. For long-term monitoring applications (current drawn is typically 1.0 mA at 9V).
8. Momentary toggle switch for optimum accuracy of scale reading. Two ranges of +3dBm, Watts x2 and —3dBm, Watts x 1/2.

**SMA or other connector option.*



CONNECTING POWER SUPPLIES TO METER

(a) Batteries

The Fibre-Optics Power Meter operates off a single PP3-type 9V battery, located in the battery compartment on the side of the equipment. The meter is supplied with the battery already fitted.

To change the battery, push the front cover of the battery holder in the direction of the arrow on the cover (using a nail or coin in the slot provided) to release the catch, and then pull out the drawer. Make sure the new battery is inserted correctly according to the diagram in the base of the battery drawer. Once the battery is in place, push the drawer firmly back into the holder. An alkaline battery is to be preferred, because it has a longer operating life. A Rechargeable Nickel Cadmium battery may conveniently be used if prolonged portable use of the equipment is required.

In order to preserve battery life as much as possible, make sure that the battery is switched off when the unit is not in use.

The battery check switch on the front panel enables a reading of the battery voltage under load conditions to be given on the linear scale of the meter. This voltage should not be less than the minimum of the 'battery check' band shown on the meter scale. The typical battery life for an alkaline battery is 500 hours.

(b) External Power Supplies

A power supply socket (2.5mm) is provided on the front panel for applications which require prolonged use of the unit. The supply voltage should be in the range +7V to +15V d.c. - IT IS IMPORTANT THAT THE +15V MAXIMUM IS NOT EXCEEDED. Diodes are connected in series from the supply socket and also from the battery supply to the circuitry, ensuring that reverse polarity will not damage the equipment. These diodes also ensure that current cannot flow between power sources, and that the equipment draws current from the source with the maximum supply voltage if more than one supply is connected up. The battery ON/OFF/BATTERY CHECK switch only controls the connection to the battery, and not to the external supply socket.

USING THE FIBRE-OPTICS POWER METER

Taking a Measurement

To measure the optical power level at an SMA* terminated cable, first use the battery check switch to ensure that the battery is O.K., and then switch the battery ON (refer to the previous section for a full description of connecting power supplies). Connect the SMA* terminated cable to be measured to the SMA* detector housing at the side of the meter. Set the rotary switch to the position that gives the maximum on-scale meter deflection, then note the scale reading and the switch position in dBm or Watts, as required, and combine them according to the following instructions:

(i) dBm:
add switch dBm setting to dBm scale reading of meter. For example, a switch setting of —30dBm, and a scale reading of —2.4dBm, gives a measurement of —32.4dBm.

(ii) Watts:
the switch Watts setting is the linear full scale meter reading. For example, a switch setting of 1µW, and a scale reading of 7.3 gives a measurement of 0.73µW (since the full scale reading of 10 units is equivalent to 1µW, as set by the switch position).

For optimum accuracy of scale reading (i.e. to maximise the on-scale meter deflection), the toggle switch should be used according to the instructions given above the meter scale. The dBm measurement is then obtained by adding the toggle dBm setting to the combined result of the scale reading/rotary switch setting. The measurement in Watts is obtained by multiplying the toggle watts setting by the combined result of the scale reading/rotary switch setting.

In order to obtain digital readout accuracy, a Digital Voltmeter (DVM) set to d.c. may be connected to the output socket. The linear full scale meter reading, as set by the switch position, is equal to 1.00V on the DVM. For example, a switch setting of 10µW and a DVM reading of 0.655V gives a measurement of 6.55µW (since the full scale reading of 1.00V is equivalent to 10µW, as set by the switch position). The DVM reading is essentially a linear measurement in Watts, but it may be converted to dBm by using the formula given in the next section.

To measure extremely low power levels (below 200pW), the "dark" reading (i.e. the DVM reading with the dust cap on the diode housing) should be subtracted from the DVM reading of the power level being measured, with the meter set on its most sensitive range of 10nW. In this way, it is possible to measure power levels below 50pW.

dBm or Watts

Either dBm or Watts may be used as units in optical power measurements, and the choice is left to the user of the equipment. dBm units are often preferred in optical insertion loss or attenuation measurements, since dB losses **add** through an optical route. Linear power units are frequently used in measuring transmitted output power levels and minimum received power levels, since terminal equipment is often specified in these units.

It is easy to convert from one unit to another by using the formula that defines dBm:-

dBm = 10 $\log_{10}$ P, where P is the power in **m**W, and, conversely, P = anti-$\log_{10}$ (dBm/10), or 10 to the power of (dBm/10).

**SMA or other connector option.*

Also, the units of dBµ are sometimes used, with dBµ = 10 $\log_{10} P_O$, where P_O is the power in µW. It follows that dBµ = dBm +30.

Optical Cable Attenuation Measurements

The Fibre-Optics Meter, in conjunction with an optical transmitter (which may be either the system transmitter or another transmitter unit such as the Ellmax Fibre-Optics Monitor Transmitter), can be used to measure or monitor (over a period of time) the attenuation (or insertion loss) of an optical route which is terminated in SMA* connectors. To measure the attenuation, readings are taken of optical power levels into the route (e.g. the power launched by the transmitter through a short reference length of the same fibre type as the route cable), and out of the route length (i.e., with the transmitter launching light directly into the route).

Calculating the route loss from the power levels into and out of the route is carried out as follows:

dBm: If dBm_1 is the power level into the route, and dBm_2 is the power level out of the route, then the route loss in dB = dBm_1 — dBm_2.

linear: If P_1 is the power level into the route, and P_2 is the power level out of the route, then the route loss in dB = 10 $\log_{10} P_1/P_2$ where P_1 and P_2 are in the same units.

Note that route loss has the units dB (not dBm or dBµ), since the loss is not relative to any absolute power level.

The attenuation of a cable route with end connectors other than SMA* may also be measured using the Fibre-Optics Meter by using short (one metre or less) interface cables connecting the meter to the route and reference cables. The interface, reference, and route cables should all be of the same fibre type for consistency of measurement. Also, for bare fibre, an SMA* bare fibre adaptor may be used,

Attenuation Monitoring Procedure

The Fibre-Optics Meter has a low temperature coefficient (±0.1%/°C or ±0.005dB/°C), and so it may be used for monitoring (over a long period of time) the attenuation of an optical route, if it is used in conjunction with a highly stable transmitter, such as the Ellmax Fibre-Optics Monitor Transmitter. For long-term monitoring, it may be convenient to use external power supplies (see Power Supplies section), and also to feed the Meter Output signal into a recording device such as a chart recorder.

Changes in route attenuation may of course be calculated without recourse to the reference signal level, using the above two formulae to give the **change** in attenuation, where the two power level readings are two readings, separate in time, of the optical route.

Additional notes for all attenuation measurements

For highly accurate route attenuation measurements of small core fibres, it may be necessary to maintain the same launching conditions at the transmitter for both route and reference readings. This is achieved by first measuring the route power level, and then cutting back the fibre close to the transmitter and measuring the signal out of this reference length. To do this, connect the cut fibre end into a low loss temporary joint, the other end of which is a similar fibre terminated in an SMA* connector, or alternatively, use an SMA* bare fibre adaptor.

**SMA or other connector option.*

It should also be noted that in order to measure the loss per unit length of a route without including the effects of a non-equilibrium light distribution at the reference fibre, then a reference length of a few hundred metres should be used, and the difference in length between the route and reference fibres must then be taken into account in the loss per unit length calculation. Alternatively, an equilibrium mode simulator and a cladding mode stripper may be used at the transmitting end to artificially produce an equilibrium distribution at launch.

Measurements at other wavelengths

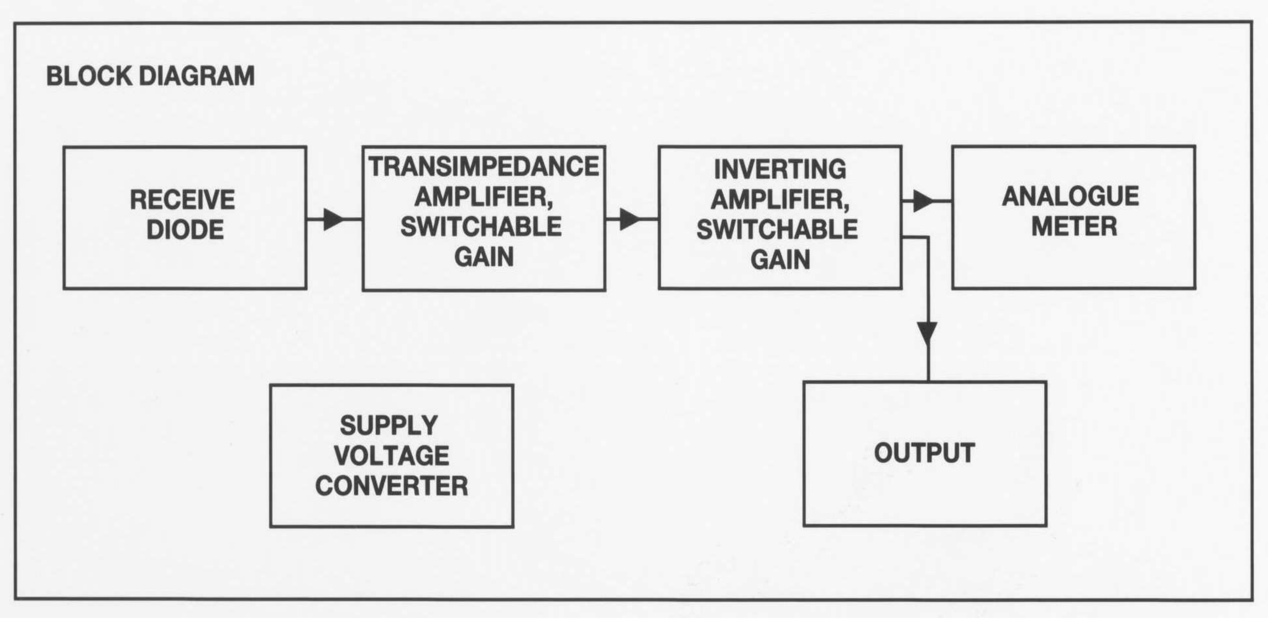
The Fibre-Optics Power Meter may be used to measure optical power at wavelengths other than 820nm, the calibration wavelength of the Meter. This is done by referring to the table in Appendix A, which gives the typical response against wavelength of the Meter's photodiode, and then utilising the ratio of the response at 820nm to that at the wavelength to be measured, according to the Calculation Example given at the end of Appendix A.

Measurements with AMP DNP connectors (as used in the Ellmax FIBRE-OPTICS EDUCATOR)

The Fibre-Optics Power Meter may be used directly to measure the light coming from polymer cables terminated with AMP DNP connectors (as well as SMA connectors). No interface cables (which are referred to above under the heading 'Optical Cable Attenuation Measurements') are needed. For example, the Meter may be used directly with the Ellmax Fibre-Optics Educator, which has AMP DNP connectors and which transmits at 660nm. AMP DNP connectors fit snugly into the SMA connector receptacle of the Meter, and ambient light is shut off at this connection. All the light from the end of the AMP DNP terminated polymer cable is collected by the Meter's receive diode if the AMP DNP connector is pushed as far as possible into the SMA connector housing.

Although the Fibre-Optics Educator transmits at 660nm and the Fibre-Optics Power Meter is calibrated at 820nm, the Meter's reading of the output power of the Fibre-Optics Educator may be used directly, as it would still be accurate to within around -20%. For more accurate measurements, the Meter reading needs to be converted using the method given on this page under the heading 'Measurements at other wavelengths'. The Calculation Example given at the end of Appendix A in fact uses the actual wavelengths involved.

BRIEF TECHNICAL DESCRIPTION OF METER



The large area receive diode mounted in the connector housing is connected in the photovoltaic mode to the transimpedance amplifier, so that noise and dark current are minimised.

Both the transimpedance amplifier and the following inverting amplifier are chopper stabilized op. amps, which have extremely low offset voltage and bias current characteristics.

A supply voltage converter provides the op. amp. negative voltage rail from the single supply voltage.

METER SPECIFICATIONS

Measurement Range: Linear: 200pW to 1mW
dBm: -60dBm to 0dBm

Accuracy: Response: ±5% or ±0.2dB (at 820nm)
Between Ranges: ±1%
Scale Reading: ±1.5% of full scale

Calibration Wavelength: 820nm (less than 2% variation from 800nm to 850nm)

Wavelength range for response greater than 20% of 820nm response: 400nm to 1,000nm

Photodiode: Silicon p-i-n (typically 0.50A/W at 820nm - see Appendix A for typical response v. wavelength),
15 mm^2 sensitive area, square,
1.4mm optical distance

Complete light acceptance by diode sensitive area for fibre up to: diameter: 1mm
N.A.: 0.5

Optical Connector: SMA* (Standard, 9mm)

Output socket: 5kΩ output impedance
Linear full scale = 1.00V
Maximum voltage without overload = 2V

Output Settling Time to with 1%: Less than 3 sec.

Operating Temperature Range: 0°C to 50°C

Temperature Coefficient at 820nm: ±0.1 %/°C

Power Supply: 9V PP3-type battery
Optional d.c. supply: +7V to +15V d.c.
Current is 1.0 mA typical at 9V
Typical alkaline battery life is 500 hours

Physical Characteristics : Dimensions: 175 x 112 x 60mm approx.
Weight: 600gm approx.

**SMA or other connector option.*

While the information is true at the time of printing, small production changes in the course of the company's policy of improvement through research and design might not be indicated in the specifications.

APPENDIX A

CALIBRATED RESPONSE OF A REFERENCE DIODE OF THE TYPE USED IN THE METER

Temperature: 21°C
Uncertainty: ±5%

WAVELENGTH (nm)	RESPONSE (A/W)
450	0.279
460	0.283
480	0.306
500	0.328
520	0.345
540	0.357
560	0.366
580	0.373
600	0.407
620	0.414
640	0.426
660	0.437
680	0.446
700	0.455
720	0.471
740	0.489
760	0.499
780	0.512
800	0.498
820	0.504
840	0.509
860	0.516
880	0.516
900	0.494
920	0.487
940	0.468
960	0.423
980	0.369
1000	0.319
1020	0.261
1040	0.184
1060	0.074
1080	0.070
1100	0.068

Calculation Example: To calculate the power level of light at a wavelength of 660nm with the Fibre-Optics Power Meter, which is calibrated at 820nm, multiply the linear reading by 0.504/0.437, i.e. 1.15 (or add 0.6dB to the dBm reading).

ELLMAX ELECTRONICS

FIBRE-OPTICS AND OPTO-ELECTRONICS

Ellmax Electronics Limited, Unit 29, Leyton Business Centre, Etloe Road, Leyton, London, E10 7BT
Tel: 020-8539 0136 Fax: 020-8539 7746
Email: ellmaxelec@aol.com Web: www.ellmaxelec.com

CE

This fibre-optics equipment complies with the EMC (Electromagnetic Compatibility) directive of the European Community and meets or exceeds the following technical standards:

EN 50081-1 - "Electromagnetic compatibility generic emission standard Part 1: residential, commercial and light industry."

EN 50082-1 - "Electromagnetic compatibility generic immunity standard Part 1: residential, commercial and light industry."

ELLMAX ELECTRONICS LTD.
Unit 29, Leyton Business Centre, Etloe Road,
Leyton, London E10 7BT, England

Tel: 020-8539 0136
Fax: 020-8539 7746
Email: ellmaxelec@aol.com
Web: www.ellmaxelec.com