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FIBRE-OPTICS EDUCATOR

A New Concept in Optical Equipment

The Fibre-Optics Educator is a versatile product that can be used for numerous applications, especially in the areas of **testing, transmission,** and **training.** The Educator consists of the following items:

OPTICAL TRANSMITTER, with infra-red l.e.d., red l.e.d., variable output control; variable frequency pseudo-random and square wave generators; TTL, CMOS, and RS232 voltage levels and manual digital inputs; high and low impedance analogue inputs, and variable analogue gain. Power is from an internal battery, or single external dc power supply (9V to 15V). A mains adaptor socket is also provided.

OPTICAL RECEIVER, with loudspeaker analogue output, and high and low impedance analogue outputs, variable analogue gain; buzzer digital output, and TTL, CMOS, and RS232 voltage levels digital outputs, variable digital sensitivity. Power is from an internal battery, or single external dc power supply (9V to 15V). A mains adaptor socket is also provided.

ACCESSORIES, including comprehensive instruction manual, book on telecommunications, 2 lengths (1m and 5m) of terminated plastic optical cable, optical connector, microphone, radio, torch, earpieces, mirror, and various electrical connectors.

All items come complete with batteries, and the Educator is housed in a customised case.

Designed and Manufactured in the U.K.

APPLICATIONS OF THE FIBRE-OPTICS EDUCATOR

TEST EQUIPMENT

The Educator transmitter and receiver units form useful pieces of portable test equipment in a fibre-optics and general optics laboratory, production facility or at an installation site.

In conjunction with an a.c. voltmeter, the Educator can accurately measure the attenuation of fibre-optics cable at 660nm wavelength to a range of 50dB. The separate transmitter and receiver modules allow the measurement of installed cable routes, as well as cable on a reel or drum. Cables terminated with AMP DNP connectors can directly interface to the Educator units, and cables terminated with other types of connectors can also be tested by using appropriate interface cables.

The Educator receiver may be used in the analogue or digital mode to test out optical transmitters. Also, its analogue loudspeaker output and digital buzzer output make it particularly useful for giving an audible indication of the presence of infra-red radiation at locations such as the remote ends of cable links, cable breaks, bad joints, and "lossy" optical coupling arrangements. A short length of optical cable (which is one of the accessories supplied with the Educator) acts as a convenient probe for the detection of optical radiation. The receiver has a high sensitivity, detecting down to 15nW on digital mode, and below 100pW on analogue mode.

The transmitter can function in either analogue or digital mode as a versatile optical source for testing out optical receivers. As well as utilising the internal variable frequency pseudo-random and square wave generators, an external signal generator may be connected to provide optical data trains up to a rate of 0.5 MBit/s. The output power control, which has a range of 20dB, provides a useful feature for receiver sensitivity checking. Optical power may be launched into the item to be tested from either the red I.e.d. housed in an AMP DNP connector, or from the un-housed infra-red I.e.d.

It is also possible to accurately measure optical absorption or reflection properties of various materials at the wavelengths of the emitting devices.

Another application of the Educator receiver is the non-contact measurement of the frequency of a rotating disc or vibrating object using light reflection or transmission, with a length of optical cable acting as a probe. The Educator may also be used in an optical pulse counting system for applications such as quality assurance, and scientific and engineering experiments.

TRAINING

The numerous demonstrations and test equipment applications that are possible with the Fibre-Optics Educator make it an ideal product to use for the training of engineers, technicians, and executives in the fast growing field of fibre-optics. The product is suitable for use in industry, colleges, and technology training centres. Many fundamental concepts of optical transmission may be shown in a constructive and convincing way. Examples of the demonstrations that may be carried out are:

- transmission of speech and music over optical cables and free-space. An FM radio and a microphone are included with the package for use as signal sources;
- transmission of digital signals over optical cables and free-space, with the integral morse key and pseudo-random and square wave generators acting as convenient sources;
- showing the relationship between received optical power and digital threshold sensitivity;
- showing the method of measuring optical fibre attenuation;
- demonstrating the variation of optical fibre attenuation with wavelength;
- showing some of the benefits of optical transmission over conventional electrical transmission;
- use of a metal diaphragm together with a torch (both of these are included in the package) to produce a novel means of transmitting analogue information;
- showing the properties of both visible and infra-red radiation;
- listening to noise sources, such as thermal and shot noise.

A buzzer and a loudspeaker may be switched into the digital and analogue circuits respectively, and these provide convenient audible outputs for demonstration purposes.

A comprehensive 40 page manual is included with the equipment, and this describes with many diagrams, the applications and demonstrations that may be carried out with the Educator, as well as giving a **practical** introduction to the principles, applications, components, opto-electronic interface circuits, and system parameters of fibre-optics.

The Educator may also be used for training in the techniques of modern telecommunications in general, and a book on telecommunications is also included to aid the preparation of a suitable course.

TRANSMISSION EQUIPMENT

The Fibre-Optics Educator can transmit **analogue or digital** data over **free-space** or **optical fibres.** With low-cost plastic fibre, transmission distances over 100 metres are possible. The normal advantages of a fibre-optics link over a conventional electrical system may be obtained with the Educator, for example:

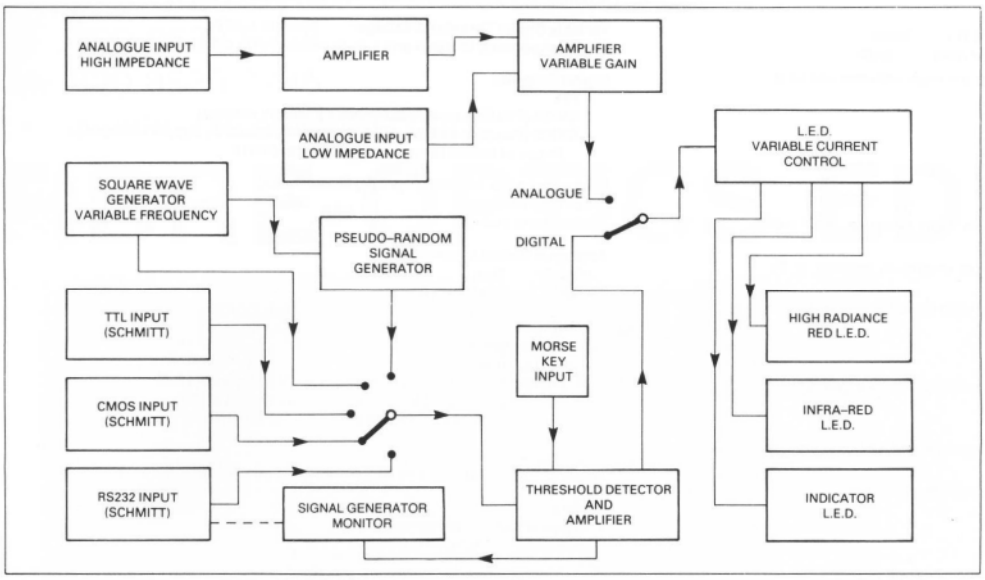
- immunity to electrical interference
- complete electrical isolation
- secure transmission, with no radiated waves from the cable
- no earth loops

TTL, CMOS, and RS232 voltage interfaces are available at the transmitter and receiver, and the system operates at digital rates from **DC** to 20kBit/s. A buzzer may also be switched into the digital circuit to give an audible indication of the output.

Both high and low impedance analogue interfaces are incorporated in the transmitter and receiver units, and the receiver also contains a loudspeaker which may be switched into the analogue output. The analogue bandwidth covers the range 25Hz to 25kHz.

The Fibre-Optics Educator is ideal for utilising or assessing the benefits of fibre-optics systems over conventional transmission systems, and the novel switchable digital/analogue nature of the Educator allows great flexibility in the type of data that can be transmitted. Also, for those organisations with no practical experience of fibre-optics, the Educator provides an effective means of obtaining a "hands-on" introduction to this new technology.

The following diagrams show the functions of the Educator transmitter and receiver units in simplified form:

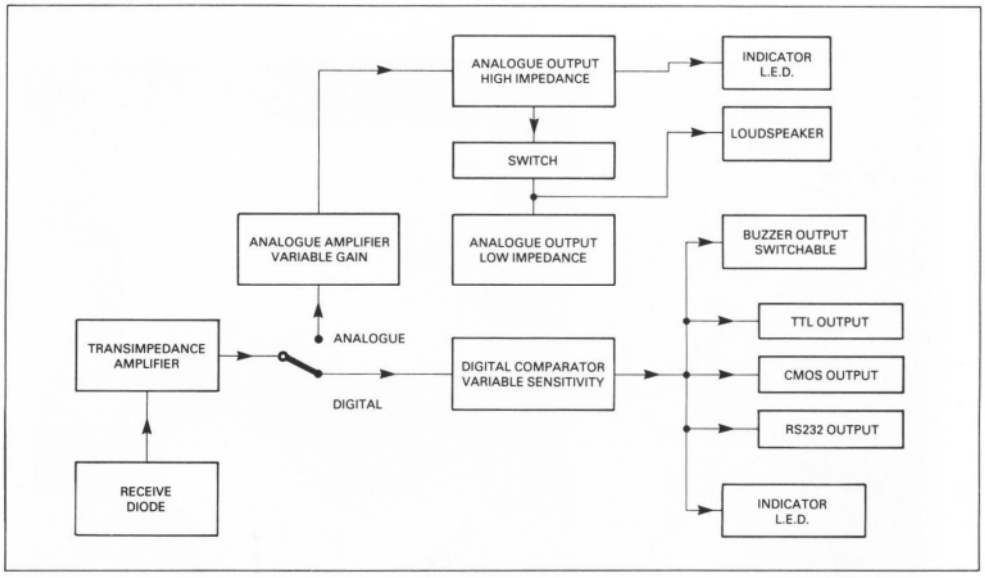


FIBRE-OPTICS EDUCATOR TRANSMITTER

BLOCK DIAGRAM

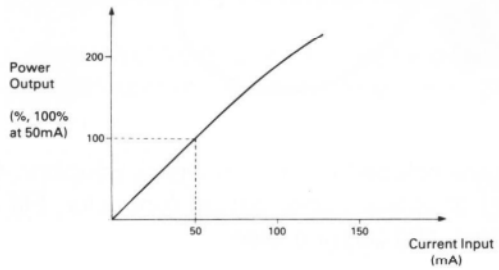
FIBRE-OPTICS EDUCATOR RECEIVER

BLOCK DIAGRAM



To give an indication of the scope and format of the manual, a sample page is reproduced below (in reduced size):

Figure B.2.2.1 *Power Against Current for Typical L.e.d.*



The roughly linear nature of the power/current graph at low currents enables analogue transmission to be carried out by biasing the diode at a low current, and then adding a modulating current signal that is proportional to the original voltage, but the signal current must be kept small in order to minimise distortion resulting from the fact that the power/current curve is not exactly linear.

To ensure minimum losses in launching light from an l.e.d. into a fibre, the emitting area of the device should be less than the core area of the fibre (otherwise the loss factor due to area mismatch will be proportional to the relative areas). It is also important to take into account the Numerical Aperture of the fibre (see Section B.2.1) when estimating launched power, since light rays at angles outside the angle of acceptance will not propagate down the fibre. The amount of light launched into a step index fibre from a device in contact with the fibre = $R\pi$ (N.A.)^{2}a Watts, where:

R is the radiance of the device in Watts/Steradian/cm^2;

N.A. is the Numerical Aperture of the fibre;

a is the area in cm^2 of the device or the fibre, whichever is the smaller.

A factor of 0.5 appears in the above equation when a graded index fibre is being considered.

Typical optical power levels that are launched into a fibre at a 50mA l.e.d. drive current are in the order of 25 micro-Watts (i.e. 25 millionths of a Watt).

B.2.2.2 Lasers

Semiconductor laser diodes produce a higher intensity output than l.e.d.s, and can normally be modulated at higher frequencies. However, they are more expensive and more complicated to drive than l.e.d.s and can only be justified for high data rate, long distance communications. Fig. B.2.2.2 shows a typical power/current curve for a laser diode. Below a certain current, called the threshold current, the output power is relatively small, since the device is operating principally as an l.e.d. Above the threshold current, lasing begins to occur and the power output rises dramatically. A typical optical power level launched into a fibre by a laser is in the region of 10 milli-Watts (i.e., ten thousandths of a Watt).

As the optical power output for a laser varies so sharply with current it is essential to provide optical feedback from the output of the device in order to detect the value of the threshold current. This fact makes laser driver circuitry design relatively complex compared to l.e.d. driver design.

Brief Specifications of Fibre-Optics Educator

a) Transmitter/Receiver Combination

Bandwidth:
- **Analogue:** 25Hz to 25kHz (3dB points)
- **Digital:** d.c. to 20kBit/s

Range for analogue transmission (better than 40dB S.N.R.): 25dB

Range for digital transmission (better than 1 in 10^9 error rate): 25dB

(The above transmission ranges are for a fibre link, with the high radiance red l.e.d. being used to launch light into a 1mm plastic fibre)

Attenuation measurement range: 50dB

Operating Temperature Range: O°C to 50°C

Optical Connectors: AMP DNP

b) Transmitter

Typical power launched into 1mm plastic fibre from high radiance red l.e.d: 20mW peak (at maximum setting) at 9V supply

Typical output power from infra-red l.e.d: 2mW (at maximum setting) at 9V supply

Variable l.e.d drive control: 20dB range (± 3dB), for high radiance red l.e.d.

Schmitt Threshold Levels:
- **TTL:** 1.2V and 1.6V
- **CMOS:** 2.8V and 3.8V
- **RS232:** 0.35V and 0.8V (optical output phase opposite to TTL and CMOS)

Signal Generator:
- 127 bit length pseudo-random generator
- Variable clock rate: 20Hz to 4.5kHz (for square wave and pseudo-random signal)

Maximum Transmitted Data Rate for less that 10% pulse width distortion:
- **TTL:** 0.5 MBit/s
- **CMOS:** 100kBit/s
- **RS232:** 0.5 MBit/s

Input impedance at analogue sockets:
- **Low Z:** 80Ω to ground
- **High Z:** 20kΩ, capacatively coupled
- High Z and Low Z inputs are at the same phase

c) Receiver

Receive Diode: Silicon P-i-n

Minimum power for better than 1 in 10^9 error rate: 50nW peak at 660nm

Variable Digital Threshold Voltage: 30mV to 1.25V (corresponding to 30nW and 1.2µW respectively at 660nm)

Digital Outputs:
- TTL
- CMOS (Positive level determined by supply voltage)
- RS232 (Positive and Negative levels determined by supply voltages) Phase of RS232 is opposite to TTL and CMOS

Minimum Power for 40dB Signal to Noise Ratio:
- 50nWpp at 660nm
- 25nWpp at 940nm

Analogue Output Impedance:
- **High Z:** 1kΩ
- **Low Z:** less than 1Ω

d) Power Supply:

9V PP3-type battery

Optional external d.c. supply:
1) Transmitter +9V to +15V (current is 25mA typical at 9V)
2) Receiver +9V to +15V (current is 25mA typical at 9V) and -9V to -15V (5mA) for RS232 Interface

e) Physical Characteristics

Dimensions: 200 x 130 x 90mm approx. for each unit

Weight:
- **Transmitter:** 750gms approx.
- **Receiver:** 900gms approx.

Besides the optical transmitter and receiver units, the following accessories are included in the Fibre-Optics Educator: 40 page instruction manual, book on telecommunications, 2 lengths (1m and 5m) of terminated plastic optical cable, optical connector, FM Radio, microphone, torch, mirror, earpieces, various electrical connectors, and carrying case.

For further details contact:
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