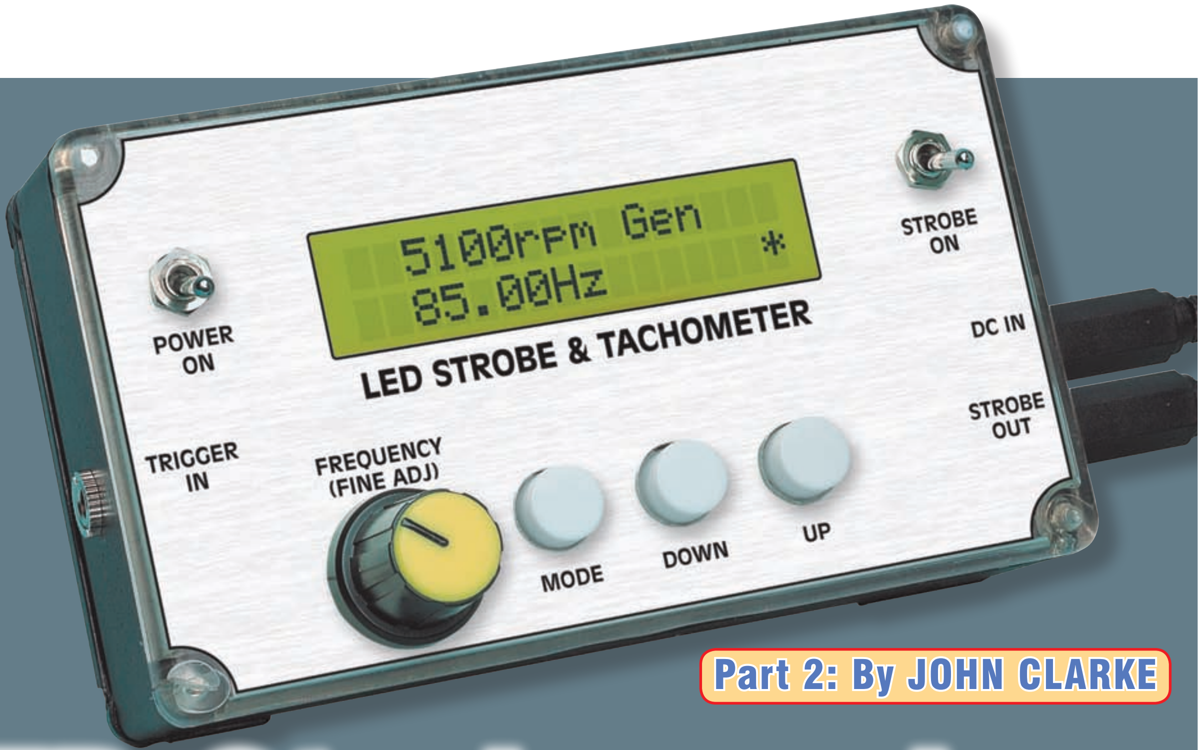


Part 2: By JOHN CLARKE

LED Strobe and Tachometer

Last month, we published the circuit of our new LED Strobe and Tachometer, and showed how to build the main unit and the strobe light. This month, we describe the assembly of the optional Photo-Interruptor and IR Reflector Amplifier boards. We also describe how the unit is used.

LET'S start with the assembly of the Photo-Interruptor board – see Fig.11. This board is coded 777 (Inter.) and carries just the photo-interruptor itself, a 150Ω resistor and three PC stakes. This board is available from the *EPE PCB Service*.

The assembly should take only a few minutes. Just be sure to install the photo-interruptor with the correct orientation, ie, with its diode symbol (indicated in blue on Fig.11) on the righthand side. It should be secured to the PC board using two M3 × 6mm screws and nuts before the leads are soldered.

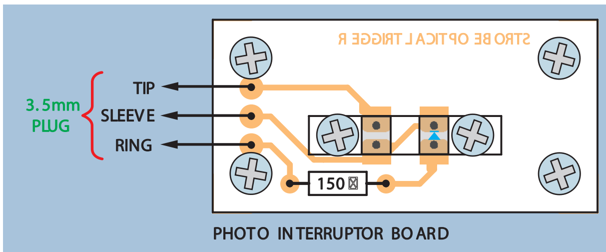
The completed assembly is wired to a 3.5mm jack plug using 2-core shielded cable, with the shield wire used as the 0V (GND) connection (ie, it goes to the sleeve) – see Fig.6 in Part 1 last month. Make sure that the tip and ring connections are made correctly. The tip connection is right at the end of the plug, while the ring is the separate section just behind the tip.

The 0V or ground terminal is the main body connection. Use your multimeter to identify the jack plug terminals if you are unsure.

Interrupt test

To test the unit, plug it into the main unit, apply power, set the unit to Trigger mode and then return to the main RPM display. If a slotted disc (or some other opaque shape) is now rotated through the photo-interruptor, a reading should appear on the display. In addition, the strobe should flash each time the light path is interrupted. If this doesn't happen, check your connections.

In practice, this unit is intended to be used with a small slotted disc (see photo) that spins within the gap of the photo-interruptor (ie, the disc is driven



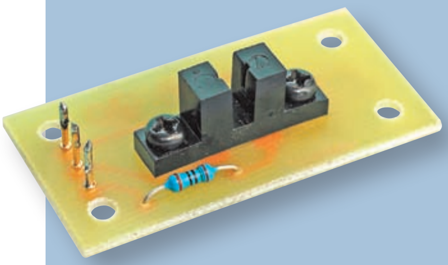
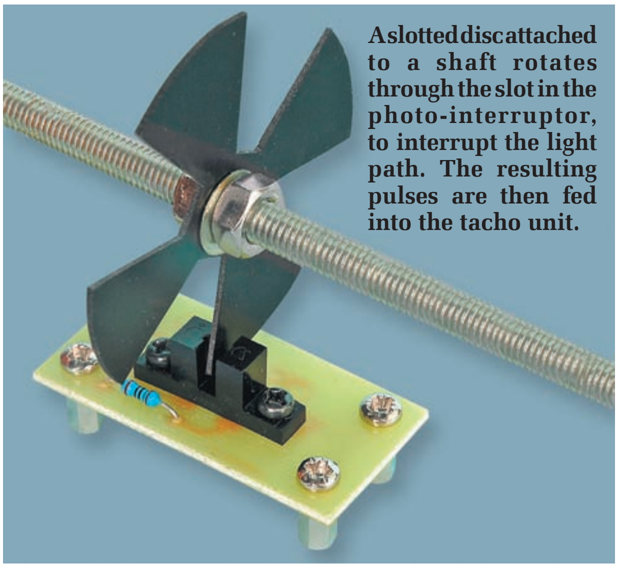


Fig.11 (above): make sure you get the photo-interruptor the right way round when building the photo-interruptor board (ie, diode symbol to the right). The PC board is mounted on nylon standoffs, to avoid shorting the tracks.



A slotted disc attached to a shaft rotates through the slot in the photo-interruptor, to interrupt the light path. The resulting pulses are then fed into the tacho unit.

by the rotating machinery). You will need to manufacture the disc to suit your application.

The completed Photo-Interruptor board can be attached to a fixed section of the machine. It is important to mount it using nylon (not metal) spacers at the output end, to prevent shorts to the soldered joints.

IR Reflector Amplifier

The IR Reflector Amplifier circuit is built on a PC board coded 778 (Reflect) and measuring 53mm × 32mm. This is housed in a plastic utility box measuring 82mm × 53mm × 31mm.

Fig.12 shows the assembly details. Begin by installing the resistors. Follow these with IC2, making sure it goes in with the correct orientation, then install the three electrolytic capacitors. Be sure to mount these capacitors with the correct polarity.

Finally, complete the board assembly by installing the three PC stakes, the infrared LED (IRLED1) and the infrared photodiode (IRSENS1). Note that IRLED1 is mounted at full lead length, so that it can later be bent over horizontally to protrude through the side of the box. Take care with the orientation of both these parts.

An accompanying photo shows how the board is mounted in its plastic case. It sits on four M3 × 6mm tapped nylon spacers, and is secured using M3 × 12mm countersink nylon screws and M3 nuts.

Two holes are drilled in one end of the box for the IR LED and photodiode, while another hole is drilled at the other end of the box to accept a cable gland.

As before, the PC board is wired to a 3.5mm jack plug using 2-core shielded cable, with the earth shield used as the 0V (GND) connection – see Fig.7 last month. Once again, make sure you get the tip and ring connections correct.

Testing the IR reflector board

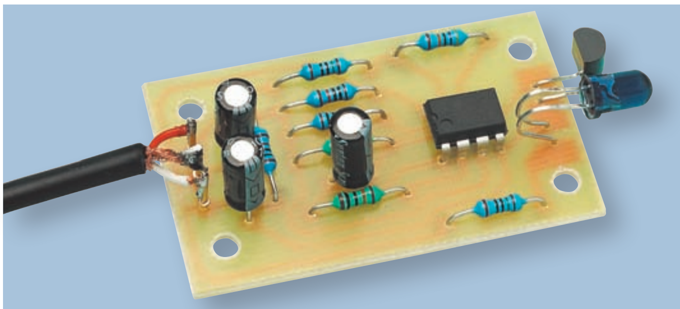
Having completed the assembly, the next step is to test the IR Reflector Amplifier for correct operation. To do this, first plug it into the trigger input of the LED Strobe and Tachometer unit, then set the Trigger mode and return to the main RPM display.

Now wave your hand in front of the sensor end of the IR Reflector box and check that the LCD shows an RPM reading. If this doesn't happen, then you need to check your wiring connections.

Note that as well as picking up reflected signals from IRLED1, the circuit will also detect signals from other infrared sources, such as incandescent lights running on the 50Hz mains. This means that RPM measurements are best done in natural light or subdued light.

Measuring the RPM of a machine should be done with the sensor about 30mm to 40mm away from the rotating shaft or fan. This means that you *must* exercise a great deal of caution, to ensure that neither the sensor or any part of your body touches any moving parts. In complex situations, the best approach may be to mount this sensor unit in a fixed position before switching the machine on. In short, use your common sense.

Note that as well as displaying the RPM value, the LCD also indicates



The IR reflector amplifier board must also be mounted on nylon spacers, to avoid shorting tracks.

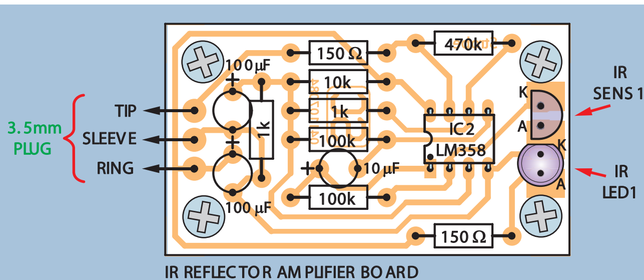


Fig.12: follow this diagram to build the IR reflector amplifier. Take care to ensure that IR SENS1 and IR LED1 are installed with the correct polarity.

Using white LEDs as strobes: busting a myth

BEFORE attempting to use a white LED as a strobe we had to be sure of its suitability. Initially, we had our doubts because we had read somewhere that white LEDs cannot be strobed at a fast rate. The reason given was that unlike coloured LEDs, white LEDs contain a phosphor and the persistence of this phosphor prevents them from switching on and off at a fast rate.

One of the reasons behind this story is that most of the phosphors we are familiar with do have long persistence. These include those used in toys that glow for hours after being exposed to light, and in fluorescent lights that continue to glow for a short time after being switched off. Similarly, some white LEDs do glow for a short period after the power is switched off.

In this case, we wanted to use a Luxeon white LED as a strobe for this project, so we set out to test its suitability. First, we checked the manufacturer's data sheet, and this specified less than 100ns for both the turn-on and turn-off periods.

From this, it is clear that white Luxeon LEDs do indeed switch on and off very quickly and so would be quite suitable for our proposed strobe.

How they're made

Further research on the web revealed that there are several ways in which white LEDs can be made. One way is to use red, green and blue LED chips and mix their outputs together to produce white light. These have a fast response because no phosphor is involved in converting the colour.

Another way to achieve white light is to use a phosphor that converts the emission from a single colour LED into a white spectrum. There are two types, one based on a blue LED and the other on a near-ultraviolet LED.

The blue-LED-based white LEDs use a phosphor that adds in colours toward the yellow end of the spectrum so that the combination of the blue light and the phosphor emission produces a white light. This construction is the most common form used for white LEDs. However, the phosphor used does not phosphoresce but emits light by a process called 'scintillation', an effect that has no light persistence.

The alternative white LED construction is not so common and is based on a near-UV LED and a mixture of a red and blue emitting phosphors, plus a green emitting copper and aluminium-doped zinc sulphide. The emission works in a similar manner to fluorescent lights. We do not have any information about the response time for these LED types, but presumably these do have a long persistence.

For our strobe, we use the more common blue-LED-based white LED. This type is manufactured by Luxeon, Cree and several others.

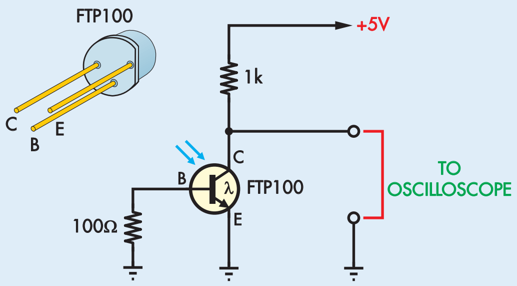


Fig.13: this simple phototransistor circuit was used to measure the response time of the white LED used in the strobe.

Measuring the response time

To further assess its suitability, we decided to measure the response time of a 1W Luxeon white LED. This was done using a phototransistor to detect the white light, as shown in Fig.13.

This circuit uses a low-value (1kΩ) collector (C) resistor to ensure that the phototransistor switches on quickly. In addition, the 100Ω resistor from base (B) to ground ensures that the phototransistor quickly switches off in the absence of light.

By pulsing the LED and monitoring this on one channel of a 200MHz oscilloscope, we could measure the response at the collector of the phototransistor on the second channel of the oscilloscope. We measured the rise-time for both a 1W white Luxeon and a Cree XR-C white LED from 10% to 90% full brightness to be just 290ns, which is really quite fast. The 'fall-time' response from 90% to 10% brightness was 360ns.

Next, we wanted to make sure that we were measuring the response time of the phosphor rather than the light from the blue LED itself. To do this, we placed a Polaroid red circular polarising filter over the white LED to block the blue spectrum from the phototransistor. When we did this, the response times remained the same, although the amount of light available for the measurement diminished markedly.

This all means that the white LED response is very likely to be better than 100ns, just as the manufacturers claim. The slower response times we measured are actually the phototransistor response times – **ie, the phototransistor is slower than the white LED.**

From this, it is clear that the 1W white LEDs specified are more than fast enough for strobe applications. However, one question remains: if white LEDs do have a fast response, why do some continue to glow for a short time after the power is switched off?

The main reason is because they are often driven by a supply with a filter capacitor, and it takes time for the filter capacitor to discharge after switch off.

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rotation by displaying an Up or Down arrow that flashes on and off. Note also, that it may be necessary to average the readings to account for slight speed variations while the machine is running.

Using the strobe/tacho unit

Each time you switch it on, the strobe/tacho unit shows the main readout on the LCD. This will either be in Generator mode or Triggered mode, depending on the last selection.

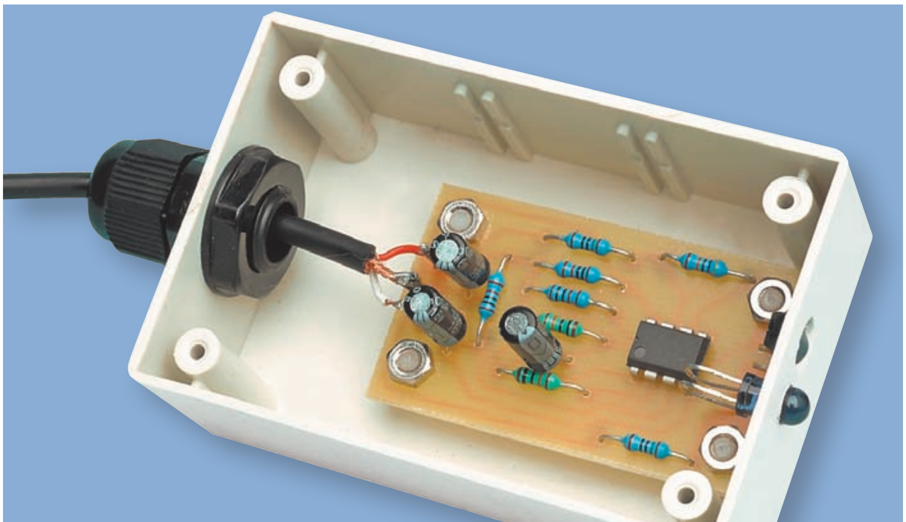
In Triggered mode, the LCD shows the RPM on the top line, then the word 'Trig' and either an Up or Down arrow if there are incoming trigger signals from an external sensor. This arrow will flash on and off, with an Up arrow displayed when rising-edge triggering is selected and a Down arrow when falling-edge triggering is selected.

The second line shows the frequency in Hz and following that the division ratio (ie, 0.5 and 1 to 8). An asterisk (*) on the far right-hand side is displayed whenever the strobe is flashing correctly, but is not displayed when the strobe LED is continuously lit (as happens when the flash period is longer than the time between flashes).

In the Generator mode, the display shows the RPM in the top line, followed by the word 'Gen'. The second line shows the frequency in Hz. As before, an asterisk (*) is shown on the right-hand side when the strobe LED is flashing.

In this mode, RPM adjustments are made using the Up and Down switches and the fine adjust potentiometer (VR1). The Up and Down switches adjust RPM in 100 RPM steps, while the potentiometer adjusts in 1 RPM steps over a 100 RPM range.

Selection of either mode is made using the Mode switch. When pressed, the display shows 'Trig/Gen' on the top line and the selection (either 'Gen or Trig') on the second line. The selection is then made using the Up or Down switches.



The Infrared Reflector Amplifier board is mounted in a small plastic case. Note how the IR sensor and IR LED are arranged.

Options

When the Generator mode is selected, a further press of the Mode switch brings up the 'Flash Mode' option. This can be set to either 'Automatic' or 'Fixed' using the Up and Down switches.

Pressing the Mode switch again brings up the 'Flash Period' setting. If the 'Fixed' mode is selected, the period can be adjusted from 32μs to 6.5ms, in 25.4μs steps. The display shows the value in 'μs' for readings less than 1000μs (1ms) and in '*ms*' for readings above 1ms.

Note that because the flash period is fixed, it is possible for the frequency of the RPM signal to be high enough for the LED to stay fully lit (as indicated earlier), ie, when the unit is flashed at a faster rate than the update period.

Correct operation is indicated by an asterisk (*) at the lower right-hand side of the LCD. When the asterisk appears, the strobe is flashing. Conversely, if the strobe is lit continuously, the asterisk is off.

If the Automatic mode is selected, then the display will show the automatic percentage value from 1% to 10% (ie, this is the strobe's duty cycle). This value is altered using the Up and Down buttons.

Pressing the Mode switch again returns the unit to the main tachometer display mode (showing RPM and frequency).

Trigger mode

The Trigger mode allows even more selections. These are Edge, Division, Flash Mode, Flash Period and Averaging (of the reading). As before, these are selected using the Mode switch.

First, the trigger edge can be set to either rising or falling. In this case, the LCD shows 'Edge' on the top line, while the second line shows either 'Rising' followed by an Up arrow or 'Falling', followed by a Down arrow (depending on the selection). The Up and Down switches allow the setting to be changed.

The Division selection allows the number of incoming trigger pulses to be divided by a set value, to give the correct reading on the LCD. When this is selected, the top line shows the word 'Division', while the second line shows the divide-by value. Division values of 0.5 and from 1-8 are available, and are again selected using the Up and Down switches.

For example, if you wanted to use the IR reflector sensor to measure the rotational speed of a three-blade fan, the division value would be set to three.

The Flash Mode and Flash Period settings are adjusted in the same way as the Generator mode. The Averaging mode is included to smooth out irregular measurements on a machine that is not running smoothly. You can average over 1 to 10 measurements and this is set using the Up and Down buttons. Higher averaging may be useful when the measured machine rotation varies markedly.

Finally, when the main RPM and frequency reading is displayed, the strobe firing position can be altered using the Up or Down switches. Note that this feature is available only when the division is set to two or more.

Using a Hall effect sensor

If you wish, you can use a Hall effect trigger instead of the photo-interruptor. As with the latter, this can be wired directly to the tachometer unit using 2-core shielded cable and a stereo 3.5mm jack plug.

Note that the supply for the Hall effect sensor connects between the ring (+5V) and the ground 0V. The tip connection is for the Hall effect sensor's output signal. ***EPE***

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Warning!

Flashing lights, particularly in the lower frequency range from about 5Hz (300 RPM) and upward can induce seizures in people subject to photosensitive epilepsy. Flashing lights can also trigger a migraine attack. It is recommended that people prone to these effects avoid stroboscopic lights.