

## TAP 318 - 3: Data transfer on an optical fibre

### Light signals down pipes

Signalling with light and other electromagnetic waves has a long and successful history. No signals can travel faster. More importantly, information transfer rates have blossomed rapidly using the wide bandwidths available at optical frequencies (around  $10^{14}$  Hz).

### You will need

A communications systems kit consisting of:

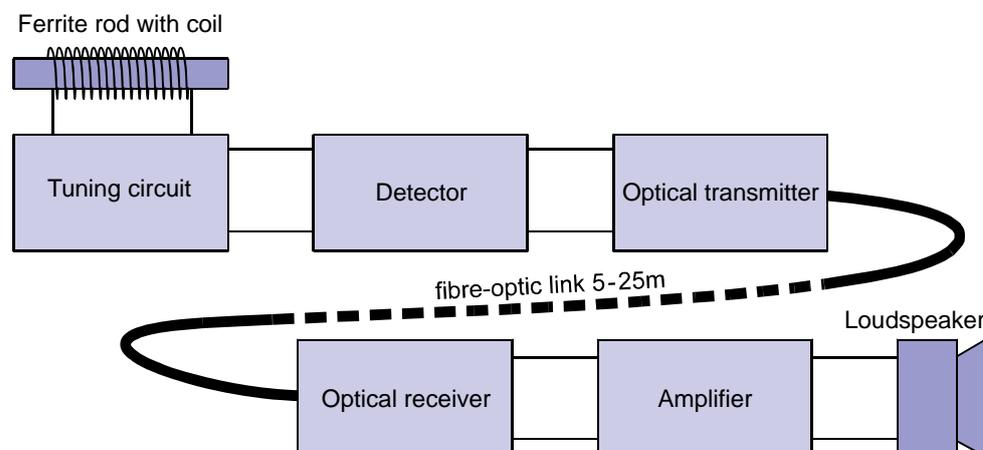
- ✓ fibre-optic transmitter with variable gain
- ✓ fibre-optics receiver / amplifier
- ✓ optical fibre, a length between 5 and 25 m
- ✓ tuned circuit for AM reception around 100 kHz using ferrite rod aerial and variable capacitor (receiver)
- ✓ radio receiver (detector)
- ✓ connectors
- ✓ audio amplifier
- ✓ loudspeaker

and also

- ✓ oscilloscope
- ✓ connecting leads
- ✓ two of power supply, 5 V dc

### Radio on a light beam

You can link up a simple radio receiver, use the sound from it to control the brightness of a light source, send the light carrying the sound signal along a fibre-optic cable, and receive, amplify and listen to the sound. An oscilloscope can show the nature of the signal as it passes along this chain.



Placed across the output of the radio receiver, the oscilloscope shows the radio-frequency carrier varying in strength (modulated) at audio frequencies. The detector extracts the audio signal. The audio signal is made to vary the brightness of a red light-emitting diode (LED). You may be able to see the brightness vary. The modulated light travels along the fibre-optic cable, getting weaker but being detected at the other end by a photodiode. You can hear over a loudspeaker the amplified electrical signal from the photodiode.

Remove the fibre-optic link and the signal disappears.

Since the photodiode also responds to infrared, you can see the digital signals from an infrared TV or video remote control, if the remote control is pointed at the photodiode and you press a button. To see the signal from the controller, you need to place the oscilloscope across the output of the amplifier.

### **You will have seen**

1. Radio signals being picked up.
2. Sound from the radio signal used to modulate the brightness of a light.
3. A light signal going through a length of optical fibre.
4. An audio signal carried by a light beam detected and amplified.
5. How to interpret various kinds of signal on an oscilloscope.

## Practical advice

The approach should be to give a quick, slick demonstration of analogue and digital methods, the use of electromagnetic waves as the fastest information carriers, and of fibre-optic techniques. The kit is self-contained and modestly priced. With an oscilloscope the signal can be followed as it is processed by the system.

It helps the realism of the demonstration if the optical transmitter and receiver are run from separate power supplies, and are separated as far as the length of fibre-optic allows.

Features that could be demonstrated:

1. Power up the boards and connect a potential divider ( $5\text{ k}\Omega$ ) across the supply with its wiper connected to the transmitter input. Show that varying the transmitter input voltage varies the intensity of the LED and that the light propagates down the length of fibre available (5 or 25 m) and is still modulated at the far end, even if attenuated.
2. Show the varying output voltage at the receiver end with the oscilloscope across the power amplifier output. Always measure voltages with respect to the negative power rail.
3. Connect the AM tuning circuit and radio receiver to the transmitter input and insert the ferrite aerial rod in the coil. Connect the fibre-optic from transmitter to receiver and the loudspeaker to the power amplifier output. Adjust the tuning capacitor and aerial rod direction until a signal is detected.
4. Show the fluctuations in the intensity of light on the fibre and how the signal decreases when one end of the fibre is disconnected.
5. Use the oscilloscope to show how the signal changes from modulated radio-frequency to an audio signal, as it passes from the tuned resonant circuit through the radio receiver into the fibre. To observe the radio-frequency signal across output of the tuned receiver, set the oscilloscope time-base at a few milliseconds per centimetre.
6. A TV or video remote control transmitting in the infrared can also be detected by the photodiode receiver. With an oscilloscope across the power amplifier output, the digital nature of the signals from different control buttons can be observed. This provides an alternative to another demonstration with a remote control.

## Alternative approaches

Any radio or fibre-optic demonstration that can illustrate some or all of these features could be adapted to introduce the key ideas.

## Social and human context

The trend in modern communications systems is to fast digital methods, with much use of fibre-optics in long-distance cables.

## External references

This activity is taken from Advancing Physics chapter 3, 30D