A High-Performance Flashgun Slave Unit

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*This document – dated September 2001 – describes **David Gibson's** flashgun slave unit, and has been adapted from earlier articles that appeared in the journal of BCRA's Cave Radio & Electronics Group.*

This highly sensitive flashgun slave unit was designed for use by cavers and other underground photographers.

Slave units sold by photographic retailers, and those sometimes seen in the hobbyist electronics magazines, are generally poor in performance. They are not sensitive enough for caving use, and can be accidentally triggered by light from a caplamp beam. My original design (Gibson, 1992), introduced features that made it suitable for underground use.

Development History

Since 1992, when my design was first published, I have (at September 2001) supplied over 500 kits of parts. The various articles, updates and construction notes are brought together in this article, although some detailed technical description that was present in the original article has been omitted. A pamphlet describing the original design (Gibson, 1994) is no longer available.

My original design was 'postage stamp' sized but, in 1995 I added some extra features which required a larger circuit board 58mm × 23mm (Gibson, 1995, 1996, 1997a). These 'RALF' features – a term coined by Mike Bedford (Bedford, 1995) – were optional; and it has become apparent, over the years, that most people are content with just the basic design. For this reason I have now produced a smaller circuit board (the RALF board was slightly too long to fit in a 35mm film container) and I have taken the opportunity to make a few enhancements, as I will now describe.

As well as a smaller circuit board (46 × 23mm), the present (2001) design includes a more reliable battery holder, and features a more robust output, which makes it easier to fire flashbulbs. There are other slight changes in response to customer requests and the occasional 'failure' that was reported to me.

If you do not wish to use the on-board battery, you can crop the board by 15mm to a size of only 31mm x 23mm.

Features of the Slave Unit

Very high sensitivity

The line-of-sight triggering range is around 1200m with a gun of GN 30m @ 100ASA. This high sensitivity allows the slave to "see" around corners in dark passages.

Infrared sensitive for use with "dark" flashguns

It is useful to trigger a slave from a flashgun mounted on the camera, but you might not want the foreground to be illuminated. The visible light can be blocked using an infrared filter. Flashguns generate a significant amount of infrared light. This is detected by the slave and triggers the main flash.

Usable underwater

The photodiode is sensitive to visible light as well as infrared. For underwater use, where infrared is attenuated, the unit works when slaves that are *only* sensitive to infrared will fail.

Not sensitive to caplamp beams

The slave is triggered by the short, sharp, bright pulse from an electronic flashgun. It should not respond when a caplamp is shone at it.

Not adversely affected by ambient light

Cavers will usually be operating the slave unit in the dark, so the question of ambient light does not arise. However, if you want to use it where there is some light you need to know how its performance is affected. The response has been tailored to work in ambient light as a fill-in flash. It will trigger when a near-instantaneous pulse of light exceeds the general light level by around 3½%. In terms of photographic "stops" this is about 1/20 stop.

Triggered by, and will fire flashbulbs

The unit is designed to be triggered by the sharp pulse from an electronic flashgun, and to ignore the much slower changes in light level caused by a wavering caplamp beam. Flashbulbs come somewhere in between. As it stands, the unit can usually be triggered by a flashbulb. The new slave unit has been enhanced to allow it to fire flashbulbs more reliably than the previous unit. A combined slave and bulb firer is also available.

Compact design

The unit fits inside a translucent container roughly the size of a 35mm film container. It could, perhaps, be placed inside the casing of a flashgun. It can be operated from the flashgun's own batteries. The size of the circuit board in the current version is 46mm x 23mm, but it can be trimmed to a smaller size if the on-board battery is not required.

Low current consumption: life of 4 years or 10,000 flashes

One 3.6V lithium cell (size ½AA) provides enough energy for 10,000 flashes, and will run the unit for 4 years. Since this is comparable with the shelf life of the batteries an on/off switch is not required. This, in turn, means that a simpler connector (which does not have to double as a switch) can be used. Alternatively, the built-in opto-isolation means that the unit can be run from the flashgun batteries themselves.

Setting-up procedure

Fit a battery

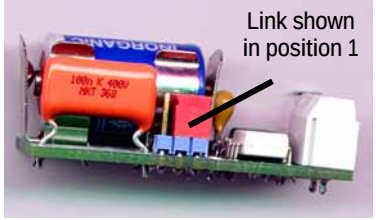
Fit a 3.6V lithium cell (size ½AA), making sure that you observe the polarity. Lithium cells are available from photographic and computer outlets. A typical part is the *Sonnenschein* SL350/S, which is a 3.6V, 1.0Ah Lithium Thionyl Chloride cell, available, in the UK, from Farnell Electronic Components, stock number 206-520 or from Maplin Electronics, stock number GS99H. Maplin also stock a Maxell battery, ER3S_TC, stock code QE49D.

Wire a connector

The slave unit is *not* supplied with a 'hot-shoe' or other connector. You will need to obtain your own connector and wire it to the two screw terminals on the circuit board.

Select the link position

Push the programming link onto one pair of the three programming pins. Referring to the photo, **position 1** (as shown) is to the right (terminal end of board), and **position 2** is to the left (battery end of board). **Position 1** works with most flashguns, and flashbulbs. **Position 2** works with all flashguns, but not with flashbulbs.



Where to Obtain the Units

This article is published so that you can build your own slave unit. To make the project easier, I am still supplying printed circuit boards and a kit of components. For those who have clumsy hands or who lack a soldering iron, I am now able to supply the circuit boards ready-built.

Kits of Parts

If you are building this project yourself, please note that construction is fiddly and you ***must*** have a good knowledge of electronics and soldering. The kit is supplied solely to save you time in hunting down the components – other than this, you are on your own, I do not make any profit out of selling the kits, and so I cannot offer much 'after-sales' service. Prices can be found on my web site at **caves.org.uk / flash /**.

Ready-Built Units

I can also supply ready-built circuit boards. Please note that it is only the circuit board that I am supplying pre-assembled – not the entire unit. You will still need to find yourself a suitable connector and container – although you can use the translucent container that I provide, if you wish. (A problem with this container is that in cold conditions it is brittle, and it can easily be cracked). I can supply a small plastic box as an alternative, but this is less easy to make waterproof, and you will need to drill holes in it and work out how to mount the board. See component list for details.

You can buy a complete commercial unit, based on my original design, from *Firefly Electronics* in the UK or *Shot-in-the-Dark Photography* in the USA. The addresses are given at the end of this article. The Firefly design does not include the enhancements I have recently made, and it uses a different photodiode, which is not so suitable for underwater use. (And I do not get a commission!).

Using the Slave Unit

Choosing a Battery

The standby current of the slave unit is about 10µA. A quick calculation shows that a 1.0Ah battery would last over ten years at this level of discharge, so if we use a lithium cell with a 10-year shelf life there is clearly no need for an on/off switch! However, if you do want to install a switch, there are two pads on the PCB to which you can connect it. These are marked on the assembly diagram.

The unit uses a 3.6V ½AA-size lithium battery. Alternatively, if you consider the lithium cell to be too expensive, you can power the circuit from two alkaline N-size cells such as the *Duracell* MN9100. To do this you will need to obtain a battery holder. You should note that, with an external battery holder, the unit will not fit into the container that I supply unless you make some slight modifications (e.g. bend C6 to lie flat). I can supply the lithium cell, and the battery holder for size N alkaline cells. See the Component List for further information

If there is room, you can mount the unit inside your flashgun. The opto-isolation of OPT1 was deliberately included so that the unit could be run from the flashgun's own batteries without difficulty. If you do this, and the flashgun is not running from 3–4V then you will need to alter some components, as described in the 'how it works' box.

Connecting the Flashgun

The unit has two terminals, and these should be connected to your flashgun through whatever connector you have chosen to use. The slave unit needs to be configured by setting a movable shorting-link on the circuit board. Push the programming link onto one pair of the three programming pins. Position 1 is towards the terminal end of board; position 2 is towards the battery end of board. Position 1 works with most flash-guns, and flashbulbs. Position 2 works with all flashguns, but not with flashbulbs.

The problem arises because of the differences in the trigger circuit in flashguns from different manufacturers. Typically, it is certain *Vivitar* guns that require the link to be in position 2 – for most guns it should not matter what the setting is. The link options are summarised in the following table.

Link	*electronic flashguns low-current triggers*	*Electronic flashguns with high-current triggers (some Vivitar guns)*	*filament flashbulbs*
1	yes	no	yes
2	yes ✶	yes	no

✶ Capacitor C6 *must* be rated at 400V or more.

Use with *Vivitar* Flashguns

A common problem with slave units is that they will not work with some models of flashgun, in particular (but not limited to) *Vivitar* guns. These use a different design of trigger circuit, which results in a larger current flowing when the contacts are closed (or in this case, when the triac fires). The current causes the triac to latch on permanently. (Technically, this is due to the 'holding current' of the triac. I have used an opto-triac for convenience, but its holding current is only 100µA so the problem can easily manifest itself on a variety of flash-guns). C6 with its bleed resistor R17 are included to get around this problem. A word of warning: you *can* use this 'Vivitar' connection to fire 'ordinary' guns too, but the capacitor ***must*** be rated at 400V or more.

Usage with Flashbulbs

The slave can be triggered by flashbulbs, but there is scope for experimenting with the value of C1. The slave will trigger a bulb flashgun but, because the triac will latch on, this will result in a continued current drain from the flashgun, which can be stopped by unplugging the slave or pressing the manual firing button on your bulb firer.

The design now includes a power-triac with a high current rating, so there is no need to worry about the ruggedness of the opto-triac. The opto-triac is still included in the new (2001) design, as it provides a useful isolation between the battery and the trigger outputs.

Notes for Kit-Builders

The document you are reading now, was written in 2001, and if for the PCB version **SLV011**. Since then, the circuit board has been revised to version **SLV021**, and there are some slight changes to the assembly instructions.

To save time, I have ***not*** amended thjis document. Instead, there are two ***Update Sheets*** which are appended to this document, and which you are advised to read before building the kit.

Contents of Kit

The kit of parts is shipped with a copy of the circuit diagram. *There are no other instructions*.

Suitability for Purpose

If, after reading these notes, and inspecting the kit, you decide that it will not be suitable for your purposes, you may return it unused within 30 days (and at your own expense) for a refund.

Warnings

Before ordering or building the kit of parts you are advised to read this note and understand it!

This kit of parts is intended for cave photographers who, as a matter of habit, work with flashguns that they have re-packaged for use underground (perhaps with different housings and different connectors). It is not primarily intended for use with commercially available flashguns, although you can fit a hot-shoe adapter to the slave unit if you wish to use it with such guns. However, you should be aware that hot-shoe adapters are not intended for use with 'dedicated' flashguns; that is, flashguns that

are designed for use with a particular camera and which offer special features when used with such a camera.

I have designed this slave unit as an aid to cave photographers. I have published the circuit diagram for your personal use. I am also making available printed circuit boards, to save you having to design your own; and I am providing a kit of parts to save you having to go through the tedious process of ordering components. Making these additional items available to you should not be taken as any sort of guarantee that the slave unit you build will work, or will be suitable for your purpose. Please note, in particular, that the instructions I supply are not intended to be comprehensive. They are not intended as a substitute for your professional electronics knowledge and your high degree of skill in the assembly of micro-electronic equipment. The basic material that I am intending you work from is the circuit diagram, component list and PCB layout – and those alone.

I *know* the circuit works. If yours does not then it is almost certainly your fault – you have damaged something building it, or you have not built it correctly, or it is not suitable for your purpose. And that is for *you* to find out and *you* to deal with. I am not intending to put myself under any obligation to you – I am publishing an electronic design and you are choosing to use your specialist electronic design and construction skills to turn it into a product for your personal use. That is *your* choice!

Of course, consumer legislation means that if I sell you something, I cannot avoid some degree of responsibility, so if you think a component is damaged when you receive it then I will replace *the component* free of charge. If you decide that the kit is not suitable for your needs then you can return it *unused* within 30 days, for a refund. If you want to dispose of the product after use, you can return it to me (at your own expense) for that purpose.

Construction

Construction using my circuit board is fiddly. You *must* have experience of micro-electronic soldering and construction. If you are not experienced in the construction of micro-electronic circuits then you should not attempt this project. The majority of people who have made use of my kit have had no problem, but you might like to watch out for these common problems.

- Read the instructions first
- You must take proper anti-static precautions during the construction.
- Use a fine-tipped electric soldering iron and flux-cored solder. Do not attempt to use plumbers' solder and a tin of flux. My kit includes a length of solder with water-based flux.
- It is almost impossible to remove a component from a double-sided circuit board without damaging both beyond repair. Get it right first time!
- It is a good idea to construct a single kit first, to see how it fits together, before building a batch.
- Clean the board thoroughly with a flux solvent or you may get intermittent operation or no operation at all. If you use a solder with a water-based flux it is important that you wash the flux off *immediately* after finishing soldering.
- If the unit works only intermittently, it may be caused by the so-called *Vivitar* problem, as explained in the notes. This is not exclusive to Vivitar guns. Make sure you have connected the programming link correctly.
- Test the unit above ground first, ***with the flashguns that you will be using underground***. Then try the unit underground on a non-critical trip!

Alternative Photodiode

The component list shows the photodiode as part number SFH206K. This is a wide-angle side viewing part. This diode is sometimes rather expensive and you might find that I have replaced it, in the kit, by a similar part, SFH213.

The mechanical differences are that this part is a narrow-angle end-viewing part. This should not matter too much, as the light will be diffused as it enters the container. You might, however, find that the slave unit has to be aimed more accurately. If you have a problem, please contact me and I will try to supply the previous diode, but you are cautioned that once you have soldered in the new diode it will be difficult to replace it without damaging the PCB.

If you want to change the diode yourself, all you need to know is that the unit will work with most types of photodiode, and it will also work with LEDs – see (Gibson, 1997b). The assembly diagram shows the orientation of D1 clearly. The PCB also includes a small 'k' on the legend to indicate the cathode.

The alternative diode SFH213 has a small 'flat' on the side of the package corresponding to the cathode, and the cathode lead is the slightly shorter of the two.

Because the alternative diode points upwards you will need to bend the leads so that it points sideways if you want it to point out of the bottom of the container, as the original diode does. You are advised to experiment with this, and with the fitting of the board in the container, before you solder the diode in place.

Make sure that you solder the diode the correct way round. The slave unit will still work if the diode is reversed, but it will be less sensitive.

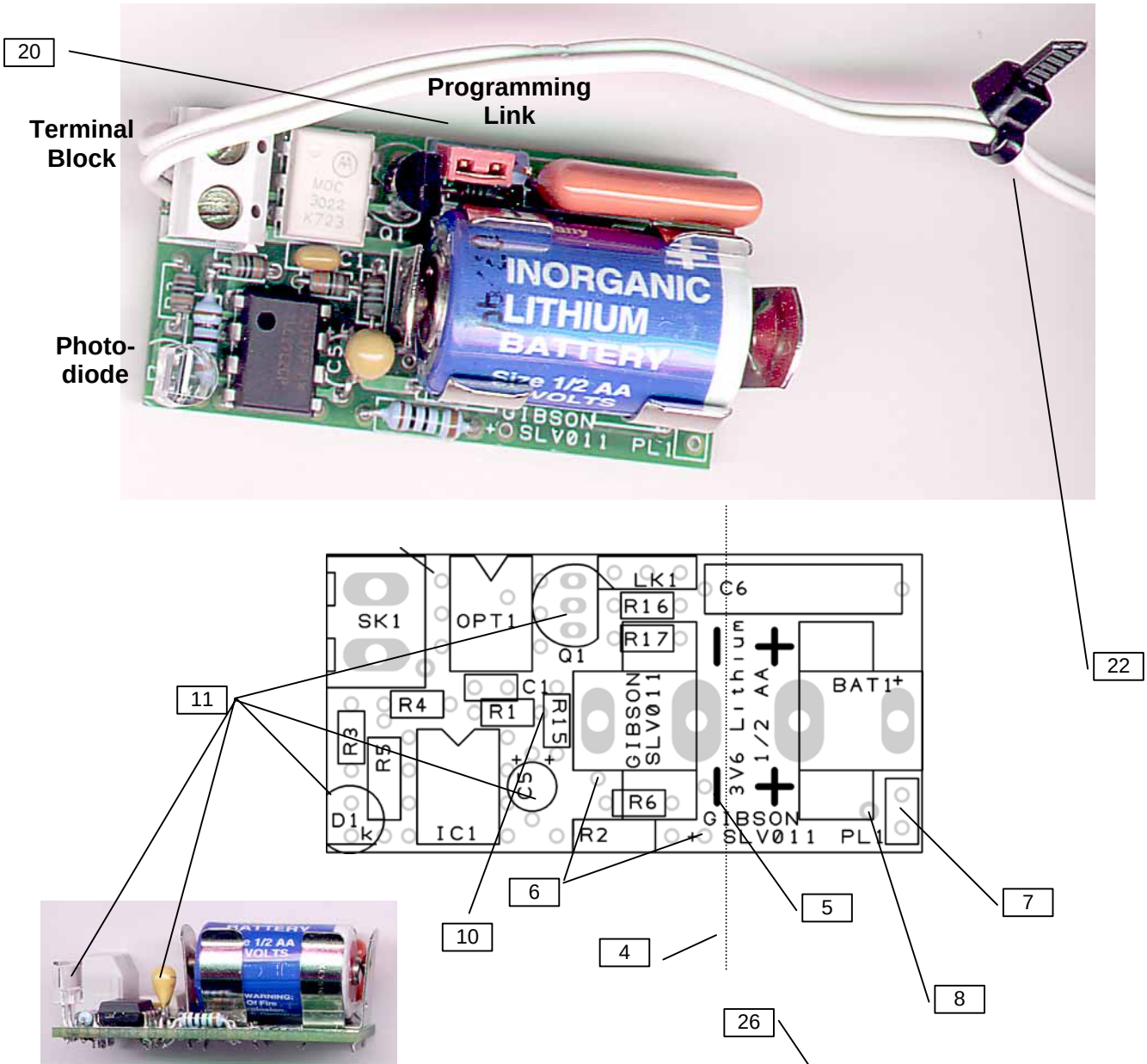
Using Alternative Components

You will notice, in the component list below, that I do not specify the exact components – only their values. This is because it is expected that, if you want to use your own components, you will have a thorough knowledge of electronics and will be able to make the correct judgements. However, some points to note are

- You must use a tantalum capacitor for C5. Electrolytic capacitors may have too high a leakage current (although they are a lot better than they used to be, and you may get away with it).
- 1% metal film resistors are preferred.
- For safety, C6 must be rated at 400V or more. You can use a lower rating, but you must be absolutely sure that you then only use the unit with a low-voltage-triggered flashgun – you must not accidentally connect the slave to a gun with a high-voltage trigger.
- The op-amp is a standard part from Texas Instruments. It is second-sourced by at least one other manufacturer in Europe. The salient features are that has a very low current consumption (the 'L' in the part number), that it will operate below 3V and that it has FET inputs. It is important that you use an FET part, because a bias current larger than a few pA will alter the performance.

Assembly Diagram for SLV011 PCBs

See later for notes on alterations for SLV021 PCBs



Side view, actual size

Completed Unit

The unit is housed in a translucent container.
The photodiode faces the bottom of the container.
In this example, the lead is fitted with an audio phono plug

Step-by-Step Notes

1. Note that the component numbers are not sequential, they have been copied over from the RALF design without being renumbered.
2. Observe proper anti-static precautions when handling *all* the semiconductors – IC1, OPT1, D1, Q1.
3. Bend the sub-min. resistors to 0.2" pitch. The 10MΩ *R*s are bent to 0.35".
4. If you do not require the on-board battery you can crop the board 15mm from the edge.
5. There is an alternative mounting hole for C6 when the board is cropped.
6. When the board is cropped, as described above, there are two holes available for connecting an external battery pack.
7. The unit does not require an on/off switch but, if you do want to fit one, you can wire it to the two connections marked PL1, but...
8. ...before you can use it, you must break the PCB link using a 'Vero' cutter, or small drill bit to ream the plated-through hole indicated.
9. Mount the components in order of size, with the lowest profile parts (the 0.2" pitch resistors) first. Some of the PCB lands are very small so you need to take care not to make any solder bridges. You must also take care not to fill any holes that belong to components you have not yet fitted.
10. Take care that R1 and R15 do not touch. You might have to bend R15 out of the way.
11. Parts Q1, C5, D1 must be mounted after the other components because they overlap lower-profile components. C6 is a tight fit (I got the size of the holes wrong) but if you grip it carefully with a pair of needle-nosed pliers and press hard it should go in.
12. Do not fit SK1, LK1 and the battery clips until after you have applied a conformal coating (if you are going to do so).
13. If you are going to apply a conformal coating, now is the time to prepare for it – before you fit the remaining components, which would be fouled by the coating. A coating is not essential if your units are well sealed; but bear in mind that even a small amount of moisture may prevent the circuit operating reliably.
14. Before applying a coating you should scrub the board thoroughly with a flux cleaner. If you are using a water-based flux, as in the solder I supply in my kit, then scrub hard with an old toothbrush under running water. For conventional fluxes, use isopropanol or *Electrolube's* 'Fluxclene'. Dry the board in a slow oven. (This is to remove any residual moisture from the PCB, which tends to attract it). ***Warning:*** if you are using a water-based flux it is important that you clean the board very soon after soldering.
15. Ideally you should use a 'solder-through' coating so that you can easily fit the remaining components afterwards. Mask the photodiode and the battery legend (this is probably important) with small pieces of sticky paper.
16. When the coating is tacky wipe any residual coating off the face of the photodiode. If the coating requires baking, do this.
17. Fit the terminal block. You may find it easier to attach the terminal block with a dab of superglue before soldering it. The reason for the large diameter holes is that some makes of terminal block have large pins.
18. If you are going to use a PCB-mounted battery, fit the battery clips. Press them in firmly with a pair of pliers. If there is any play, position them as far apart as you can. I placed them slightly too close together when laying out the board.
19. Alternatively, because the trigger contacts are opto-isolated you can power the slave from the flashgun's own batteries, which must be 3V unless you alter the values of R1 and C1 appropriately- see 'how it works' section.
20. Fit the programming link to LK1. The photos show the link in position 1.
21. If you are going to use the translucent container I supply then either punch a small hole in the lid of the container, or melt a *small* hole with a fine-tipped soldering iron from the inside of the lid.
22. A cable-tie is supplied with the kit. Tightening it around the lead will allow it to act as a cable grip, and will prevent the cable from being pulled out of the terminal block.
23. If you want to make the unit waterproof, you will need to seal around the cable. This could be a little tricky, as not all sealants will stick to the plastic. Clean it thoroughly and roughen the surface. Hot-melt glue is apparently a good sealant, but do not get this anywhere near the PCB, as it may be electrically conductive enough to cause spurious operation.
24. I usually just seal the hole with a piece of electrical tape – one piece over the top of the container, and another around the circumference to hold the lead (and the first piece of tape) in place – and I do not normally apply a conformal coating either.
25. Stick the *Velcro* strip to the side of the container. The matching half can be stuck to your flashgun but you will need to give this some thought, because the cylindrical container does not allow you to make full use of the strip.
26. Wire up a connector of your choice. Some people use a 5 pin DIN, but most people use BNC connectors nowadays, or cannibalise a hot shoe lead. I prefer to use an audio phono connector. See page 7.

Testing

See next page…

Component List

The following components are supplied in a small plastic container that can be used to house the built unit.

✓	Ref.	Part No.	Identification (Guide Only)
❑	C1	10n	103
❑	C5	33µ	33u + (or similar) Note 1
❑	C6	100n 400V	100n (large, orange)
			The fifth band on all the resistors is usually brown
❑	R1,6	3k3	orange orange black brown
❑	R2,5	10M	brown black black green
❑	R3,4	100k	brown black black orange
❑	R15,16	100R	brown black black black
❑	R17	1M0	brown black black yellow
❑	SK1		2-way terminal block
❑	LK1		3 link pins, 0.1" pitch
❑	BAT1		pair PCB clips for ½AA cell
❑	programming link for LK1		
❑	printed circuit board		
❑	translucent plastic container		

The following components are currently supplied in a black cardboard anti-static box.

✓	Ref.	Part No.	Identification (Guide Only)
❑	D1	SFH206K	viewed from above, as a "D", cathode is lower pin. Notes 1,2,3
❑	IC1	TLC 27L2CP	8-pin IC, pin 1 marked. Notes 1,2
❑	OPT1	TIL3022	(or similar) 6-pin IC, pin 1 marked. Notes 1,2
❑	Q1	Z00607MA	Z0607. 3 pin pkg. Notes 1,2

The following components are currently supplied in a plastic bag.

- ❑ twin-core wire for connection to flashgun
- ❑ Velcro strip (mating pieces)
- ❑ length of solder with water soluble flux
- ❑ Grommet
- ❑ Phono plug with moulded lead.
- ❑ Two cables tie, to use as cable grip

Notes:

1 Check polarity – orientation is marked on PCB.
2 Static sensitive.
3 An alternative may be supplied – see page 3.

In addition to the components listed above you will need:

- A conformal coating compound.
- Non-slump silicone sealant or PVC tape.
- Your choice of connector to your flashgun.
- A 3.6V ½AA-size lithium battery.
  These are fairly widely available, or I can supply one in my kit. A typical part is the *Sonnenschein* SL350/S, which is a 3.6V, 1.0Ah Lithium Thionyl Chloride cell, available, in the UK, from Farnell Electronic Components, stock number 206-520 or from Maplin Electronics, stock number GS99H. Maplin also stock a Maxell battery, ER3S_TC, stock code QE49D. An alternative is to use two MN9100 alkaline cells (size N) and a battery holder, e.g. Maplin stock code JG80B.
- A box, or a translucent film container, unless you use the container I supply.
  Farnell sell a small ABS box – stock code 326-161 – which measures 23 x 54 x 38mm, although it will not be as easy to make waterproof as a 35mm film container. I can supply this on request.

Farnell stock codes
See web site, **caves.org.uk / flash / docs.html**.

Testing

It is not practical to explain this in detail here; but, if you are lucky, you should not have too many problems. A common fault is not having a perfectly clean PCB, or letting moisture or mud get into the connector. If you do not trust your soldering abilities then you should not apply a conformal coating until you are certain that the unit works.

If you regularly seem to have problems with the unit it might be worth checking the batteries. As explained in the "how it works" box, operation at 3V is marginal. You could also try using different flashguns in case there is a problem with your connector, or the flashgun trigger circuit, but most problems seem to arise from dampness on the PCB.

Trouble-Shooting Guide

This guide is based on the questions constructors have asked me over the years.

Unit does not work at all

- Does the gun fire when the trigger leads are shorted at the terminal block? If not then your trigger lead is faulty. If you are using a hot shoe lead with more than two wires coming out of it, make sure you connect to the correct two. Do not just guess – do a continuity check!
- Have you used the correct link position for LK1?
- Is the battery correctly inserted? If not then you may have damaged the unit.
- Have you cleaned the PCB properly?
- Have you put the components in the right way round, in the correct places, and soldered all the joints properly?

Unit works intermittently

- You are using the incorrect position for the programming link, LK1.
- The battery is dead, or not decoupled properly (check you have fitted C5 correctly).
- PCB is damp; you should conformally coat it.

Unit is not very sensitive

- Is the battery dead? Replace it if it reads below about 3.4V as it is, for practical purposes, dead at this voltage. The unit will operate down to about 2.6V or so with alkaline batteries.
- You have conformally coated the PCB with an electrically incompatible compound – bad luck!
- You have not properly cleaned the board after soldering.
- You have damaged the photodiode or IC by not taking proper anti-static precautions.

Questions and Answers

I'm thinking of getting a Firefly, which I think is based on your design. Are your units better?

The Firefly is a commercial product; it comes ready built, with a hot-shoe connector. It is based on my earliest design, but with some small changes. My unit uses a different photodiode and is more sensitive underwater. In practice you should not notice much difference in the performance. Please note that if you are not skilled in electronics then I do not advise that you try to build my kit. Also, I cannot provide any technical support for the *Firefly* – it is not my product!

Can I save batteries by running your unit from a flashgun?

Yes, the opto-isolation of the output makes this possible. But the flashgun must operate from 3V unless you are prepared to change some components on the PCB.

How do I know if the battery is dead?

A new battery should give you at least four years of life. If the unit starts to operate intermittently, or seems to be too sensitive then check the battery voltage. It is supposed to be 3.6V. If it is down to 3.4V, it is time for a new one, as it is, for all practical purposes, dead. If it is below 3V then it is *definitely* time for a new one. The unit will, in fact, operate down to about 2.6V or so with a pair of alkaline batteries, but there is no point to running it that low with a lithium battery.

The battery does not seem to last as long as you say it should

If you are worried about this you can fit a switch (see earlier text). But if you are getting through batteries quickly then either they were not fresh when you bought them, or there is a fault in the circuit. Check that you have fitted C5 the right way round, and measure the voltage across R6 using a high-impedance (e.g. digital) meter. R6 is 3.3kΩ so, if the circuit is using less than 20μA, the voltage across R6 should be less than 66mV.

You claim a range of 1200m but I don't get anything like that underground.

The line-of-sight triggering range is around 1200m with a gun of GN 30m @ 100ASA – with a smaller gun, the range will be lower. This high sensitivity allows the slave to "see" round corners in dark passages. Suppose the light bounces round a passage, hitting the walls four times. If the walls have a reflectance of 10%, then a calculation shows that the range would drop to only 10m. Cave walls can have a reflectance of less than this.

The range will also be reduced if the op-amp is faulty (e.g. progressive damage due to your not taking proper anti-static precautions during assembly; or if the board is damp or dirty. If you use a water-based flux you must scrub it off *immediately* after soldering.

The slave unit appears to fire at random, whenever I hand it to an assistant.

Although the unit is insensitive to cap-lamp beams, it is not *completely* insensitive. If you shine a light on it suddenly, or move it to intercept a beam then it will likely fire. A good way to test it is, in fact, to point it at a light source and snap your fingers in front of it. The rapid movement of your finger creates a pulse of light sharp enough to trigger it.

But if it does appear to be behaving intermittently then you should suspect that it has got damp. Apart from direct contact with dampness, it seems that some flashguns are quite sensitive to water in the connectors.

Can I use the unit with flashbulbs?

Yes. This new design features a more rugged output stage than previously. (In the past it was possible to damage the unit if you were not careful about how you fired the flashbulbs).

You can use a battery to fire the flash-bulb directly, or you can use a conventional capacitor discharge circuit. In the latter case, the slave will latch on, and you will need either to unplug it to re-set it, or to briefly press the flashgun's manual firing button, which achieves the same effect.

I do not have much experience of electronics – can I still build your kit?

I do not advise it. It is very easy to make a mess! If you have an electronic soldering iron and some experience of hobby electronics then you should be OK, but this is not a project for beginners. You'd be better off buying a Firefly (Incidentally, I *don't* get any commission). You can buy a partially built kit from me if you think that would help. It consists of the populated circuit board – but you find your own connector and box.

Does the kit use easy-to-obtain parts?

Apart from the printed circuit board – which you can get from me – you should be able to get the other components from a professional electronics supplier. Some of the parts might not be available from a high-street 'hobby' electronics shop. If you live outside Europe then you might have trouble identifying some of the part numbers. Some electronics knowledge will help here. Read the information in the 'using alternative components' section of this article.

I've built it & it doesn't work. Will you fix it?

No. My kit of parts has been provided purely as a service to experienced electronics constructors because some are difficult to obtain. If any components are faulty then

they will be replaced free of charge, but this offer does not extend to fixing or replacing built or partially built units. If you wanted 'after-sales service' then you would need to pay more, or buy a finished product – I do not make any profit out of selling these kits!

What is RALF? Are the RALF units really that much better?

RALF stands for "redundant array of little flashguns". The concept was invented by Mike Bedford. It allows you to, for example, program a delay so that the unit does not trigger instantly. This can help to avoid contentions between automatic-exposure flashguns, and with an array of slaves all set to a different delay, you can 'smear' a moving cascade of water instead of freezing it into little drops, as a single electronic gun would do. RALF never really caught on and, unless you have a specialised application you do not really need it.

CREG

The "Standard" Caving Flash Connector

*This is based on **Mike Bedford's** article in* CREGJ **22** *(Dec 95) in which he reviewed a number of possible connectors.*

When this article first appeared, a common connector used by cavers was the 5-pin DIN but, as Mike says, this was not really a standard. Since then, with the prevalence of Firefly II units, most people use the BNC connector that Mike goes on to describe.

The Problem

Flashguns have a confusing array of different connectors for their trigger circuits. Some only have hot-shoes, but most have some sort of 2-pin jack-type connector. In the case of some studio flashguns, this may be a true 2.5mm jack, but in many cases it is a proprietary "jack-like" connector. Except for the plug on the supplied pc cable, suitable connectors are usually not available from electronic component suppliers.

Where the flashgun is only going to be triggered from the camera, this isn't a problem. In cave photography, however, it may also require triggering from slave units, cascade units and so forth. The usual solution is either to replace the connector on the flashgun, or to use an intermediate connector. In both cases a commonly available connector is used. Clearly there are advantages of standardisation in allowing equipment to be "mixed and matched".

The *de facto* Standard

David Gibson (1992) *[see 'further reading' list for this and other references]* alluded to the *de facto* caving connector, namely the 5-pin 240º DIN plug and socket. This uses pins 1 and 2 for the trigger circuit, and the battery circuit is on pins 4 and 5. Note, however, that this is the official DIN numbering scheme, and differs from the generally accepted caving numbering scheme, which has later been adopted by Gibson (1994). Confusion regarding pin numbering is clearly rife, and standardisation is jeopardised. In the latter reference, Gibson also points out that some cave photographers use the 180º part instead, so once again, the universality of this "standard" is in question. Furthermore, in many applications, only the trigger circuit is required, so people have opted for less clumsy 2-pin connectors. This will increasingly be true as slave units are being designed for ultra-low power consumption. *[as has now happened – DG]*

The Problem with DIN

I have recently used 2-pin DIN connectors for attaching the flashguns that constitute a RALF array – see Bedford (1995) – to Ian Drummond's cascade unit. The results were disastrous. The flashguns triggered less than 50% of the time, and once they'd failed to trigger, the situation could only be recovered by repeatedly disconnecting and re-connecting the plug / socket pairs. It seems, from inspection of the Farnell catalogue, that these parts probably have a working voltage of less than 100V which is, of course, is much lower than the voltage on a flashgun's trigger circuit. People have got away with using DIN connectors, but clearly they cannot be relied upon for this application.

The BNC Standard

UK cave photographer Chris Howes recommends replacing the hot shoe and connector on flashguns with BNC sockets. These are mechanically robust, are easy to connect and disconnect, and are of a bayonet design preventing accidental disconnection. They are also rated at 500V working voltage, but a proof voltage of 2kV. For those who are not prepared to modify their flashguns, in-line BNC sockets are available, so BNC connectors can still be used as an intermediate connector, although the flashgun plug and socket will then still be prone to accidental disconnection.

BNC connectors are cheap, and I would lend my support to the adoption of BNC connectors for the growing amount of flash-related equipment that does not require an external power circuit. (BNC systems come in two impedances – 50Ω and 75Ω – which are mechanically interchangeable. The terminology refers to r.f. useage and is irrelevant to our use of them.

Useful Addresses

(Date: September 2001)

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+44 (0)29 2049 8112
www.fireflyelectronics.co.uk
nigel@fireflyelectronics.co.uk

Shot in the Dark Photography
Peter Jones, 80 Mountain Street, Camden,
MAINE 04843, USA. **pjcaver@gwi.net**.

Farnell Electronic Components
(Professional world-wide distributor)
www.farnell.com

Maplin Electronics
(Home-electronics supplier, ships world-wide)
maplin.co.uk

Selected Further Reading

Original Slave Unit

Gibson, David (1992), *A High Performance Flashgun Slave*, CREGJ **10**, pp 7-12. Dec. 92

Gibson, David (1994), *A High Performance Flashgun Slave*, publ. CREG – *now out of print, although David Gibson has a few copies.*

RALF Slave Unit

Bedford, Mike (1995), *The RALF Concept*, CREGJ **21**, pp20-22, Sept 95

Gibson, David (1995), *A Slave for RALF*, CREGJ **22**, pp8-10, Dec. 95

Also see:

Gibson, David (1996), *A Slave for RALF – part 2*, CREGJ **23**, p11, March 96.

Gibson, David (1997a), *Update: Flashgun Slave*, CREGJ **29**, p13, Sept. 97

Enhancements to circuit

Gibson, David (1997b), *Using LEDs as Photodiodes*, CREGJ **29**, p14, Sept. 97

Firer for Flashbulbs

Gibson, David (2001), *A High-Performance Slave Unit and Flashbulb Firer – part 1*, CREGJ **45**, pp11-12, Sept. 2001

Flashgun Slave Unit: Update for 2003

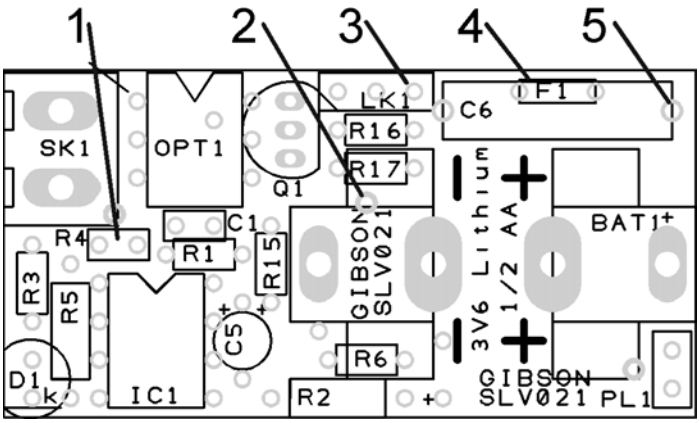
I have made some slight modifications to the printed circuit board to make the construction slightly easier. I have shifted some components slightly and increased the hole sizes for C6. (See **[5]** on the diagram below). In addition, all the pad sizes have been increased to make the soldering easier.

These modifications have not yet been incorporated into the main text, so please read the following notes.

R4 is now mounted vertically on a 0.1" pitch **[1]**

It seems best to fit the components one by one so that the leads do not get in the way of the soldering iron. Also, there are one or two components where it is best not to solder one of the leads until the adjacent component is inserted, otherwise you run the risk of filling a hole with solder. (This was mentioned in construction note 9 in the article). The main places to watch are close by pin 4 of IC1 and by LK1

One of the pins of LK1 has only a very small pad on the PCB. You do not need to solder to this pad, as the pins do not need an electrical connection here. It is just a 'parking' place **[3]** for the programming link when it's not in use.



Conformal Coating

I do not usually coat units for my own use, but I have been applying a solder-through coating to the semi-built units I have for sale. In fact, this coating is more trouble than it is worth, because it does not coat very well, requires baking, and gets everywhere it shouldn't. I think I will stop using a coating, but if you want to use, one then refer to construction notes 15 and 20. When the coating is tacky you can clean it from the photodiode and battery legend area using a cotton bud dipped in Oranex or Electrolube's 'Fluxclene'.

Thermal Fuse – NEW!

I have added the tracks for a thermal fuse **[4]**. This new component, F1, is not normally fitted and won't be supplied in the kits. However, if you are in the habit of using the slave unit to fire flashbulbs directly (i.e. without a capacitor-discharge bulb firer), then you might like to consider fitting it. It prevents damage to the unit in the unlikely event that the bulb blows short circuit, or you do something silly like accidentally connecting the slave unit across the battery. If you wish to fit F1, it nestles underneath C6 and to utilise it you need to drill out a plated-through hole as shown at **[2]**. I suggest a part by Multifuse rated at 0.1A 30V. The Farnell stock code is 772-252.

Problems with the SLV021 PCB

The printed circuit board with reference number SLV021 suffers from a potential fault. This note applies ***only*** to printed circuit boards with the number SLV021. Boards with part number SLV011 are not affected.

The fault will ***not*** affect the 'normal' operation of the slave unit. It is only of significance if …

a) you want to mount the unit inside a flashgun, ***and***
b) you want to power it directly from the flashgun's own battery, ***and***
c) you have already fitted the on-board battery clips, ***and***
d) the fault is actually present on the board (which it might not be)

If the above conditions all apply then you could damage your flashgun.

if you are using the slave unit with its own battery, then there is no problem.

Nature of the problem

The output of the slave unit is normally isolated from its battery using an 'optocoupler'. The reason for this is so that you can – should you wish – power the unit from a flashgun, without worrying about the polarity of the flashgun's trigger circuit. However, printed circuit board SLV021 contains a segment of track that passes very close to the negative battery clip and may possibly cause a short circuit to it. The effect of this short circuit would be to connect one of the screw terminals to the negative side of the battery.

The short circuit is not present on any of the built units I have tested – but there the potential for it to occur – especially if you are building your own unit.

What to do if you think you have a problem

1) For 'normal' use of the slave unit you do not need to take any action.
2) If you have a ready-built unit, prior to 2003, and you think you have a problem, please contact me.
3) If you are about to build your own unit then you can protect against the problem by either a)placing a small piece of insulating tape or blob of paint over the plated-through hole marked [2] on the diagram above or b) not fitting the battery clips

Please note that the problem only exists if you are intending to power the unit from the flashgun's battery (which must be 3V of course). In this situation, you would probably decide to omit the battery clips – in which case you do not have a problem.

4) If you have already built your own unit then you should check to see if you have a problem. Measure the resistance between the negative battery connection and the top left screw terminal, as viewed in the diagram above. If the meter reads 'open circuit' you do not have a problem. If it reads short circuit, you have a problem, and you should contact me. This only applies to a very few of you, who have built your units before I issued this notice in 2003.

Flashgun Slave Unit: Update for 2004

These modifications have not yet been incorporated into the main text, so please read the following notes.

Moulded Phono Connector

Kits are now shipped with a lead containing a moulded-on phono plug. When connecting this, make sure you prepare the end of the wire carefully, and secure the wire well using the cable ties – see photos below.