Camper Van Conversion Ebook
A Ford Transit conversion to a motor home

Chapter 5 - Electrics

Table of Contents

Preface

Hello and welcome to my book: an account of how I took the idea, "it would be nice to have a camper van for the family" (instead of camping) through to buying a minibus and converting it to a four berth, fully functional camper van.

I would by lying if I said it was easy. It takes hard work, often in the dark and cold, especially if you are doing a Winter project as I did. It is a series of problems or challenges to be overcome. However, I can assure you that the end result has been well worth the effort. We now have a bespoke camper van designed to meet our family's individual needs. This was achieved at a fraction of the cost of buying a commercial camper van. The 'Cost breakdown' section shows the details.

I spent about 12 months thinking about my idea and getting it into a workable form before I started the conversion. I researched all aspects of 'self build' camper van converting. It took about 7 months over the Autumn and Winter of 2009/10, working at nights and weekends to complete the conversion. The 'Build Diary' section shows the exact time taken to complete each job. I'm hoping that this publication will make it easier and quicker for you to plan, build and convert your camper van.

This publication is part diary and part photo catalogue. It has my comments, ideas and thoughts on my own conversion of a minibus into a camper van. Although I know that my conversion may differ from what you intend yours to be, this publication aims to help you through the process of turning your idea into a reality.

As well as documenting my experience, I've tried to answer the questions I had before I started the project and offer solutions to the many challenges that presented themselves during the conversion.

I have had help through out and I would like to thank all those who have provided moral support as well as practical and professional advice. This includes friends (you know who you are), who are experienced camper van converters, aspiring converters and owners.

All the companies who provided skills and advice are referenced in the book. Most of all I'd like to thank my family for getting on with life whilst Dad was in the garage again, for another Saturday or Sunday. The future holidays and adventures should make it all worth it.

I hope you enjoy reading it and that it is useful to you. This is exactly the information that I looked for whilst I was deciding whether to take on the challenge of a self build camper van.

Regards and good luck,
Colin

1. Introduction

What does a camper van mean to you ? For me it means spending time away on 'adventures' with my family (2 adults + 2 kids), both family holidays (on a camp-site), but also 'days out' to the coast or countryside, hopefully in nice weather.

However everyone I have spoken to has a different view and different requirements of what a camper van means to them. An good example is a friend of mine who is converting a van which is very different to mine, he needs to be able to carry two sets of windsurfing equipment and wild camp for a few days often in bad weather (i.e. windy, usually stormy) and large enough for him, his partner and their dog.

You might think that his camper van conversion is totally different from mine. However in practice the projects are nearly identical, we may have purchased very different vehicles and have different layouts / designs, but in practice we have followed the same process and used probably 90% of the same materials and skills.

My point is this, no matter what type of camper van you would like to have (VW T4,T5, Mercedes Sprinter etc.), this book can help you.

So the first thing to do to convert your idea into reality, is to ask yourself "What will I use my camper van for and what do I want in it". This sounds easy but to be honest you won't know all the answers until you have been out in your finished camper van for a few times, but we can at least try and determine your main requirements. Chapter 2 - Planning covers this in more detail.

Once you have decided what your requirements are, you can then use these to help you design your ideal camper van. As you'll discover by reading this publication I found no commercially available van builder who had what I considered to be my ideal van configuration, so I took good points from other layouts and put them together to form my own design to suit exactly what I needed.

This design is obviously linked to the space available and so the design goes hand in hand with choosing which van to use. Chapter 3 – Design & layout covers these topics.

Well so far it sounds easy right ! It took me around 12 months to get to the point, where I had a drawn up design and thus determined what size of van I would need. To be fair to myself during this 12 months I was also establishing what skills, tools, equipment, suppliers, money and time I would need. You won't take this long as all that I learnt along the way is detailed in this book.

I had not attempted anything like this before so was unsure of a lot of things. The biggest unknown I had before embarking on the conversion was how long it would take in hours to complete all the work. Having finished, I now know this and I have devoted Chapter 12 – Time & money and appendix 3 & 4 to this subject.

The rest of the chapters in the book cover the conversion work : insulating, wiring, kitchen, gas, water etc. Before embarking on your project I would read these, so as to understand the types of work and jobs that you will need to complete or contract out.

At the end of the book are a number of appendix's which you can read or dip into when you need some information in that area. These are :-

Number	Name	Description
Appendix 1	The right stuff	The skills and attributes of a Camper van converter
Appendix 2	The workshop	List of tools and equipment that you will use.
Appendix 3	Diary	A diary of each completed job and how long it took.
Appendix 4	Expenditure diary	A full list of expenditure on my project.
Appendix 5	World Wide Web	A full list of internet sites that can assist you
Appendix 6	Suppliers	A full list of companies I've used and found useful.
Appendix 7	Full electrical wiring diagram.	
Appendix 8	Other useful publications	A full list of commercially available camper vans etc

I hope you enjoy this book and good luck with your project.
Colin.

PS If you have not already have a look at the video of my finished camper van on my web site, visit : www.mycampervanconversion.co.uk

5. Electrics

5.1 Electrical installation planning

WARNING : Electricity is dangerous. If you don't feel confident working with it then get a professional electrician or automotive electrician to do the work for you. All work you attempt is at your own risk !

The leisure electric system that you design and fit to your your van is, in my opinion, the most important part of the conversion process. Without power a camper van is fairly useless, no lights, fridge or water pump !

I believe the vehicles battery and the leisure system should be separate so that no mater how you use your leisure electrics system your vehicle will always be able to start. The other reason for keeping them separate is that you will probably use a different type of battery, as its usage is totally different. This is covered more in section 5.2.

You may recall from Chapter 2 that I required my van for days out (no mains electric hookup) and family holidays (Mains hooked up all the time). Lets take the first scenario and work out how much power we think we will use, we can then use this to determine the battery bank capacity and thus its physical size. The second scenario, i.e. being on mains hookup, is easier as long as we calculate the correct sized battery charger we will need.

I planned to have the following electrical appliances in my van :

- 12v Compressor fridge (40 watts)
- Water pump (10 watts)
- Lights (LED) (15 watts)
- Battery monitor (0.4 watts)
- Gas alarm (0.4 watts)
- Laptop (12v charger) (80 watts)

I obviously would not be using all of these all day, so we need to calculate what the average daily consumption of power will be. In power systems we calculate the total amount of energy consumed over a certain period in Amp hours (Ahr). E.g. .one amp consumed for 5 hours has used a total of 5 Ahr of power.

To be able to calculate our Ahr's we need to be able to convert between the common measures of power i.e. Amps, Watts and Volts.

Volts: Electrical force of pressure behind the electrons in a circuit. Analogous to water pressure or PSI, it tells us the system voltage (12, 24).

Amps: The number of electrons flowing past in a second. Like litres per second in a pipe, it defines the electrical current in a wire.

Watts: Total amount of electrical energy, per second.

The conversion formulas are:

- Watts = Volts times Amps
- Volts = Watts divided by Amps
- Amps = Watts divided by Volts

Therefore 40 Watts (Fridge) divided by 12 Volts equals 3.33 Amps. Take this 3.33 Amps and multiply it by the number of hours it will be consuming power (estimated to be 16hrs for each 24 hour period) equals 54 Ahrs (Max of 80 Ahr, if running continuous for 24 hrs.).
I therefore calculated my average 24 hour period power usage as follows :-

- 12v Compressor fridge (40 watts / 12v = 3.33 Amps) * 16 hours = 54AHr
- Water pump (10 watts / 12v = 0.84 Amps) * 1 hours = 1Ahr
- Lights (LED) (15 watts / 12v = 1.25 Amps) * 3 hours = 3.75Ahr
- Battery monitor (0.4 watts /12v = 0.03 Amps) * 24 hours = 0.75AHr
- Gas alarm (0.4 watts /12v = 0.03 Amps) * 24 hours = 0.75AHr
- Laptop (12v charger) (80 watts / 12v = 6.66 Amps) “ 2 hours = 13.5AHr

This totals 74 Amp Hours of power, the standard rule of thumb, is to then add on 25% to allow for battery deterioration, poor charging etc. My total was **92.5 Ahr.**

Battery / Electrical Precautions

- If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters the eye(s), immediately flood eye(s) with running cold water for at least 20 minutes and seek medical attention immediately.

- Never smoke or allow a spark or a flame in the vicinity of a battery or an engine.

- Be extra cautious not to drop a metal tool onto a battery. It may spark or short-circuit the battery or other electrical parts that may cause an explosion.

- Remove all personal metal items such as rings, bracelets, necklaces, watches and jewellery when working near a battery. A battery can produce a short circuit powerful enough to weld a ring or any metal, causing serious burns.

- Make sure the area around the charger has been well ventilated before you connect the charger.

- Do not charge the batteries at least 4 hours prior to the installation to avoid the formation of explosive battery gases.

5.2 Batteries, locating and securing

For a leisure electrics system we need 'deep cycle ' leisure use, i.e. we need the battery to provide steady (low) amps over a sustained period and then the battery to be able to be recharged to full capacity (i.e. a cycle). Leisure batteries are usually capable of 200 to 300 cycles.

A standard car battery could be used, but it would not last very long as its designed to provide a high amp capacity for a short period (i.e. starting a car) and will typically only last 15 to 20 cycles..

There are three main types of batteries :-

Flooded: These are so called wet batteries, filled with sulphuric acid. They are manufactured with lead plates which are designed to handle high starting capacity for automotive use, or plates designed for deep cycle leisure use, but Not both. Even leisure types can be easily damaged by deep discharge.

Carbon Fibre: The Elecsol range are a type of flooded battery with carbon fibre reinforced lead plates. This gives more power for less weight and better cycling performance. Unlike normal leisure batteries, they offer dual purpose, both deep cycle for leisure use and high starting capacity for automotive use.

GEL: The Exide GEL range are absolutely maintenance free, clean and environmentally friendly with no release of acid vapours. Extremely low gassing for use in closed compartments. Constant cold cranking performance over the entire service life. Minimal self discharge. Extremely high cycling capability. 100% leak proof. Deep discharge proof. Unlike normal leisure batteries, they offer dual purpose, both deep cycle for leisure use and high starting capacity for automotive use.

They all of course differ in price, performance and how they should be charged, but it is generally accepted that 'flooded leisure batteries' are the best value for the standard camper van. Most professional manufactures fit this type of battery.

However please note that even 'deep cycle' batteries can be damaged if they are discharged more than 50% of their capacity. Batteries are rated in Amp hours (as per our previous calculation). Therefore take your calculation and double it, this will then be the total capacity you will require in your battery bank, i.e. 184 Ahr in my case.

Leisure batteries are supplied in capacities of 65 Ahr to 120 Ahr. The main manufacturers of 12 Volt leisure batteries are Elecsol, Numax, Exide, Lucas and Varta.

However there are many manufactures and as long as they are sold by a reputable company they should be fine. After exhaustive price matching on the internet I found that my local Automotive discount centre could match the best price for Lucas, Numax and Varta products. This was because they could buy direct from the UK distributor (www.manbat.co.uk) at trade price.

I decided to purchase them locally for a few reasons, but the most important one being that I could pick the batteries up myself. If batteries are transported badly the acid can leak out of them, which did happen to a friend of mine.

I bought two Numax LV26MF's, which are 95Ahr each, giving me a total battery bank (when connected in parallel) of 190Ahr.

You can connect many batteries together and they effectively just become one big battery bank. How you connect them together is important. Two methods are available :

Parallel : Connect the positive terminal to the positive terminal and the negative terminal to the negative terminal. This maintains the voltage at 12V but doubles the current (i.e. 180 amp hours)

Series : Connect one positive to one negative and using the other two terminals as the supply. This doubles the voltage, i.e. 24 Volts and maintain the amps i.e. 95Ahr.

Your batteries will last longer if they are looked after :-

- Always keep you battery fully charged, even when not in use
- Coat terminals with petroleum jelly
- Keep in a frost free location
- If battery is not sealed, check electrolyte levels regularly. If required, top up with deionised water.

The first point above can easily be addressed by installing a solar panel. This is discussed later on, but its worth noting that a Solar installation will provide a continuous trickle charge. This can considerably extend the life of your leisure battery and save you from having to 'hook up' your van whilst at home.

On my van I installed a digital battery monitor, which is usually fitted to yachts. This allows me to see at a glance what current is going in or out of the battery bank and also the current battery bank voltage and charge. Battery voltage indicates its current charge state :-

Note This is accurate 4 hours after any charging has taken place.

- 12.7 Volts or more = 100% charged
- 12.5 Volts = 75%
- 12.4 Volts = 50%
- 12.2 Volts = 25%
- 12 Volts or less = Discharged

Locating where you should put your battery bank is important as you need to minimise cable runs, it has to be ventilated, accessible but most importantly it has to be securely fastened to the van thus safe. Batteries are very heavy and do contain sulphuric acid.

They therefore need to be housed securely either in the vehicles engine bay or within its interior. In my van the logical position for my battery bank was under the double passenger seat. This was because the area was accessible, it was close to the vehicles main battery (under the drivers seat in a transit van), it was close to the electric components, i.e. chargers, fuse box etc. and it could be secured to the seat frame using 5 ton ratchet retaining straps.

Some batteries (flooded) types mainly that are not sealed can give off explosive gasses and often come with some tubing to vent them to the outside of the vehicle.

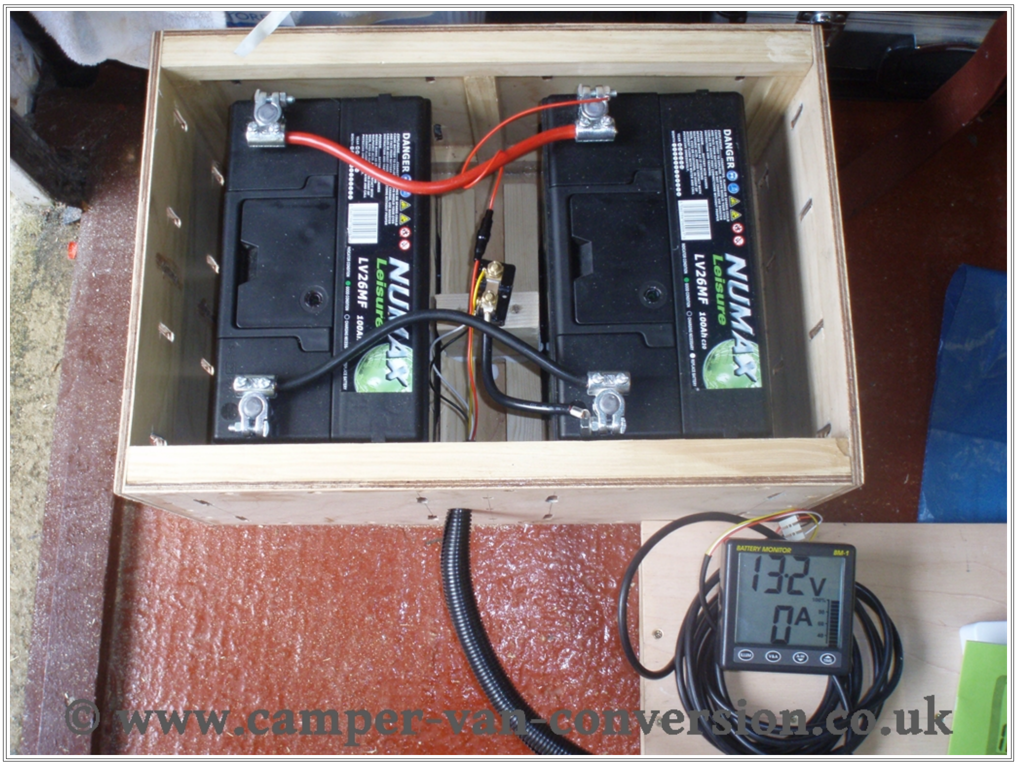
Note : See the gap under the double seat in the picture below.

For me to use this space I would have to construct a custom made battery box to house my two batteries :

This was constructed out of 34mm batons and 6mm ply board, bonded together with wood glue, Sikaflex 512 and wood screws.

Please ensure that you leave some spare space in the box, as your next set of batteries are unlikely to be exactly the same size as your current ones. I tried my batteries in for size and screwed some additional wooden bars into the box so that they would not be able to move around.

The batteries are connected in parallel using 170amp battery starter cable. You can also see here the battery monitor (BM1) connected. This is connected via a 'Shunt' that is installed in the middle of the batteries, all charging and load for the battery bank on the negative side has to be connected to and thus pass through this shunt.



This battery box would be securely strapped to the seat frame using two 5 ton ratchet straps, I confirmed this with an automotive crash test engineer, who informed me that one strap would have been adequate. This box is designed to be able to slide out from under the seat and then slide along to the side door of the van to allow easy access to the batteries if required. This meant I would need an 'Umbilical' cord of cables to attach it to the electric components.

Battery box secured under the seat.

Battery box and umbilical (seat removed) and battery box slid out

5.3 Cable Selection

To wire up all your appliances you will need to calculate what size cable to use. You may think this is not very important as our leisure system is at a low 12 volts. However in practice, as its low voltage this means we need a higher current (Amps) to pass along the cable to the appliance than if it was a mains voltage system.

This means that we need thicker cable to handle the increased current. Let me illustrate this point :

At 220 volts: 40 Watts divided by 220 = 0.18 Amps
At 12 volts: 40 Watts divided by 12 Volts = 3.33 Amps

So the cable we need to use for this appliance has to be at least rated at 4amps. This is important as if the cable can't handle the current then it could melt and cause a fire. Another important factor is 'voltage drop'. A current running through a cable encounters resistance and so the longer the cable the more resistance, this can cause the voltage to drop over the length of the cable.

To fix this you use a thicker cable (i.e. a thicker pipe to carry the current). Fortunately you don't need to calculate this you can use a reference table, see next page. You can also use on line calculators, like this one :http://www.solar-wind.co.uk/cable-sizing-DC-cables.html

12 Volt Direct Current (DC) wire selection table								
Circuit		**Length of cable run**						
Amps	**Watts**	**3'**	**5'**	**7'**	**10'**	**15'**	**20'**	**25'**
0 – 5	**30**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8
6	**36**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	16 / 1
7	**42**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	16 / 1
8	**48**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	16 / 1	16 / 1
10	**60**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	16 / 1	16 / 1	16 / 1
11	**66**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	16 / 1	16 / 1	14 / 2
12	**72**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	16 / 1	16 / 1	14 / 2
15	**90**	18 / 0.8	18 / 0.8	18 / 0.8	18 / 0.8	14 / 2	14 / 2	12 / 3
18	**108**	1 18 / 0.8	18 / 0.8	16 / 1	16 / 1	14 / 2	14 / 2	12 / 3
20	**120**	18 / 0.8	18 / 0.8	16 / 1	16 / 1	14 / 2	12 / 3	10 / 5
22	**132**	18 / 0.8	18 / 0.8	16 / 1	16 / 1	12 / 3	12 / 3	10 / 5
24	**144**	18 / 0.8	18 / 0.8	16 / 1	16 / 1	12 / 3	12 / 3	10 / 5
30	**180**	18 / 0.8	16 / 1	16 / 1	14 / 2	10 / 5	10 / 5	10 / 5
40	**240**	18 / 0.8	16 / 1	14 / 2	12 / 3	10 / 5	10 / 5	8 / 8
50	**300**	16 / 1	14 / 2	12 / 3	12 / 3	10 / 5	10 / 5	8 / 8
100	**600**	12 / 3	12 / 3	10 / 5	10 / 5	6 / 13	6 / 13	4 / 19
150	**900**	10 / 5	10 / 5	8 / 8	8 / 8	4 / 19	4 / 19	2 / 32
200	**1200**	10 / 5	8 / 8	8 / 8	6 / 13	4 / 19	4 / 19	2/ 32

Use this cable selection table by selecting the amp / wattage of your appliance then look up the length of you cable run and where the two rows meet is the AWG size and the metric size in mm of the cable you require.

In my van I only used three sizes of cable :-

- Twin core flat PVC cable 2* 1mm thick (8.75 amp rated)
- Twin Core flat PVC cable 2* 3mm thick (27.5 amp rated)
- Battery starter cable 25mm^2 (170 amp rated)

I used the 170 amp cable to connect the batteries together and to connect the leisure batteries to the vehicles battery via a Battery to Battery charger (explained later).

I used the 27.5amp cable to connect the leisure battery bank to the fuse box / distribution panel.

The 8.75amp cable was used to connect up all appliances to the distribution panel. If required I ran two cables (2 * 8.75 = 17.5 amps capacity) to ensure it could handle the appropriate current / voltage drop, i.e. to the fridge.

You will use a lot of cable, I used nearly 100 metres of the 8.75 amp cable, so order it in as you don't want to hold up the job waiting for cable.

One other point on cable selection is make sure you use automotive multi stranded cable, I have read of some people using domestic (solid core) mains twin and earth cable. This would work but in a vehicle with vibrations it does tend to work loose from connections or snap.

Here are the 8.75 amp, 27.5 amp and 170 amp cables :-

5.4 Leisure system explained

In appendix 7 there is a full diagram of the electrical system I installed. Let me explain why I arrived at this system, as you may wish to have a less complicated or cheaper system in your conversion.

We have already covered the batteries and the cabling. The other main components of my installation are :-

1) **BM1 – Battery Monitor.**
2) **Sterling B2B charger**
3) **Switched fused distribution panel**
4) **Waeco CR50 compressor fridge**
5) **Solar Panel and controller**
6) **Whale submersible water pump**
7) **LED lighting**
8) **Gas leak alarm**
9) **12v Aux sockets**
10) **Mains electrical system, RCD distribution, sockets and main battery charger.**

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<u>BM1 – Battery Monitor</u>

I felt it was important to be able to monitor my battery usage. The BM1 battery monitor from Nasa Marine Instruments (http://www.nasamarine.com/) continuously monitors voltage, current (charge or discharge), number of amp/hours (charge or discharge), the batteries state of charge and the time to charge or discharge. They do produce a BM1 compact also. The BM1 can be attached to battery banks up to 650 amp hours. The product is £100 or so and there are cheaper monitors on the market.

<u>Sterling Battery to Battery (B2B) charger</u>

My van is designed for use as a day van, wild camping for 24 to 30 hours or long holiday (mostly hooked up to mains). So this shaped my thinking on which battery charging mechanisms to use. The normal vehicle battery is trickle charged from the alternator when the engine is running, there are three charging methods that can split that charge from the alternator to charge a second battery bank.

- Split charge relay system
- Split charge diode block
- Alternator to battery charger (from sterling)

I decided against using these methods for the following reasons :-

- Cabling to the alternator required.
- More cabling than for a B2B.
- They split the charge, so your car battery is not always getting the charge it needs.
- Charging speed is slow.
- Just one step charging method, i.e. trickle charging

The Sterling B2B charger (BB121250 – 12volts to 12 volts 50 amps) from Sterling Power Products (http://www.sterling-power.com) appears to me to be the best solution. It works by constantly monitoring the engine start battery. When the starter battery voltage exceeds about 13 volts (which is usually the case when it is being charged) the B2B charger will activate itself. It will then start its charging operation during which the starter battery voltage will be pulled down to no less than 13 volts. This enables the engine battery to still receive sufficient charge and ensures that the alternator works at its full potential The unit takes the 13 volts from the starter battery into the control box and boosts it up to a maximum of 14.8 volts (depending on what battery type has been selected) at the output.

This will charge the secondary bank of batteries fast (probably 5 times faster than an alternator) and up to their full capacity. The charger then automatically calculates the optimum absorption time and keeps the voltage at absorption level until the batteries are fully charged. After that the system will maintain the batteries at a lower float voltage, while always ensuring that the engine battery has priority.

The benefits of this are that when you are driving you are charging your leisure battery bank very fast and efficiently using a 4 step charging pattern. This will not only ensure you have power but will prolong the life of your deep cycle leisure batteries.

What I liked about this is that I did not have to change the car alternator cabling at all. Also as the vehicle battery on the Ford Transit is under the drivers seat the cable runs between the two batteries were very short. However the most important point in my opinion is that the vehicle battery (for starting) will always be fully charged.

The B2B unit also comes with temperature sensors which are easily fitted to the leisure batteries and the vehicles alternator. The B2B unit shuts down if either start to overheat for any reason. This I considered to be a nice safety feature, especially given that my leisure batteries would be under the seat my children would be using.

This unit does not come cheap though, I paid £205 for mine.

Also it took me a long time to find reasonably priced fuses for this installation. As the B2B unit is rated at 50amps, you need to fit 100amp auto fuses. Some companies were asking about £30 per fuse and the holders were extra. I managed to source them for approx £12 delivered to my door from http://www.thetoolboxshop.com/.

<u>Switched fused distribution panel</u>

In an leisure electrics system (like a vehicles electric system) we need to protect all circuits by installing fuses. Fuses are designed to interrupt the flow of power to a circuit when the current exceeds safe levels, thus preventing the cable melting or the appliance being damaged. Fuses are rated in amps.

We therefore have to ensure that each fuse for each circuit is rated less than the cable capacity (to stop the cable melting before the fuse disintegrates) but that it is also rated higher than the maximum load that the appliance requires (or the fuse would blow every time you used the appliance).

Initially I planned using a standard automotive blade fuse box fixed in my battery box. However I also felt it important to be able to isolate (switch on & off) each circuit so I planned to install a switch panel of some description.

However after searching through the internet I found that yachts often used switch panels that also have resettable fuses built in to them. This appealed a lot as if I did have a short circuit for any reason and a fuse tripped, I would not have to carry physical replacement blade fuses. I could fix the problem and then just reset the fuse.

Waeco CR50 compressor fridge

As I have explained my leisure electrics system was designed to incorporate a 12 Volt compressor fridge, this was because they operate a small compressor motor and so they are relatively quiet. But more importantly they don't require a flue or ventilators to be cut in the side of the van. This makes their installation a lot simpler.

They can also be left to run all night with no concerns about gas or flames, as you have with absorption fridges.

Waeco from Germany are probably the best known manufacturer of Motor Caravan fridges and their products are installed into a lot of commercially available vans. They are imported into the UK by Dometic Ltd http://www.dometic.com/enuk/Europe/United-Kingdom/Start/, but are available from a lot of Chandlers and caravan equipment suppliers.

Solar Panel and controller

Initially I had not planned to install Solar on to my camper van. However after speaking to a friend who had installed over 100 watts of panels and found that he could run his compressor fridge for about 5 -7 days with no mains hookup. I was convinced that I should consider this.

Solar panels are not cheap items, however having one would ensure that my batteries would always be in prime condition and should prolong the batteries life.

There are four main types of Solar panels :-

1) Single Crystal Silicon (Mono-crystalline)
The cells are sliced from a pure crystalline ingot. This type of panel is the most commercially available efficient type, giving 15% - 20% conversion efficiency.

2) CIS (Copper Indium Diselenide)
this is a thin flexible film technology giving 11% - 14% conversion efficiency.

3) Poly-crystaline silicon
Molten silicon is poured into a mould and then sliced in to cells. Gives 13% - 15% conversion efficiency.

4) Amorphous silicon
This thin film silicon is used in toys and calculators. It gives 8% conversion efficiency.

This is all very well but how do you choose ? Unusually I found that the most efficient type is also the best value for money once you get above 50 watts. So the decision was easily made, mono-crystalline it would be. The draw back to this type of panel is that they are rigid and therefore have to be fitted in a frame, this raises the height of your vehicle more than a flexible panel. As I have a high roof line vehicle another 10 centimetres in height did not concern me.

Solar panels are measured in watts. An easy way to calculate the maximum amps that a solar panel will generate is to divide the wattage by 17. e.g. 100 watt panel, in very sunny conditions will generate 5.8 amps. As you have already read my fridge would consume 3.33 amps when running. Given the budget pressure I decided to buy a 65 watt panel, thus giving me a maximum of 3.8amps power during the sunniest summer days. Enough to run the fridge !

My solar installation, solar panel, 10A charge controller (needed if the panel is over 20 watts), fixing kit, VAT and delivery came to £322. It was supplied by www.sunshinesolar.co.uk.

Whale submersible water pump

As you will read further on I decided on a submersible water pump as opposed to a fixed piped solution. Whale are regarded as the best manufacturer of motor home submersible pumps.

LED lighting

All ready fitted in the minibus were two fluorescent ceiling lights, with each light containing two 8 watts 12” tubes. So in total these lights would consume 2.66 amps per hour of power. This was too much and I researched replacing the fluorescent T5 tubes with LED tubes. The problem I encountered was that T5 LED tubes were just starting to be manufactured in China, but the suppliers here did not yet stock them.

LED lights need a little driver unit for them to work, this driver unit is incorporated into the casing, which is why the early LED bulbs were so bulky. Manufacturers have easily incorporated this driver into large strip light fluorescent tubes but only a couple of manufactures have managed to incorporate them in to T5 i.e. 12 inch tubes.

To cut a long story short, after 6 months I took delivery of 5 12volt DC, 3.5watt , 3500k – 4500k T5 tubes. These were warm white light tubes (that's the 3500 to 4500k rating), in total they take 1.2 amps per hour, they are brighter that the old fluorescent tubes and they give a lovely warm white light.

These tubes cost me £10 each, but I know they are now (July 2010) about £20 each due to the pound devaluing and the upward trend in raw material costs.

Gas leak alarm

One safety feature I wanted to fit, was a gas (butane, propane) alarm, as it happened I noticed my local Lidl was selling them for £6, so I bought one and wired it in next to the gas cylinder.

12v Aux sockets

I planned to install 3 auxiliary 12 volt sockets, one for an awning light, near the sliding door, one on the kitchen for a 12v kettle or small AA battery charger, if required and one near the table to run a laptop. You can buy 12 volt laptop power supplies cheaply from Ebay. Do ensure these auxiliary sockets have the appropriate amp rated cable and fuse for their intended uses.

Mains electrical system, RCD distribution, sockets, mains battery charger and plinth heater.

You can buy mains hook up kits that include fitting instructions and although I found them a little bit expensive, they are very good for someone less confident of the kit and wiring required. I have had experience of fitting mains electrical equipment so I purchased my own bits and fitted them . If you are unsure at all about fitting this equipment then please get an experienced / qualified electrician to do it for you.

I purchased the main battery charger from my local motorist discount centre, as they price matched the internet. The manufacturer is CTEK (http://www.ctekchargers.co.uk), I found these to be the best value, intelligent 4 stage charges, (cheaper than Sterling ones) that would also act as a power supply when hooked up. They are designed to run permanently so there are no problems when you are hooked up for a long period.

They continuously check the battery charge and then use a 4 stage charging curve to charge the batteries back to full capacity, the charger then reverts to supply mode and responds to demand placed on the batteries. I installed the 7amp model, XS7000. One additional item I fitted was a 1.8kw (7.5 amps) mains electric fan heater which fits in the plinth under the kitchen.

5.5 Leisure Power System installation

To install a leisure electrics system you have to decide where to put the batteries (under the seat in my case) and where to put the electric equipment. The electric equipment needs to be in a well ventilated area and should be close to your main appliances, to minimise cable runs

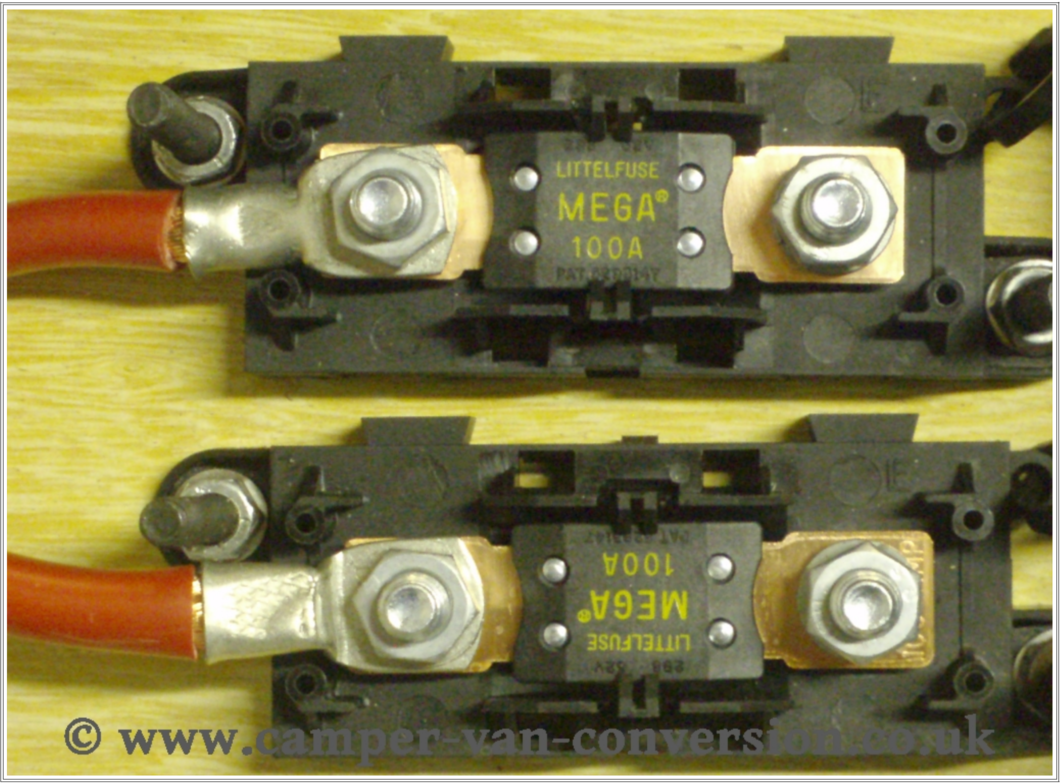
5.5.1 Electrical component locations

As you have read in section 5.2 Batteries, locating and securing my batteries are stored under the double passenger seat and the cables (umbilical cord) then come out of the box at the back. The reason for this is that, my design has a partition wall running along the back of the passenger seats (the is covered in the next section) and this creates a space behind the seats where the electrical components could be located.

With this in mind I first constructed a back plate made out of a sheet of aluminium and ply wood that I could fix all the electrical components on to. This plate would then be fixed to the back of the partition wall once constructed.

I first fixed the Sterling B2B charger and the two required 100amp fuses to the board. I used the 170amp battery starter cable, which I had crimped (using a vice) screw terminal lugs on to. I later on soldered these connections also, to ensure that they would never work loose and to provide a better connection than just crimping alone. The connections on the B2B charger and the mega fuses had M8 connections, which means holes to fit 8mm diameter threaded posts.

Mega fuse holders, with the 100amp mega fuses fitted, note this is with out the fuse holder covers fitted.



Before fitting any more components I removed the B2B unit and painted the ply board black. A tin or two of spray paint from the local motorist discount centre came in very useful on this conversion. I then fitted the CTEK charger and Mains RCD fuse box. I also worked out where the Solar panel regulator would be fixed .

This was then left whilst I fitted the solar panel and the Mains hookup circuits.

5.5.2 Solar Panel fitting

Once I had decided to fit a solar panel I had to determine where and how to fix it to the roof. Now as you can imagine I was a bit nervous about cutting the ply lined internal roof and drilling holes in the metal roof. The solar panel came with an aluminium fixing kit which was to be bolted through the roof at 4 places.

The partition wall construction (covered in the next section, Section 6) needed an aluminium angle fixing to the inside of the roof, so I decided that I would combine all of these into one fix. I would bolt through the internal aluminium angle, the roof and then the front two fixing points on the solar panel. The back two fixing feet on the solar panel would then be bonded to the roof with Sikaflex 512. Incidentally I have read of people using Sikaflex 512 only to attach their solar panels to their roofs, which I'm sure would be secure enough, but you would still have to drill a hole for the cable..

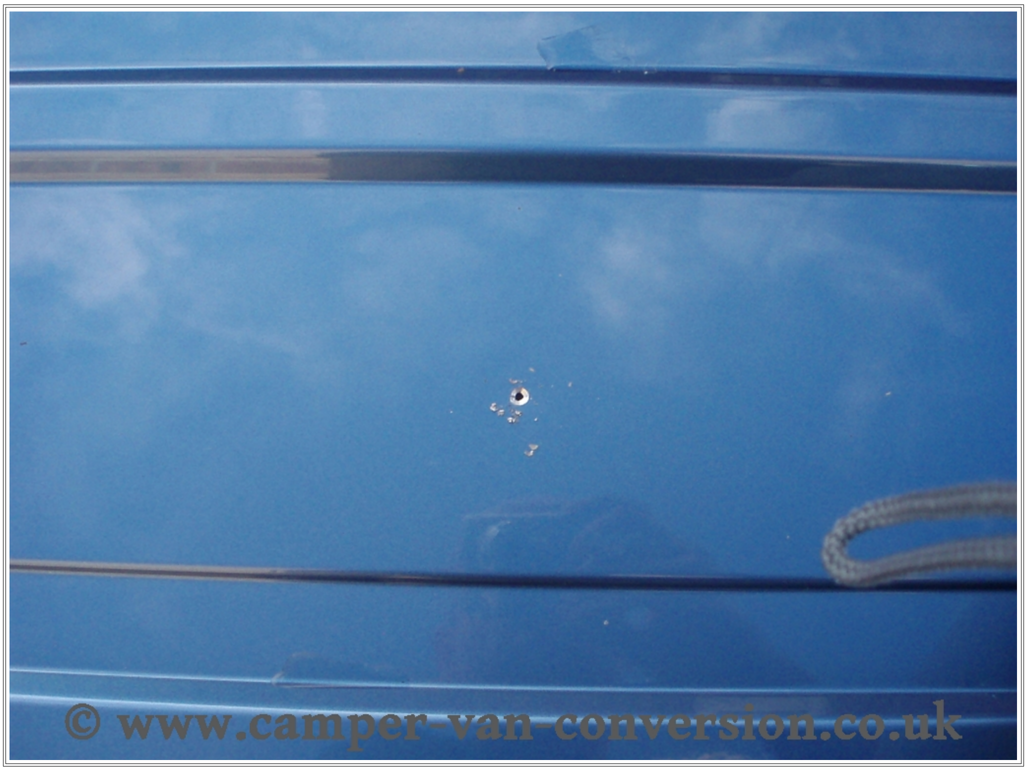
I checked the weather forecast and on a dry and sunny day I fitted the Solar panel. Here is the 60 watt (front and back) solar panel.

Note: The back two mounting brackets are loosely attached to the panel on the below photo.

All the holes and bolts would be sealed with Sikaflex 512 to prevent any water leaks. The cable entry point would also be fitted with a waterproof cable entry box :-

After measuring and measuring again, I drilled the aluminium angle that would be fitted inside the roof to match the holes on the solar panel brackets. Here is the panel upside down with the fixing brackets and aluminium angle lined up.

I next measured, marked, cleaned and degreased the roof, where I would be using Sikaflex 512. I then drilled the first pilot hole, using a 2.5mm drill.



I then drilled the final 6mm hole, masked up the area and then sprayed on anti rust paint, to ensure the metal never oxidised.

(Available at motorist shops)

The same process was repeated for all four fixing holes and then the cable entry point :

Where Sikaflex 512 would be used to bond and seal, I scoured the paint surface to provide a better key and then I degreased again.

With all the preparation complete, I assembled it all up dry to ensure it all fitted. I also made up some small spacer plates out of Aluminium so as to make the panel level when fitted on the roof. This was because the Transit roof is ridged and my holes were on the high and low parts of the profile.

Once it all fitted I removed it all and then applied the Sikaflex 512 to all the parts as required and bolted the panel, roof and aluminium angle together, ensuring that plenty of Sikaflex was in and around the holes to prevent any water leaks. Here is the completed installation :

To test the installation, the cable from the panel was attached to the solar regulator and then attached to the batteries, free electricity then flowed !

I now installed the solar regulator on to the electrics back plate and connected the output from it to the BM1 Battery monitor shunt / batteries, this then showed the amp charge the solar panel generated.

Here is the BM1 shunt again, the four coloured thin cables are the BM1's power (red and black) and the yellow and white cables are how the monitor measures the current that goes through the shunt (either way, i.e. in or out of the batteries).

Here is the BM1 monitor attached to the batteries. Note the solar regulator restricts supply to the batteries when they are fully charged. So even on a sunny day the charge can read zero if the batteries are already fully charged..

5.5.3 Mains Hook up installation

I next wanted to install the mains hook up so that I had mains sockets in the van so that I could use an oil filled radiator to keep me warm and use a fluorescent inspection lamp for light. I wanted the battery charging system all complete and working before I installed any appliances (via the fused switch panel) that would drain any power from the batteries. This involved :

- Drilling and cutting a hole in the vehicle body to fit an external hook up point.
- Wiring it to the mains RCD box
- Wiring the mains charger to the RCD & batteries
- Wiring the mains sockets to the RCD

Note the equipment used should be for a motor home and comply with the relevant British Standards. Do not undertake mains installation unless you are totally sure of what you are doing. Vehicles are metal boxes and can be electrified if the installation is not completed correctly. Before using the electrics ensure they are inspected by a NICEIC qualified electrician.

Note The Build your own Motorcaravan book written by John Wickersham and published by Haynes has a good section about electrics.

After inspecting the van externally, I found a section of the van free next to the drivers door, this was used on the other side of the van for the Diesel filler point. This section had a empty box construction behind it and was of an ideal size for a hookup socket.

The area was cleaned and degreased then measured and marked up, masking tape was applied to protect the paint work. A pilot hole was drilled and then using a jigsaw the hole was cut. The edges were filed smooth and the socket pushed in to ensure a correct fit. Next the area was masked more and anti rust paint applied.

Be careful not to get spray onto other parts of your van.

The area was cleaned and degreased again, the socket was then wired up (with the cable pushed through the hole from the inside !). Pilot holes were drilled for the self tapping screws. The unit was inserted into the hole and screwed to the vehicle. Note I did not use Sikaflex 512 to bond it, as I felt that if the unit broke or got damaged I would have to replace it. Sikaflex 512 is a very strong bond and would be very difficult to remove. I sealed around the unit using black silicone.

A hole was drilled through the floor near to where the Mains RCD box would be located. The cable was cut to the required length and a cable shield was pushed along the length of the cable. Holes were then drilled through the supporting struts so that the cable could be routed from the socket to the RCD. Note after any drilling anti rust paint was used.

Once the cable was routed, Sikaflex 512 was used at each hole to ensure the cable was secured and to prevent chafing. The cable was also secured using 'P' clips and self tapping screws.

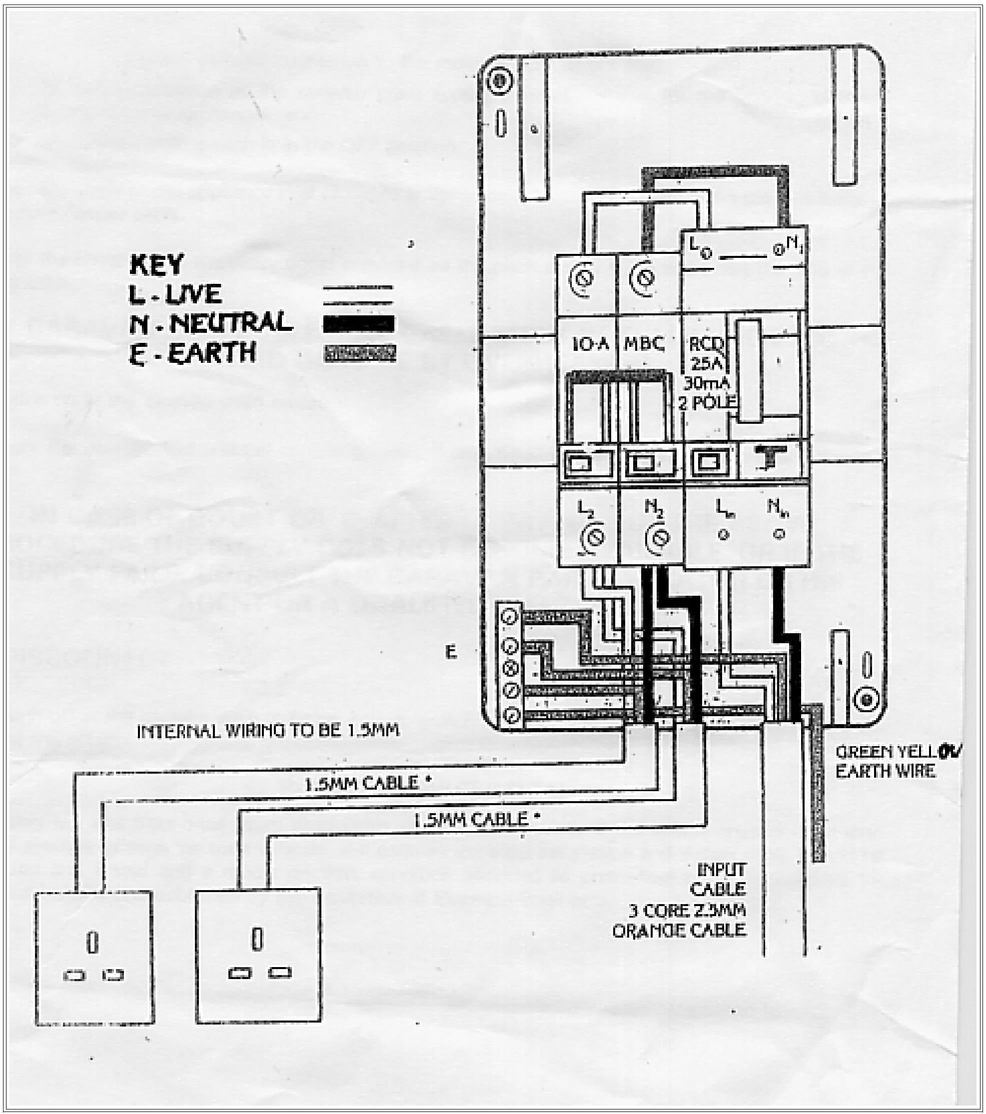
Rear of the mains hook up socket

Secured cable (with cable shield fitted) under the van.

Here is the finished installed socket :-

The cable from the socket was wired into the RCD fuse box, The fuse box did require an earth and so a connection to the van body was made near to the unit. This would also be used as a negative connection for the Sterling B2B unit. The paint was removed (to ensure a good connection) and a M6 bolt used to secure it.

The wiring up of the fuse box was completed as per the instructions, copy below. The mains cables for the sockets were cut to approximate length and sockets and back boxes attached. These would be fixed to the partition wall and the seat box when I had completed building them. A mains tester was used to test the sockets. NOTE its worth have one of these to test polarity of hook up posts on the continent.



The 'Mains Fuse Box' contains a RCD, residual current device. This is designed to prevent electric shock and other accidents due to faulty electrical appliances or wiring. The RCD can detect changes in the proper flow of electric current (when a flex is damaged, or an appliance malfunctions). Within milliseconds of this happening, the RCD automatically cuts the power supply before anyone can be electrocuted or further damage can be done.

The mains fuse box also contains a MCB Miniature Circuit Breaker, which is in essence a resettable 10 amp fuse. This protects against the circuits (sockets) being overloaded

After the installation was checked and tested the battery charger (CTEK XS7000) was connected and tested. Note to test this, I connected a 12v bulb to the leisure batteries to consume some power, I then connected up the mains hook up via a hook up adapter (see below) and I monitored the charge given to the batteries via the BM1 battery monitor, which I had temporally connected

Mains tester

Hook up adapter

The mains 'kick plate' heater was also wired up, although it could not be installed in to the kitchen yet, it did keep me nice and warm through the build from this point onwards.

At this point the electrics housing board was stood to one side for the installation of the partition wall to commence. Once the basic frame of the partition wall was built (see next section) the electrics board was bolted to the partition wall frame. This allowed the vehicle to be driven. The cabling would in time have to be tided up and secured properly..


CTEK
MULTI XS 7000
STERLING
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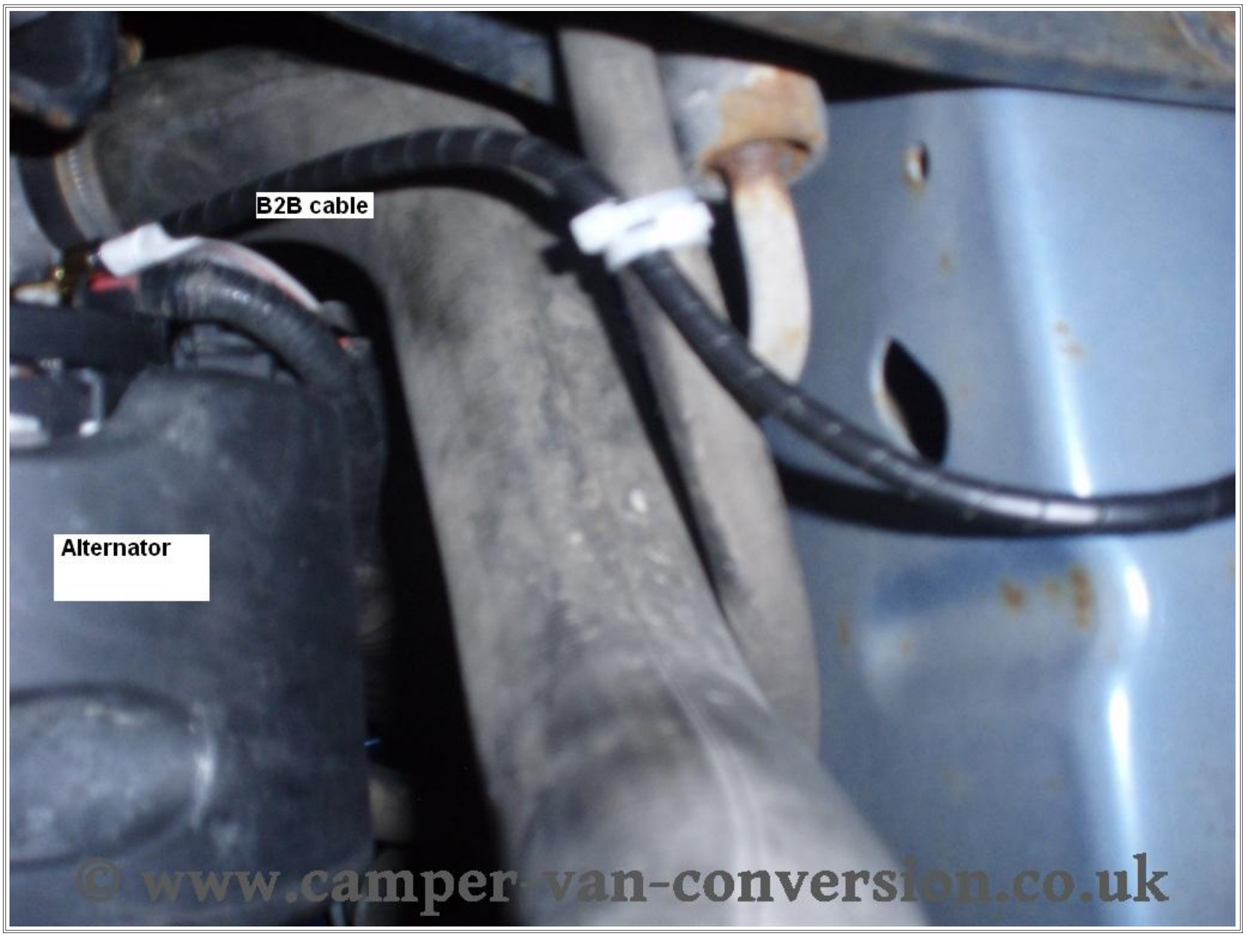
5.5.4 Completing the B2B wiring

With the electrics panel secured, I completed wiring up the B2B charger. The two live cables (170 amp cable) that were fused with 100amp fuses were wired to the leisure batteries and the vehicle car battery. The negative supply to the unit was via the vehicles body, the same connection as the earth for the RCD fuse box.

In addition temperature sensors were installed on the leisure batteries and the vehicles alternator. These are provided with the B2B unit, for the cable run to the alternator I did have to extend the cable and protect it with shielding, the temperature sensor bolts onto the alternator negative post, see photo below.



Note: In the next diagram, it shows that any extra power source, alternator and solar panel should be connected to the engine battery. Now this is true of the alternator. However I connected my solar panel direct to my leisure battery pack. This is to ensure that the leisure batteries are kept in top condition. The vehicle battery will be fully charged by the existing vehicle electrics.

This has all worked with no problems as the Solar regulator only gives a charge when one is required and so does the B2B charger.

The B2B wiring schema is :-

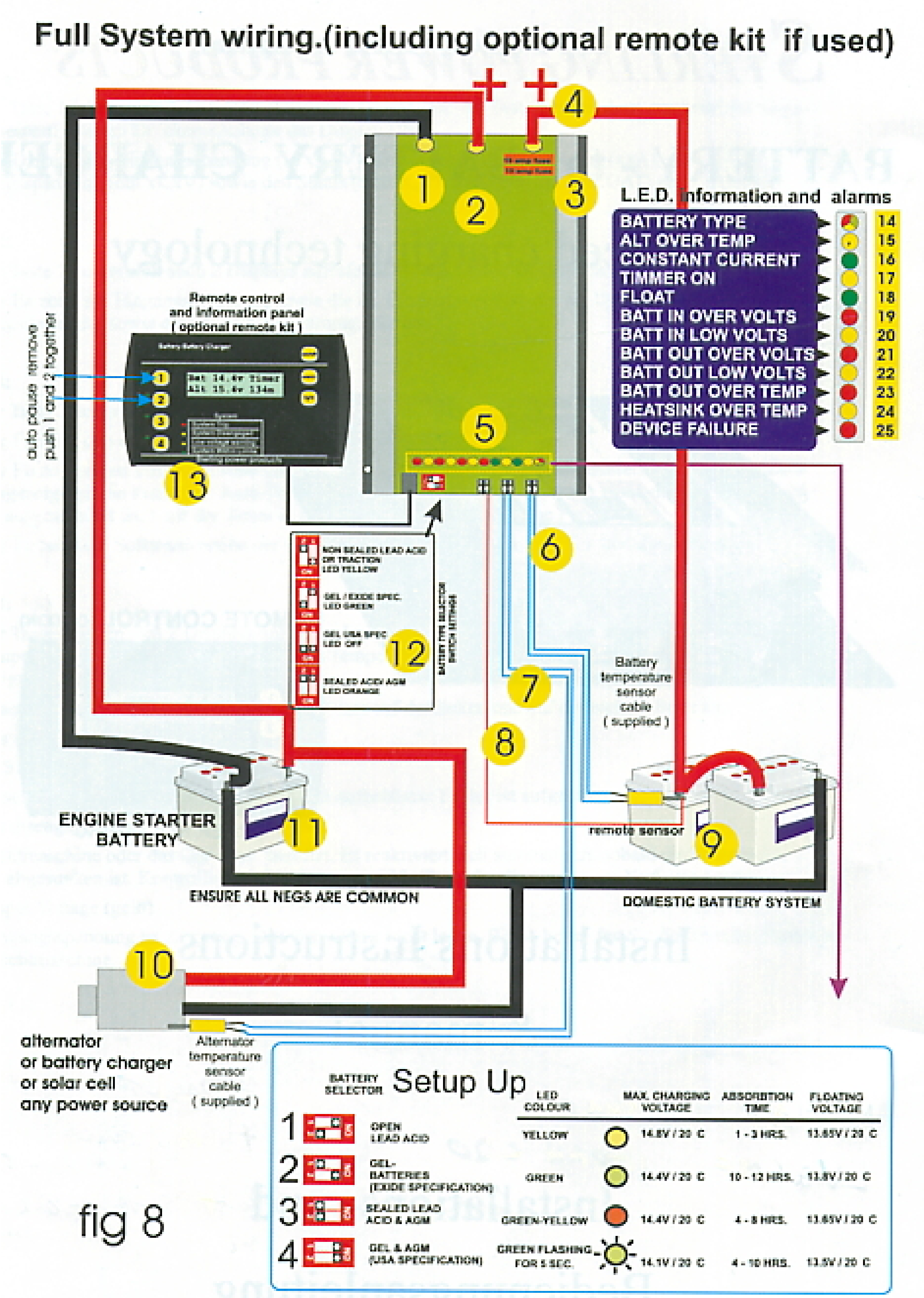


fig 8

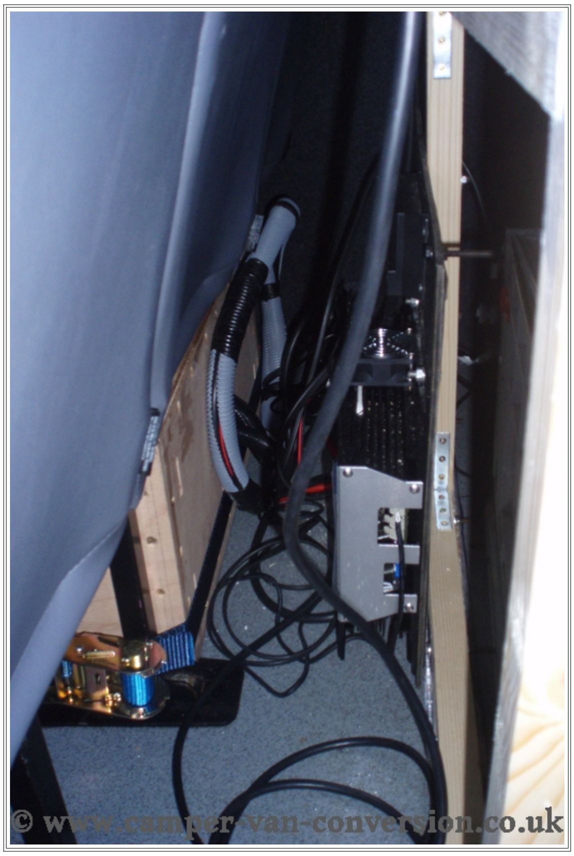
5.5.5 12v distribution and monitoring

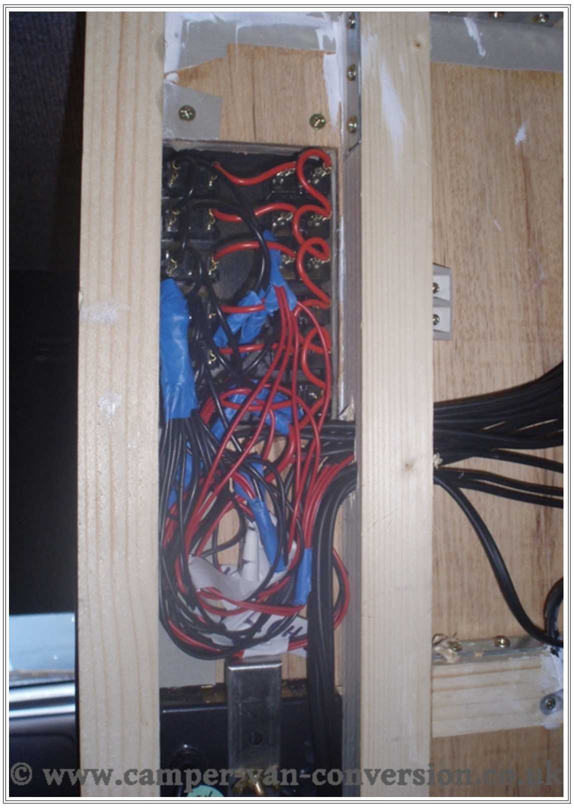
With the basic partition frame build I next decided where the 12 volt fused distribution panel and battery monitor would be located. The 12v switched fused (resettable) distribution panel was purchased from a Chandler, its usually for yacht installations. However it matched what I needed and it had the added advantage of having resettable fuses and the ability to switch (i.e. isolate) each circuit.

I would obviously have to change the labelling on it, and it came with sticky labels to do so. This was temporally screwed to the partition wall frame to allow me to run the supply cable to it (27amp) and also run cables to each of the appliances.

The BM1 battery monitor was also temporally attached and wired up to the leisure batteries :-

I then ran cables of the approximate length for each circuit, from the 12v distribution panel through the frame and out at the bottom of the frame, behind where the kitchen units would be going. All cables were labelled, as they would be attached to each circuit as each appliance was installed. The first circuit to be connected was the fluorescent ceiling lights which were already part of the vehicle, which I intended to re-use with LED tubes.





All the cable joints were soldered to ensure a good electrical connection and a durable physical connection.

5.5.6 Completing the electrics.

Near the end of the conversion, when I was laying the flooring I removed the 2nd row of seats and completed the electrics housing, by tiding up the cables and boxing around it. This was to ensure that the electrics had suitable ventilation, were safe from things being dropped on them but still allowed me access to see them if required.

One seat removed, batteries strapped under seat.

All 3 2nd row seats removed.

Note: The 'umbilical cord' connecting the electrics to the batteries was an old washing machine waste water pipe.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Completed housing, with removable side panel (with handle).

Here is the completed installation, with seats.

Here is the completed installation of the battery monitor and distribution panel.

Appendix 7 - Full electrical wiring schema.