SPECIFICATION

Transmitter:

Optical output: Red LED at 630nm

Modulation: External - max ±15V
Internal - 300kHz oscillator

Monitor: Output via 2mm or 4mm sockets

Power supply required: 5-6V d.c. smoothed

Dimensions: 150mm x 120mm

Receiver:

Outputs: Output 1 - d.c. coupled 0-5Hz, analogue or digital

Output 2 - high speed digital 20Hz-300kHz

Power supply required: 5-6V d.c. smoothed

Dimensions: 150mm x 120mm

Optical Fibre: Double layer polymer,
1mm nominal diameter

COMPREHENSIVE FIBRE OPTICS APPARATUS

P42000/7

(Q63500/7)

philip harris

EQUIPMENT NOTES

COMPREHENSIVE FIBRE OPTICS APPARATUS - P42000/7

PURPOSE

An apparatus to demonstrate and examine the transmission of intelligence 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 300Hz 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 1 is a direct coupled output from zero frequency to 5kHz 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 300Hz 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.

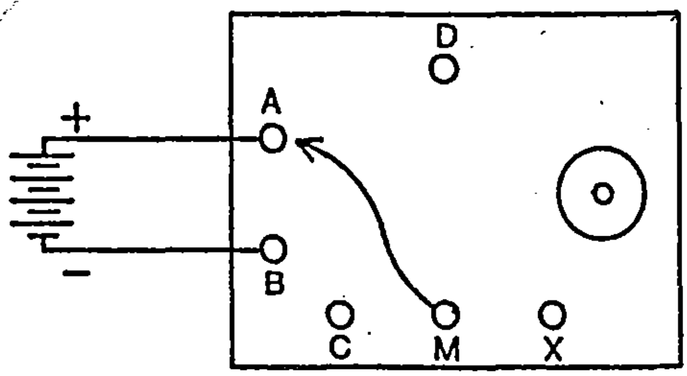
OPERATING INSTRUCTIONS

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 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.

1. Experiments using the OPTICAL TRANSMITTER alone

Investigation of modulation

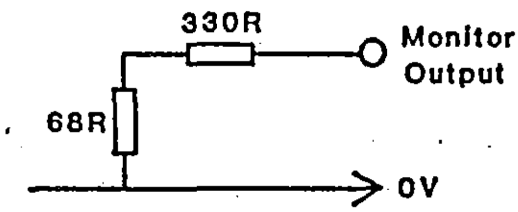


1.1 Connect a battery or smoothed d.c. supply of 5-6V to POWER INPUT. On looking through the small hole, the red LED will be seen to glow.

1.2 Connect a lead from the MODULATION INPUT (middle socket) to the positive supply input A. The light will increase in brightness.

1.3 Connect the lead from M to C, to short the modulation input. The light will decrease in brightness.

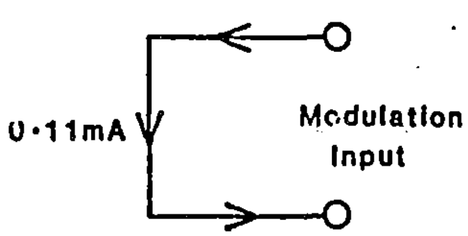
~~1.4~~ A high resistance voltmeter can be connected between a 0V socket (B or C) and the MONITOR OUTPUT. This measures the p.d. across a 68 ohm resistor effectively in series with the LED.

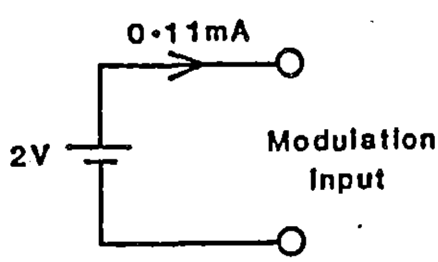


The voltage will be found to vary between 0.1V and 2.5V, giving an LED current of 0.1/68 or 2.5/68, e.g. 1.5 or 37mA respectively.

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.

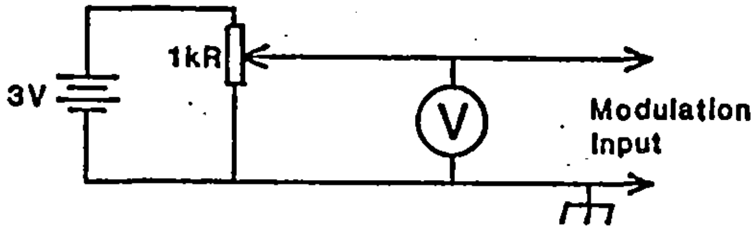
1.4 ~~1.5~~ The modulation input will supply a current of about 0.11mA when shorted to 0V, and it requires an input current of about 0.11mA when fed from a 2V supply. With no input, the p.d. between the sockets is about 1.2V. Modulation input voltages up to ±15V will not do any damage.



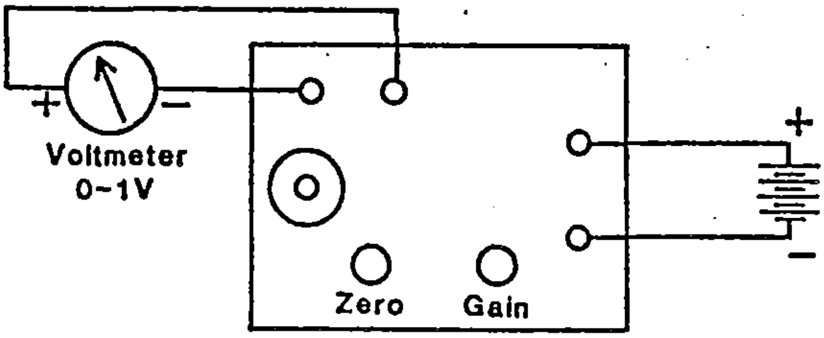


A graph can be plotted to show MONITOR OUTPUT voltage, or LED current, against MODULATION INPUT voltage. The MODULATION INPUT voltage can be varied from about 0-3V from two cells and a potentiometer of about 1000 ohms.

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



2. Experiments using the OPTICAL RECEIVER alone



2.1 Connect the POWER INPUT to a 6V battery or smoothed d.c. supply of 5-6V.

2.2 Connect an analogue or digital voltmeter of range 0-1V to the OUTPUT 1 socket.

2.3 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 0V and about + 0.4V.

2.4 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.

2.5 OUTPUT 2 - This is a digital output which, with no light modulation, could either be at 0V, 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 5kHz, as it will also work down to d.c.

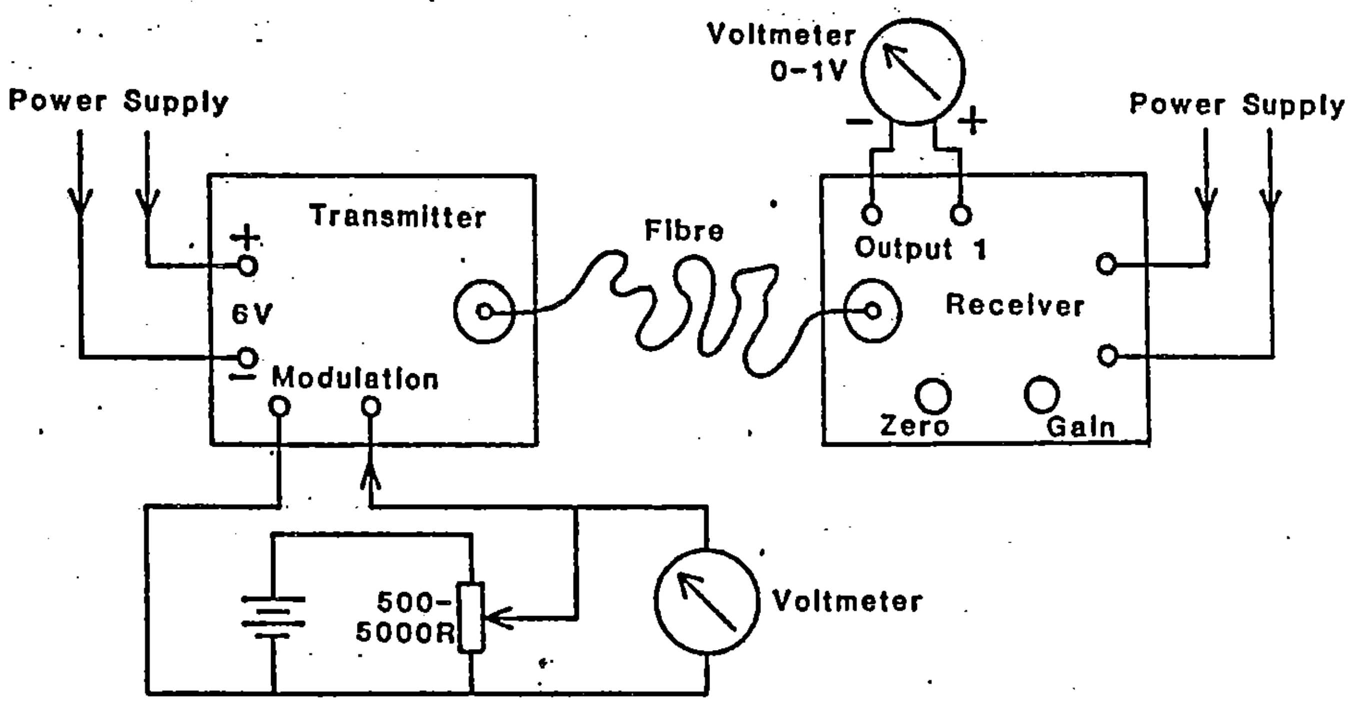
3. Experiments using both the OPTICAL TRANSMITTER and the OPTICAL RECEIVER

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

3.1 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.

3.2 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.

3.3 Connect a voltmeter of range 0-1V or 0-3V to OUTPUT 1 of the Receiver.



3.4 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 labelled 1mm DIA FIBRE.

3.5 Adjust the potentiometer to reduce the input voltage to zero, then 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.

3.6 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.

This arrangement can be used to:

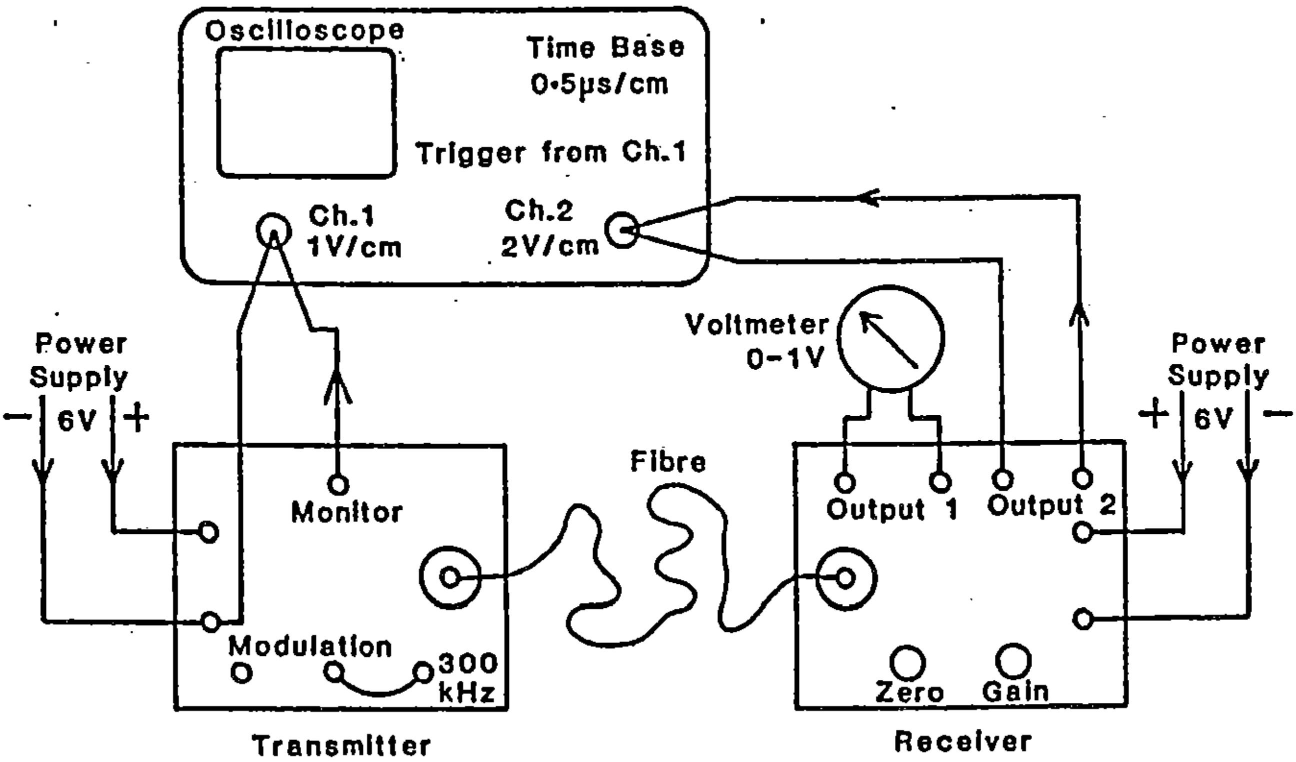
(i) Test linearity by plotting a graph of output voltage against input voltage.

(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%, e.g. 5:1. A length of 40m would reduce the output by a further factor of 5, e.g. 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 having an attenuation of 700dbs km^{-1}. Glass fibre, with its much lower attenuation of 3-5dbs km^{-1}, has to be used for long distance communication.)

(iii) Observe the effects of a cut in the fibre. A short length of fibre can be used. The fibre is then cut and the two ends held 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 fibre is scratched with fine glass paper, the increased loss of light can be observed, and it can also be visually seen at the surface.

4. Measurement of the speed of light transmission



4.1 The apparatus is set up as shown, using the 20m length of fibre.

4.2 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.

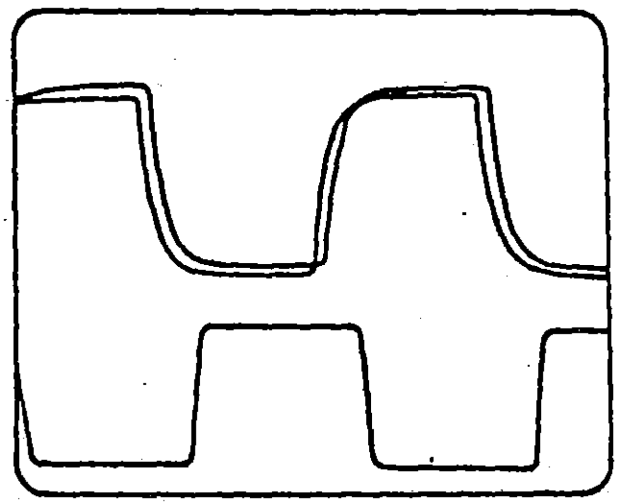
4.3 The 20m of fibre is then replaced by a short length, and the end at the transmitter (and at the receiver, if necessary) is pulled out until the same meter reading is obtained again.

The top trace will be seen to have shifted 2mm to the left, showing that the time for light to travel down the fibre has been reduced by 0.2cm x 0.5µs/cm = 0.1µs.

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

The speed of light in air is 3. 10^8m s^{-1}

(It is reduced in the fibre by the refractive index of the fibre - 1.49)



OUTPUT 2
For short and 20m fibre
2V/cm 0:5us/cm

MONITOR OUTPUT
1V/cm
Timebase triggered from this output

Note: The MONITOR output and the output from OUTPUT 2 appear to be almost out of phase. In addition to the time delay in the fibre, the received signal passes through a five-stage amplifier. This mainly accounts for the extra delay. If the modulation frequency is reduced, by using an external source, the input and output will be observed to be in phase at lower frequencies.

5. Transmission of a computer program along 20m of fibre

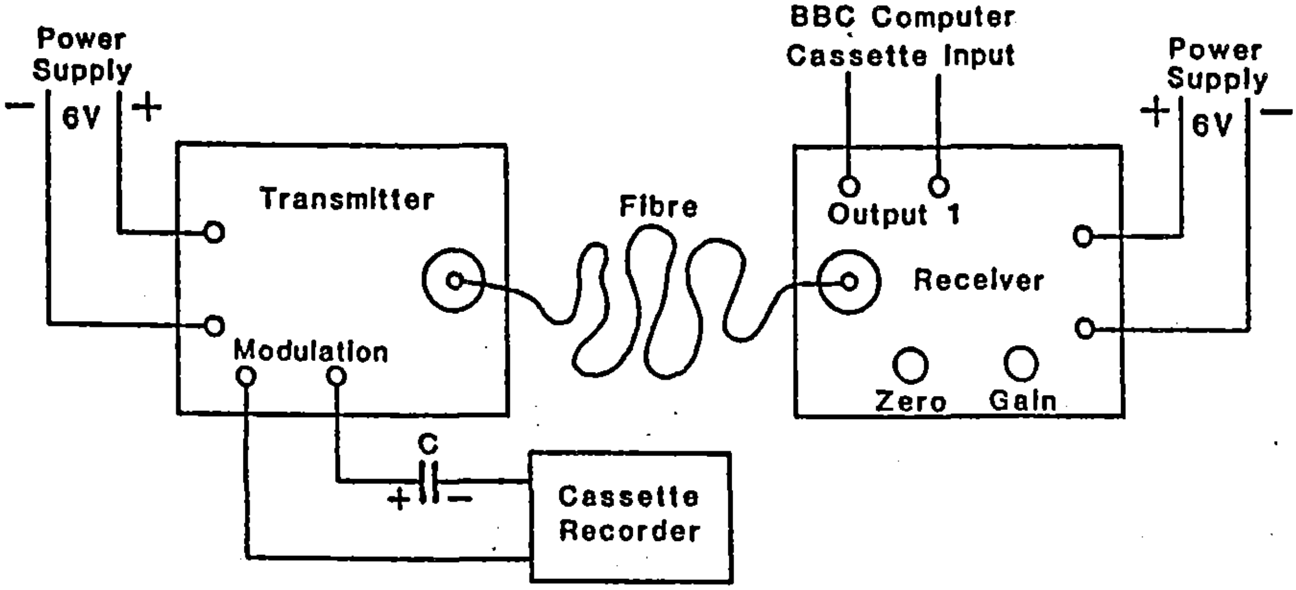
A BBC computer with a cassette recorder can conveniently be used. Some extra DIN plugs will be required.

5.1 Adjust the controls on the cassette, with it connected normally into the computer, until the computer receives the program without errors.

5.2 Replay the tape again, but with an oscilloscope connected to the cassette instead of the computer, and observe the output amplitude.

5.3 Connect up the circuit shown, with the oscilloscope connected to

OUTPUT 1, and adjust the ZERO and GAIN controls until the trace appears to be similar to that obtained in 5.2, e.g. the same amplitude, and no obvious distortion.

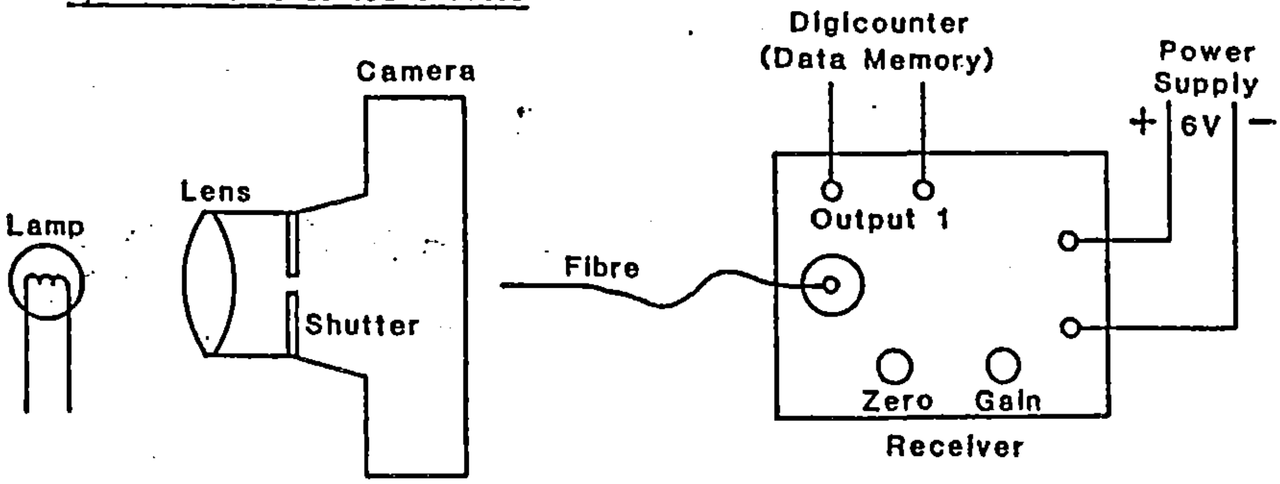


5.4 Connect up OUTPUT 1 to the BBC computer input, and replay the tape again. The computer should load in the program.

Note: A small electrolytic capacitor of about 1-100μF may have to be inserted at C.

A similar arrangement can also be used to transmit speech or music along the fibre. The computer is replaced by an audio amplifier and a speaker.

6. Operation of a camera shutter



This arrangement can be used either in a digital or analogue manner.

6.1 Use with Digicounter

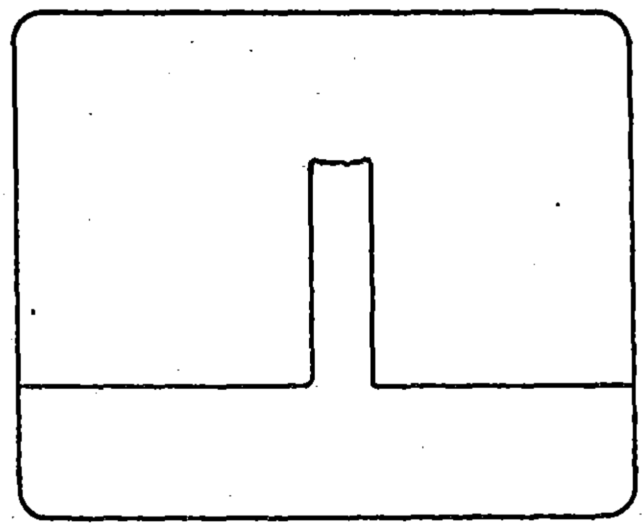
Set Digicounter:	FUNCTION switch	-	timing
	RANGE switch	-	anticlockwise (0.1ms)
	STOP/START	-	down, at START
	TRIGGERED	-	off

OUTPUT 1 from the Receiver goes into the black and blue STOP input sockets.

The nominal shutter speed was 1/30; the reading obtained from the Digicounter was about 49ms, e.g. the shutter speed is 1/20s.

6.2 Use with Data Memory:

The output was fed into one channel of the Data Memory (3V), recording at 1000 readings per second. The time scale for the trace below is 0.5s across the screen, e.g. the shutter was open for about 50ms.



The Receiver on its own can also be used as a general purpose light gate for timing purposes, or for analogue measurement of light levels in inaccessible places.

SPECIFICATION

Transmitter:

Optical output: Red LED at 630nm

Modulation: External - max ±15V
Internal - 300kHz oscillator

Monitor: Output via 2mm or 4mm sockets

Power supply required: 5-6V d.c. smoothed

Dimensions: 150mm x 120mm

Receiver:

Outputs: Output 1 - d.c. coupled 0-5Hz, analogue or digital

Output 2 - high speed digital 20Hz-300kHz

Power supply required: 5-6V d.c. smoothed

Dimensions: 150mm x 120mm

Optical Fibre: Double layer polymer, 1mm nominal diameter

philip harris
Education

COMPREHENSIVE FIBRE OPTICS APPARATUS

H28627

previously A46619, Q63500/7 and P42000/7

philip harris

EQUIPMENT NOTES

COMPREHENSIVE FIBRE OPTICS APPARATUS - P42000/7

PURPOSE

An apparatus to demonstrate and examine the transmission of intelligence 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 300kHz 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 1 is a direct coupled output from zero frequency to 5kHz 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 300kHz 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.

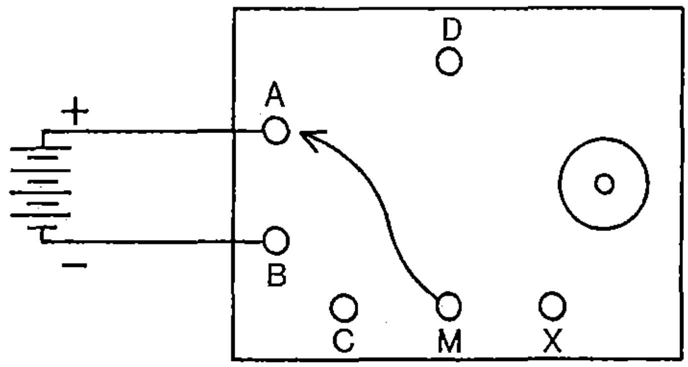
OPERATING INSTRUCTIONS

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.

1. Experiments using the OPTICAL TRANSMITTER alone

Investigation of modulation

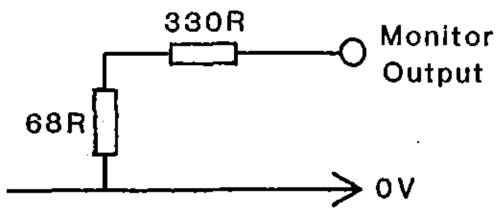


1.1 Connect a battery or smoothed d.c. supply of 5-6V to POWER INPUT. On looking through the small hole, the red LED will be seen to glow.

1.2 Connect a lead from the MODULATION INPUT (middle socket) to the positive supply input A. The light will increase in brightness.

1.3 Connect the lead from M to C, to short the modulation input. The light will decrease in brightness.

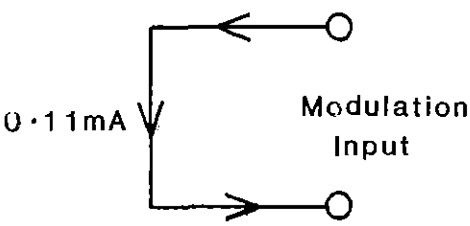
1.4 A high resistance voltmeter can be connected between a 0V socket (B or C) and the MONITOR OUTPUT. This measures the p.d. across a 68 ohm resistor effectively in series with the LED.

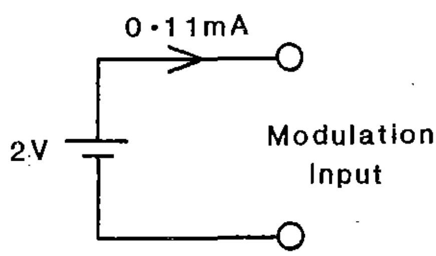


The voltage will be found to vary between 0.1V and 2.5V, giving an LED current of 0.1/68 or 2.5/68, e.g. 1.5 or 37mA respectively.

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.

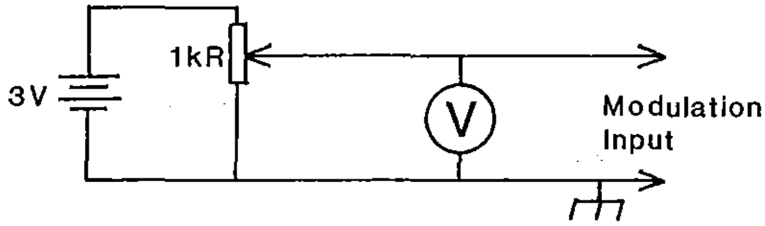
1.5 The modulation input will supply a current of about 0.11mA when shorted to 0V, and it requires an input current of about 0.11mA when fed from a 2V supply. With no input, the p.d. between the sockets is about 1.2V. Modulation input voltages up to ±15V will not do any damage.



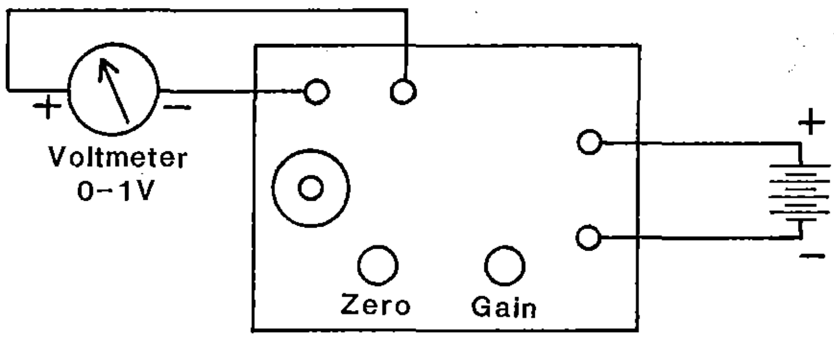


A graph can be plotted to show MONITOR OUTPUT voltage, or LED current, against MODULATION INPUT voltage. The MODULATION INPUT voltage can be varied from about 0-3V from two cells and a potentiometer of about 1000 ohms.

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



2. Experiments using the OPTICAL RECEIVER alone



2.1 Connect the POWER INPUT to a 6V battery or smoothed d.c. supply of 5-6V.

2.2 Connect an analogue or digital voltmeter of range 0-1V to the OUTPUT 1 socket.

2.3 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 0V and about + 0.4V.

2.4 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.

2.5 OUTPUT 2 - This is a digital output which, with no light modulation, could either be at 0V, 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 5kHz, as it will also work down to d.c.

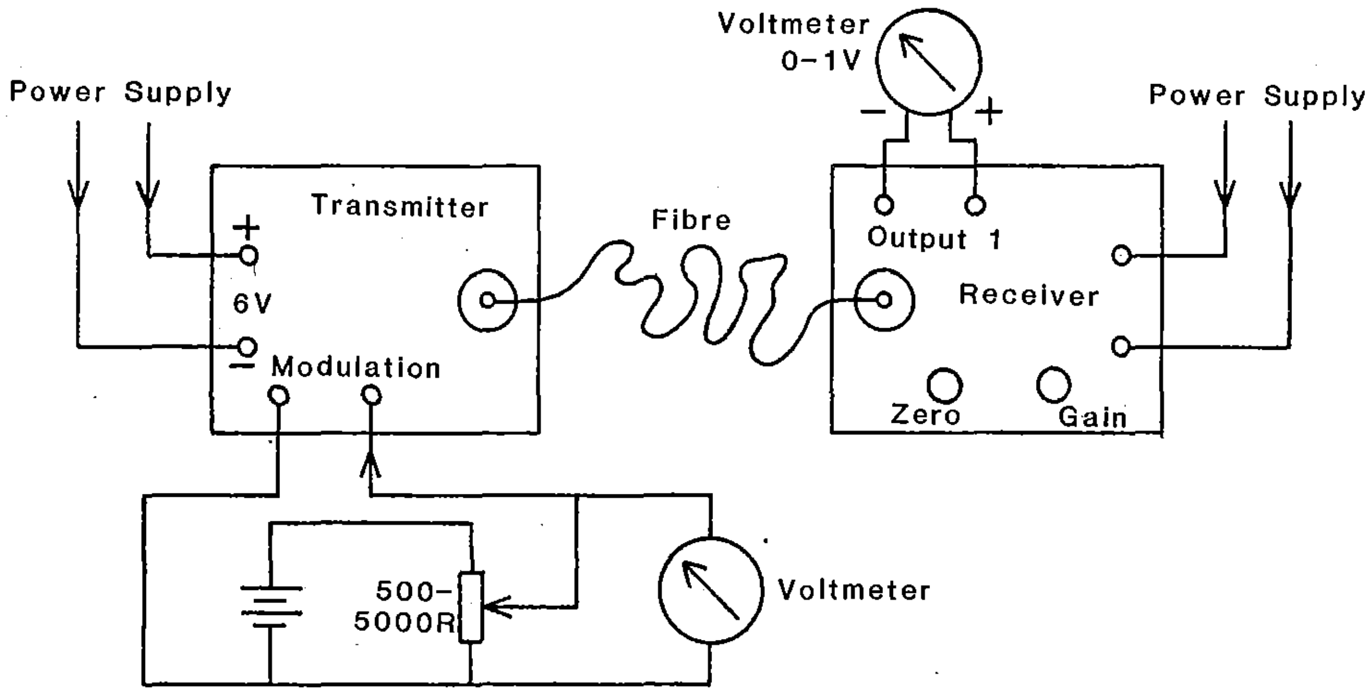
3. Experiments using both the OPTICAL TRANSMITTER and the OPTICAL RECEIVER

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

3.1 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.

3.2 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.

3.3 Connect a voltmeter of range 0-1V or 0-3V to OUTPUT 1 of the Receiver.



3.4 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 labelled 1mm DIA FIBRE.

3.5 Adjust the potentiometer to reduce the input voltage to zero, then 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.

3.6 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.

This arrangement can be used to:

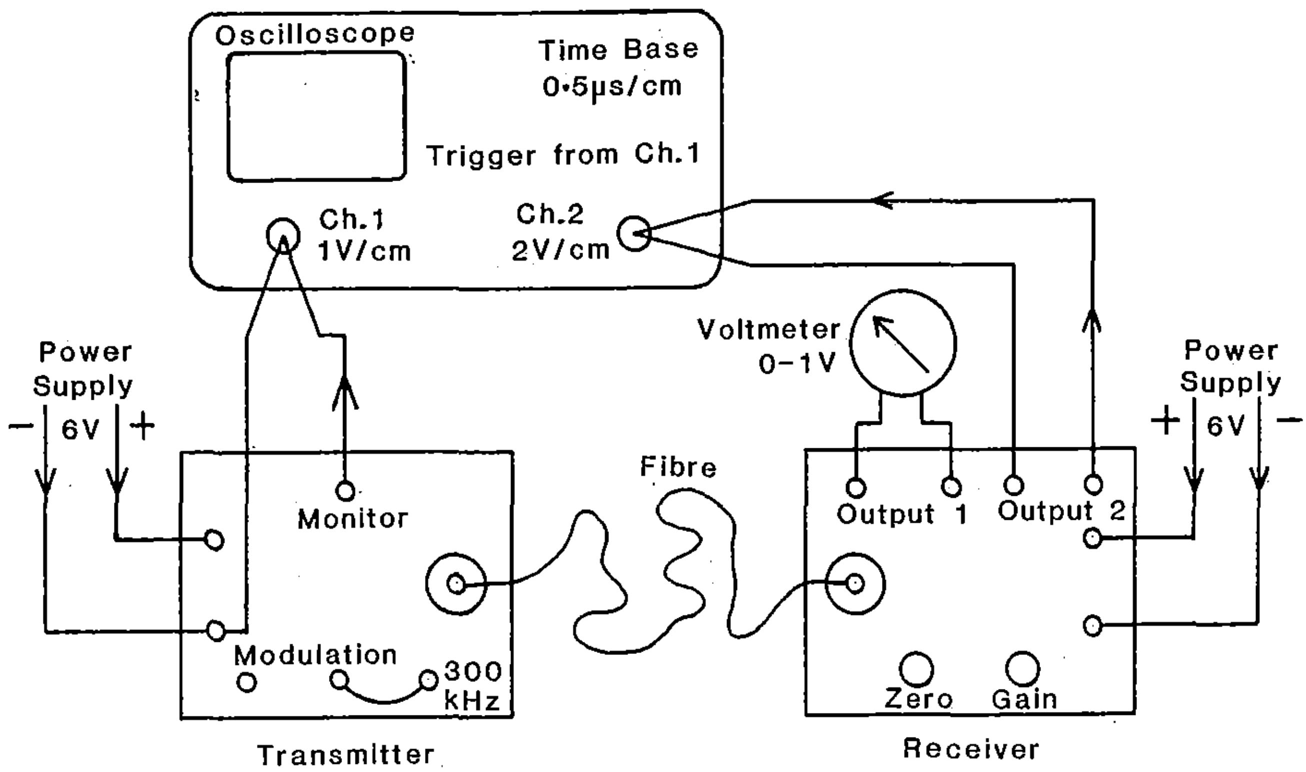
(i) Test linearity by plotting a graph of output voltage against input voltage.

(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%, e.g. 5:1. A length of 40m would reduce the output by a further factor of 5, e.g. 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, with its much lower attenuation of 3-5dbs km^{-1}, has to be used for long distance communication.)

(iii) Observe the effects of a cut in the fibre. A short length of fibre can be used. The fibre is then cut and the two ends held 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 visually seen at the surface.

4. <u>Measurement of the speed of light transmission</u>



4.1 The apparatus is set up as shown, using the 20m length of fibre.

4.2 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.

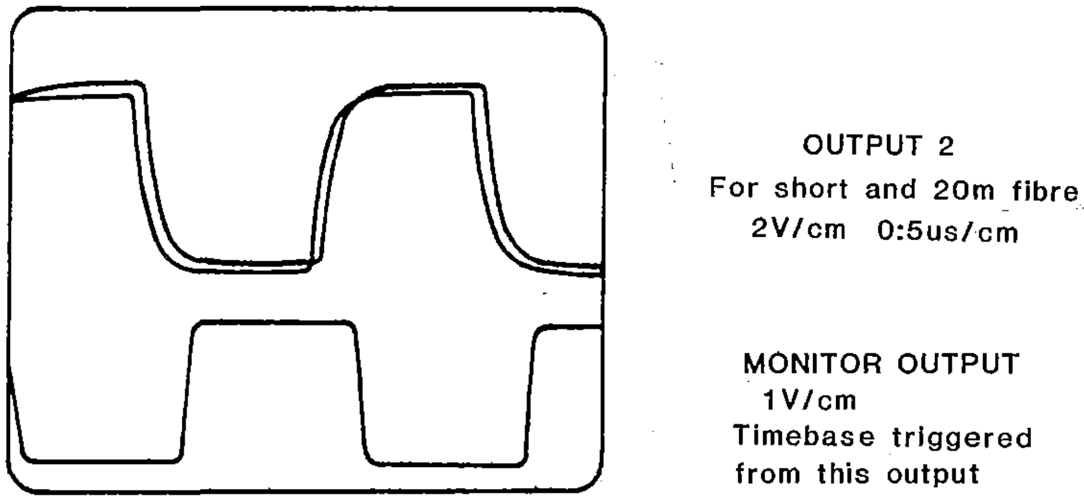
4.3 The 20m of fibre is then replaced by a short length, and the end at the transmitter (and at the receiver, if necessary) is pulled out until the same meter reading is obtained again.

The top trace will be seen to have shifted 2mm to the left, showing that the time for light to travel down the fibre has been reduced by 0.2cm x 0.5μs/cm = 0.1μs.

The speed of light in the fibre is 20m/0.1μs = $2.\ 10^8$m s^{-1}

The speed of light in air is $3.\ 10^8$m s^{-1}

(It is reduced in the fibre by the refractive index of the fibre - 1.49)



Note: The MONITOR output and the output from OUTPUT 2 appear to be almost out of phase. In addition to the time delay in the fibre, the received signal passes through a five-stage amplifier. This mainly accounts for the extra delay. If the modulation frequency is reduced, by using an external source, the input and output will be observed to be in phase at lower frequencies.

5. Transmission of a computer program along 20m of fibre

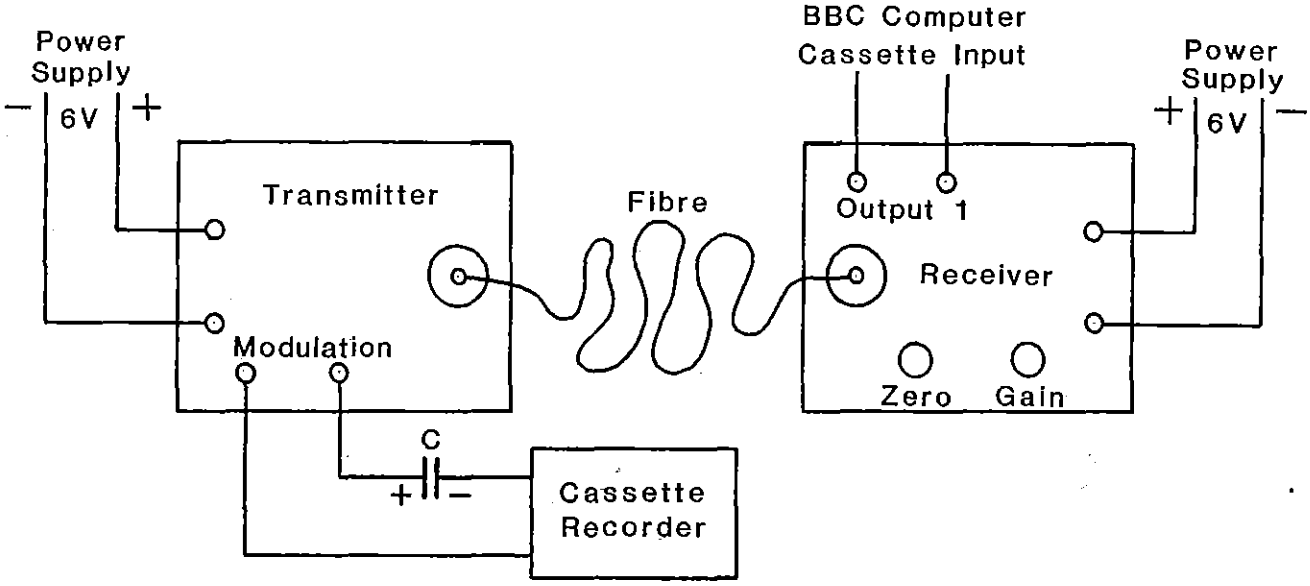
A BBC computer with a cassette recorder can conveniently be used. Some extra DIN plugs will be required.

5.1 Adjust the controls on the cassette, with it connected normally into the computer, until the computer receives the program without errors.

5.2 Replay the tape again, but with an oscilloscope connected to the cassette instead of the computer, and observe the output amplitude.

5.3 Connect up the circuit shown, with the oscilloscope connected to

OUTPUT 1, and adjust the ZERO and GAIN controls until the trace appears to be similar to that obtained in 5.2, e.g. the same amplitude, and no obvious distortion.

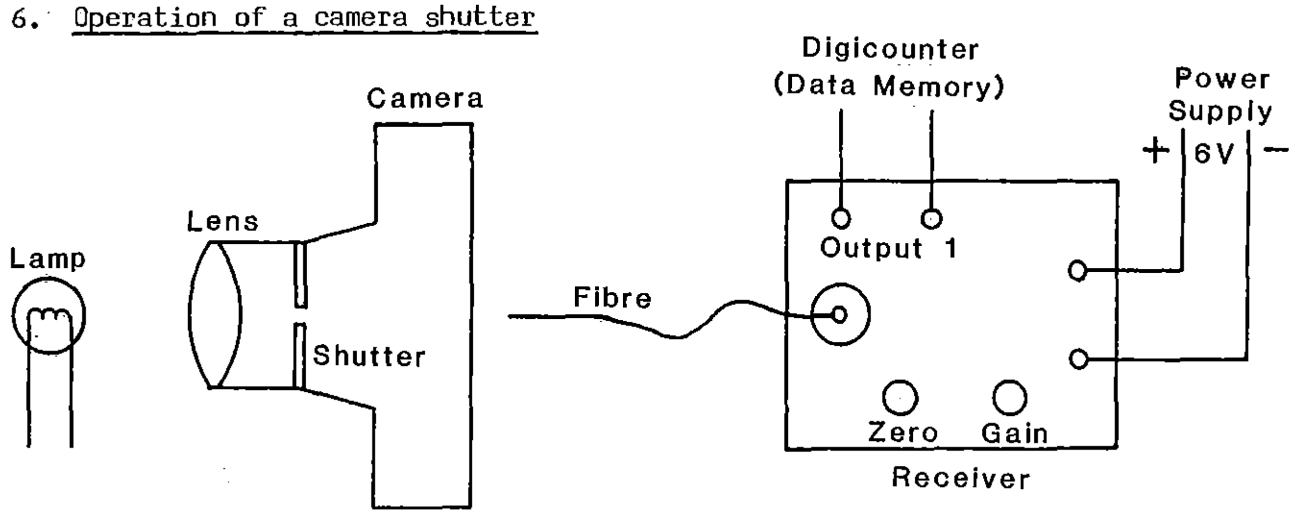


5.4 Connect up OUTPUT 1 to the BBC computer input, and replay the tape again. The computer should load in the program.

Note: A small electrolytic capacitor of about 1-100μF may have to be inserted at C.

A similar arrangement can also be used to transmit speech or music along the fibre. The computer is replaced by an audio amplifier and a speaker.

6. Operation of a camera shutter



This arrangement can be used either in a digital or analogue manner.

6.1 Use with Digicounter

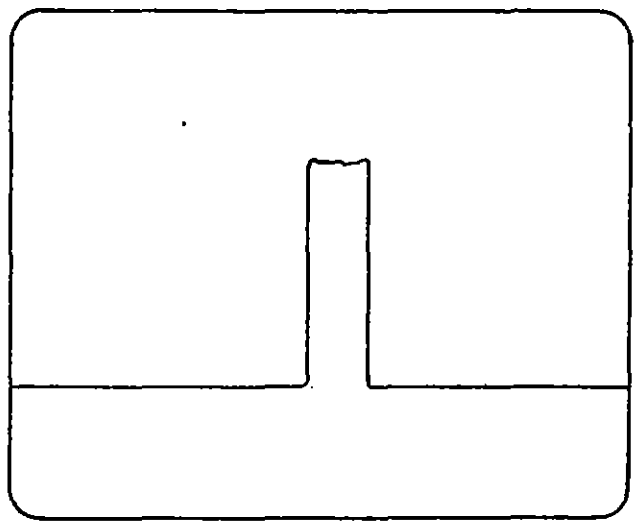
Set Digicounter:	FUNCTION switch	-	timing
	RANGE switch	-	anticlockwise (0.1ms)
	STOP/START	-	down, at START
	TRIGGERED	-	off

OUTPUT 1 from the Receiver goes into the black and blue STOP input sockets.

The nominal shutter speed was 1/30; the reading obtained from the Digicounter was about 49ms, e.g. the shutter speed is 1/20s.

6.2 Use with Data Memory:

The output was fed into one channel of the Data Memory (3V), recording at 1000 readings per second. The time scale for the trace below is 0.5s across the screen, e.g. the shutter was open for about 50ms.



The Receiver on its own can also be used as a general purpose light gate for timing purposes, or for analogue measurement of light levels in inaccessible places.

SPECIFICATION

Transmitter:

Optical output: Red LED at 630nm

Modulation: External - max ±15V
Internal - 300kHz oscillator

Monitor: Output via 2mm or 4mm sockets

Power supply required: 5-6V d.c. smoothed

Dimensions: 150mm x 120mm

Receiver:

Outputs: Output 1 - d.c. coupled 0-5Hz, analogue or digital

Output 2 - high speed digital 20Hz-300kHz

Power supply required: 5-6V d.c. smoothed

Dimensions: 150mm x 120mm

Optical Fibre: Double layer polymer, 1mm nominal diameter