H28627 Comprehensive Fibre Optics Apparatus NFU 319M

This apparatus is designed to demonstrate the transmission of information and determine the speed of light in an optical fibre.

Apparatus Detail

The apparatus comprises two printed circuit boards, a transmitter and a receiver. Both boards require a 6V smoothed d.c. supply, which can be common to both, or two separate supplies. The transmitter is linked to the receiver by 1mm diameter optical fibre inserted into connectors.

The transmitter is provided with modulation input sockets and output monitor sockets suitable for either 2mm or 4mm plugs. A 300 kHz oscillator is included to provide the required modulation for determining the speed of light transmission. The optical output is a red light emitting diode (LED) at 630nm.

The receiver has two pairs of output sockets:

OUTPUT I is a direct coupled output from zero frequency to 5 kHz and is suitable for both analogue and digital signals. Potentiometers are provided to adjust both zero and gain.

OUTPUT 2 is a high speed digital output of approximately 5V peak value. It will operate from below 20Hz to 300 kHz with 20 metres of fibre. This output is used to measure the speed of light transmission and for fast digital communication.

The optical fibre is a double layer polymer of 1mm nominal diameter, 25m long.

version H28627.15.05

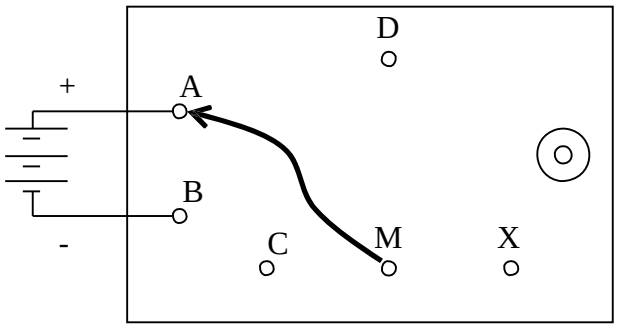
Operating Instructions

Important Note: The plastic fibre can be cut with a sharp knife or scalpel against a hard surface. It is suggested that initially it is cut into one length of 20m and another of 5m. The 20m length is retained for speed of light and communication experiments; the 5m length can be cut up for other experiments.

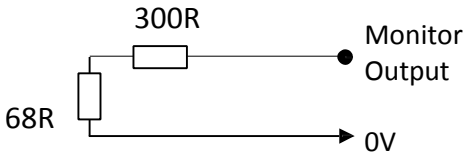
If fibre is being used with the receiver alone, the cut end can be rounded off to form a convex lens by removing the outer cover and holding it vertically for a very short time over a match flame. Do **not** attempt to force an end formed in this way into the fibre connectors on either the transmitter or receiver boards.

Experiments Using the Optical Transmitter Alone

Investigation of Modulation



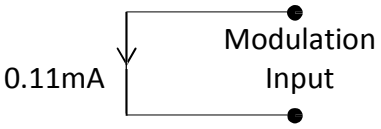
1. Connect a battery or smoothed d.c. supply of 5-6V to POWER INPUT. On looking through the small hole, the red LED will be seen to glow.
2. Connect a lead from the MODULATION INPUT (middle socket) to the posi-tive supply input A. The light will increase in brightness.
3. Connect the lead from M to C, to short the modulation input. The light will decrease in brightness.
4. A high resistance voltmeter can be connected between a DV socket (8 or C) and the MONITOR OUTPUT. This measures the potential difference across a 68 ohm resistor effectively in series with the LED.

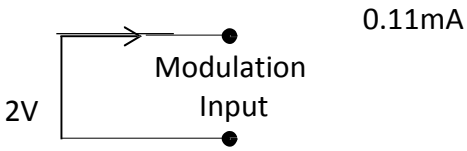


The voltage will be found to vary between 0.1V and 2.5V, giving an LED current of 0.1/68 or 2.5/68, e.g. 1.5 or 37mA respectively.

The circuit is designed so that the LED does not go out completely. If it did, the maximum usable rate of modulation would be reduced.

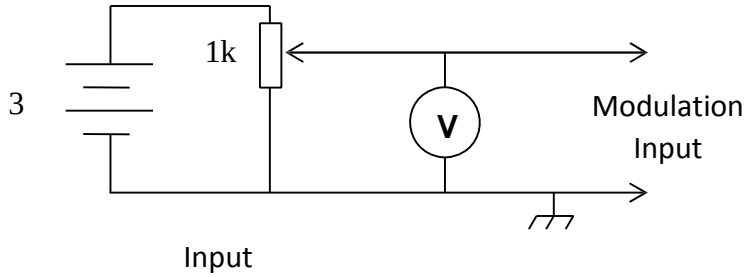
5. The modulation input will supply a current of about 0.11mA when shor-ted to DV, and it requires an input current of about 0.11mA when fed from a 2V supply. With no input, the potential difference between the sockets is about 1. 2V.
Modulation input voltages up to ±15V will not do any damage.



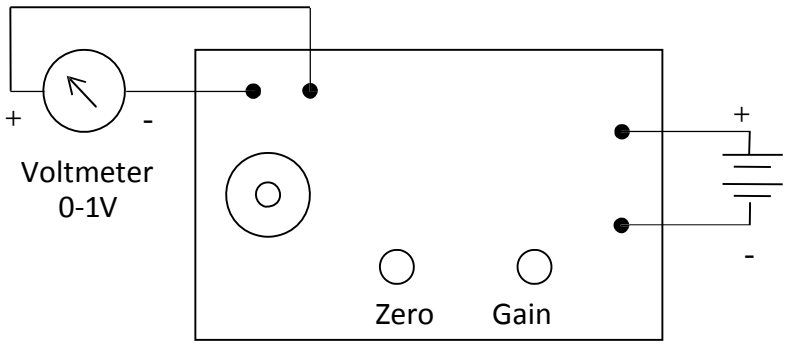


A graph can be plotted to show MONITOR OUTPUT voltage, or LED current, against MODULATION INPUT voltage. The MODULATION INPUT voltage can be varied from about 0-3V from two cells and a potentiometer of about 1000 ohms.

6. The 300 kHz MODULATION can be observed with an oscilloscope. It will be seen to be a square wave of about 300 kHz, and 5.5V peak to peak.



Experiments Using the Optical Receiver Alone



1. Connect the POWER INPUT to a 6V battery or smoothed d.c. supply of 5-6V.
2. Connect an analogue or digital voltmeter of range 0-lV to the OUTPUT 1 socket.
3. Turn the GAIN control fully anticlockwise. If there is not much light entering the fibre orifice, it will be found that the ZERO control can be used to shift the output voltage between OV and about + 0.4V.
4. With a light shone into the orifice, it will be found that the GAIN control can adjust the sensitivity over a range of about 15:1. It also has affect upon the zero. The minimum output voltage will probably be about 50mV at high gain.

   Note: When the gain in nearly correct (for the required application), the light into the receiver orifice should be adjusted to its minimum, and the zero control turned clockwise from fully anticlockwise, until the output voltage just starts to increase from its minimum value with the ZERO control turned anticlockwise. E.g. at maximum gain, the minimum output voltage might be about 30mV (0.03V). The ZERO control should be turned clockwise until the voltage increases to say 50mV. The amplifier will then be linear from 50mV to above 1V output.

5. OUTPUT 2 - This is a digital output which, with no light modulation, could either be at OV, or at about +5.5V. If a mains voltage lamp is held near to the orifice, a square wave of 100Hz will be observed at OUTPUT 2 (120Hz in the USA).

   The GAIN and ZERO controls have no effect upon OUTPUT 2.

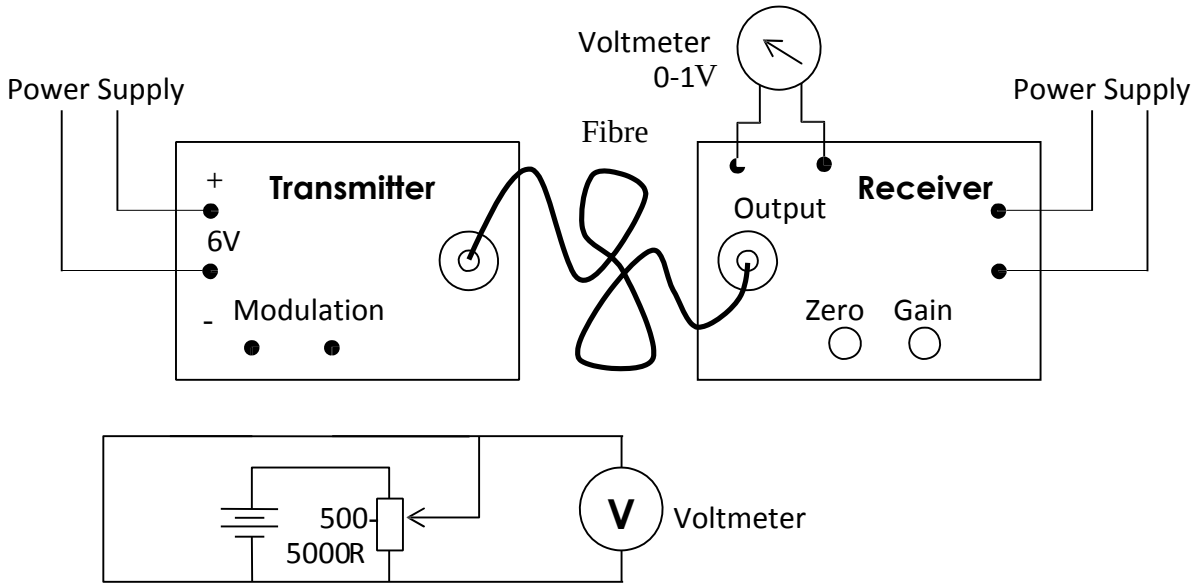
   Note: OUTPUT 2 is intended to be used for fast data transfer, and for measuring the speed of light through a fibre. OUTPUT 1 is more suitable for use at frequencies up to about 5 kHz, as it will also work down to d.c.

version H28627.15.05

Experiments using both the OPTICAL TRANSMITTER and the OPTICAL RECEIVER

Investigation of low frequency transfer of analogue voltage from Transmitter Input to Receiver Output

1. Connect the POWER INPUT sockets of the Optical Transmitter and Optical Receiver to single or separate smoothed d.c. supplies of about 5-6V. Dry cells may be used as an alternative supply.
2. Connect a 3V battery to a potentiometer of about 500-5000 ohms. The output from this should be connected to a voltmeter and the MODULATION INPUT of the Transmitter.
3. Connect a voltmeter of range 0-1V or 0-3V to OUTPUT 1 of the Receiver.



4. Cut the ends of a piece of optical fibre off square by pressing with a sharp knife or scalpel against a hard surface. Insert the two ends into the Transmitter and Receiver orifices labeled 1mm DIA FIBRE.
5. Adjust the potentiometer to reduce the input voltage to zero and adjust the Receiver output voltage to zero with the ZERO control.

   Note: The reading obtained will be affected to some extent by ambient light. It is best to keep the ambient light constant, and not to experiment in bright sunlight.

6. Increase the input voltage to its maximum value, and adjust the Receiver GAIN control for a suitable output reading on the meter. Check the zero reading, and readjust if necessary.

version H28627.15.05

This arrangement can be used to:

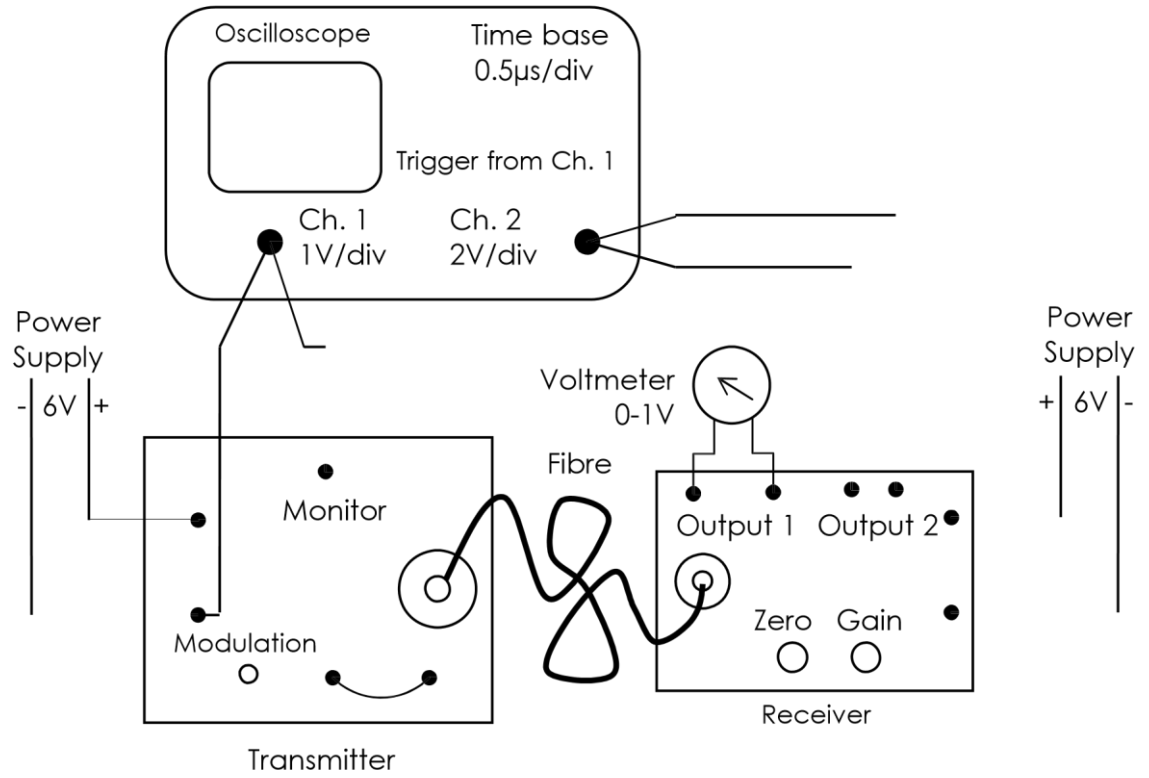
i. Test linearity by plotting a graph of output voltage against input voltage.

ii. Compare the attenuation produced by a long length of fibre, say 20m, with a short length. A typical reduction in output is from 100% to 20%, i.e. 5: 1. A length of 40m would reduce the output by a further factor of 5, i.e. to 1/25 or 4%, and 60m would reduce the output to 1/125 or 0.8%. The attenuation is often expressed in dBs km^{-1}, this fibre has an attenuation of about 700dBs km^{-1}. (Glass fibre has a much lower attenuation of 3-5dBs km^{-1}, so must be used for long distance communication.)

iii. Observe the effects of a cut in the fibre using a short length of fibre. Cut the fibre then hold the two ends together. It is interesting to observe the loss caused by the air surface. The two ends can be made wet, so that the air surface is replaced by water - is there any difference?

iv. Observe the effects of a scratch on the fibre. Light is transmitted through the fibre by "total internal reflection". The main core of the fibre has a refractive index of 1.49, and it is then coated with a thin layer, of refractive index 1.4. If the outer cover is removed and the fibre is scratched with fine glass paper, the increased loss of light can be observed, and it can also be observed at the surface.

Measurement of the Speed of Light Transmission



Philip Harris Technical Support **0845 120 4520**

www.philipharris.co.uk **techsupport@philipharris.co.uk**

1. The apparatus is set up as shown, using a 20m length of fibre.

2. The OUTPUT 1 gain is adjusted to give a convenient reading on the meter (between about 50 and 100%), and the Y shift is adjusted to display the MONITOR output below the signal from OUTPUT 1.

3. The 20m of fibre is then replaced by a short length, and the end at the transmitter (and at the receiver, if necessary) is pulled out until the same meter reading is obtained again.

   The top trace will be seen to have shifted approximately 1/5 of a division to the left, showing that the time for light to travel down the fibre has been reduced by
   0.2cm × 0.5µs/div = 0.1µs

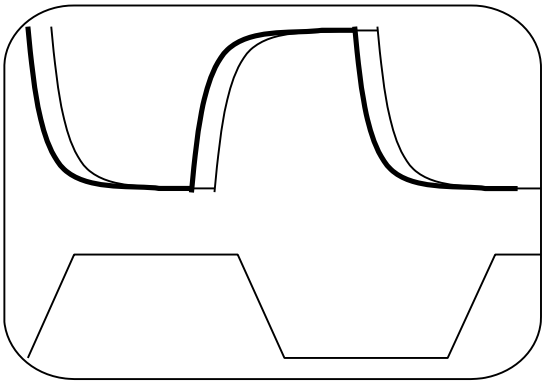
   The speed of light in the fibre is 20m/0.1µs = 2×10^{8}ms^{-1}.
   The speed of light in air is 3×10^{8}ms^{-1}.

   The refractive index *n* of 1.49, so the speed of light in the fibre *c* is given by:

$$c = c_0 \frac{n_0}{n} = 3 \times 10^8 \times \frac{1}{1.49} \approx 2 \times 10^8 \text{ ms}^{-1}$$

   Where:

   n_0: refractive index of air
   c_0: speed of light in air



OUTPUT 2

For Short and 20m fibre

2V/cm 0.5µs/cm

MONITOR OUTPUT

1V/cm

Timbase triggered from this output

Note: The phase difference between the MONITOR and OUTPUT 2 is due to the received signal going through a five stage amplifier. If the modulation frequency is reduced using an external source, the input and output will appear in phase at lower frequencies.

version H28627.15.05

Warnings:
For your safety, this product should be used in accordance with these instructions, otherwise the protection provided may be impaired.

Warranty, repairs and spare parts:
The Comprehensive Fibre Optics Apparatus is guaranteed for a period of one year from the date of delivery to the customer. This warranty does not apply to defects resulting from the action of a user such as misuse, improper wiring, any operations outside of its specification, improper maintenance or repair, or unauthorized modification.

Our liability is limited to repair or replacement of the product. Any failure during the warranty period should be referred to Customer Services.

Please contact Customer Services or techsupport@philipharris.co.uk for advice

Instructions for authorized service technicians:
Please refer to the detailed service procedures, safe servicing and continued safety
For any manufacturer specific parts please refer to our recommended repairer.
Please refer to product specific risks that may affect service personnel, the protective measures and verification of the safe state after repair.

Supplier Details:

Philip Harris Education, 2 Gregory Street, Hyde, Cheshire SK14 4RH

Orders and Information Tel: 0845 120 4521
Fax: 0800 138 8881
Repairs Tel: 0845 120 3211

E-mail: techsupport@philipharris.co.uk

Website: www.philipharris.co.uk

version H28627.15.05