Electrical Distribution System – Swing Cat

Version 2, dated 6th February 2013

Contents

References

Sources of information are:

Reference A	Boat Owner's Mechanical & Electrical Manual, Third Edition, Nigel Calder
Reference B	Mastervolt Combi 12/1200-60 Manual http://images.mastervolt.nl/files/ManualMCombi1200_070717EN.pdf

Overall Plan

The overall plan is to have a sophisticated system supplying AC & DC power around the boat, whilst maximising the use of renewable energy and making sure that that energy is used as efficiently as possible.

Combination Inverter/Charger

A key component of the installation is the Mastervolt Combi Inverter/Charger which can operate both as an inverter (providing 230V AC from the 12V batteries) and/or a battery charger supplying a charging current as high as 60A. If an external power source is available (e.g. shore power or a generator), the Combi will not operate as an inverter but will supply both AC and charge the batteries. Battery charging is a microprocessor-controlled 3-step process, tailored to the temperature of the batteries, to maximise battery life. The AC output is a pure sine wave to ensure that sensitive mains-operated equipment can be used on-board. For more details see Reference B.

Manuals

For all complicated equipment mentioned in this document, a manual is carried on-board.

General Principles – Electrical Distribution

The overall plan follows the prescriptions described in Reference A. Some key points are:

1. a short circuit anywhere should not result in wires melting or the insulation catching fire;
2. fuses or circuit breakers (CBs) protect the smallest diameter wire in a circuit, not the equipment being powered by the circuit, and should trip at a current less than the maximum current rating of the smallest diameter wire;
3. all wires need protecting by a fuse or CB: e.g. the 200A fuse in Figure 1 would protect against a short between A & B; the 40A fuse protects against a short between C & B;

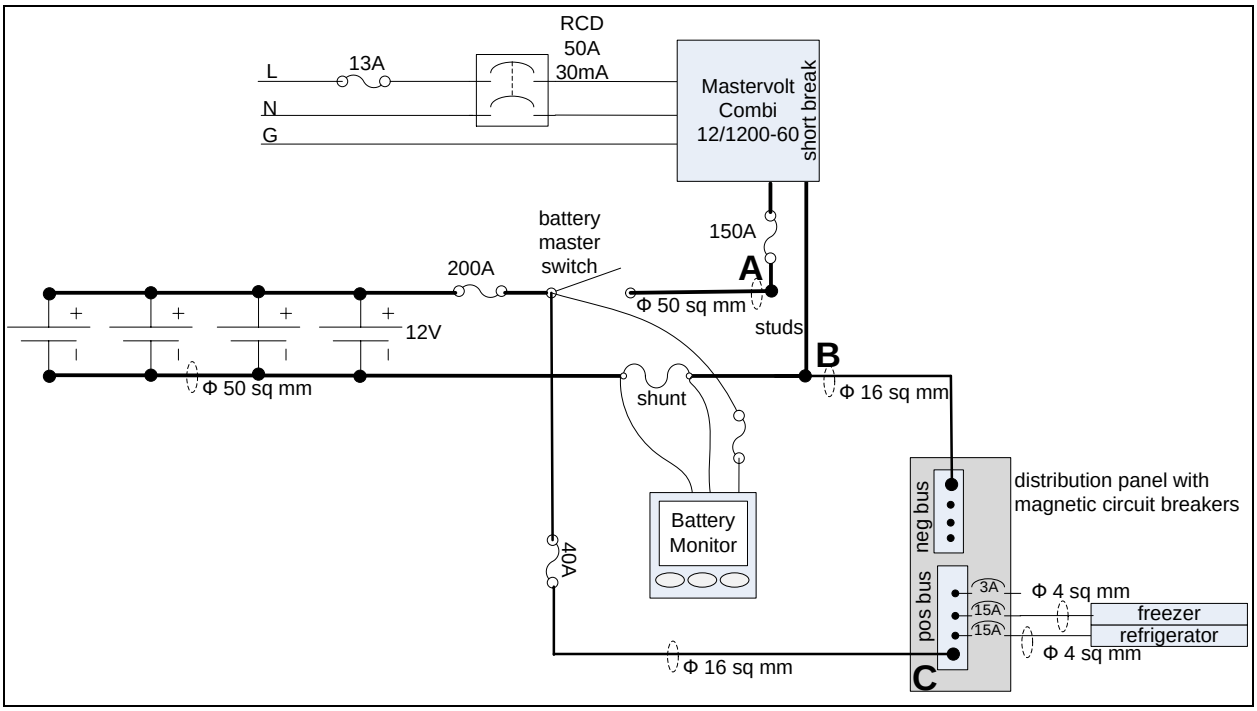


Figure 1: First Circuit Implemented

4. CBs are preferred to fuses and magnetic CBs are preferred to thermal CBs;
5. if only one piece of equipment is being powered by the circuit it can be protected by a CB (provided, of course, the rating is less than the max rating for the wire);
6. high current carrying cables, e.g. to condensing units or from solar panels, need to be sized according to volt drops, not the maximum current carrying capability of the cable:
    a. if a 1sq mm cable carries 1A, it drops approx. 20mV over 1 m;
    b. therefore, for a current of I amps in L metres of cabling with a desired voltage drop of V millivolts, the formula to give the required cross-sectional area of A sq mm is:
    $$A = 20 \times L \times I \div V$$
    note that L is the total length of cable, to **and** from the appliance;
    c. we should aim for a 1-3% volt drop – i.e. for 1%, $V = 120mV$;
7. all DC cable should be multi-strand and tinned, even battery cables;
8. all AC cable should be multi-strand (i.e. flexible);
9. ring terminals should be used – sometimes push-on ones are required by the equipment being installed;
10. adhesive-lined heat shrink should be used to seal the ends of the cables;
11. there are some items of equipment for which I am interested in measuring the power consumption (e.g. refrigerator, freezer) or power generation (e.g. solar panels);
    a. the cables to these pieces of equipment have been broken to allow an amp-hour meter to be inserted in series with the equipment;
    b. when the meter isn't being used, the break is bridged with a link;
    c. on the wiring diagrams, ⊸⊷⊸ depicts where this has been done

12. there should be no more than 4 terminals on any stud.

Installation of the Wiring Loom

The wiring should be discrete. Where ever possible it should be hidden from view. The wiring should also be accessible; it should be possible to either remove or add a circuit once Swing Cat has been built. This means the wiring should not be hidden behind insulation. The solution is to use trunking with a detachable lid to carry the cables. Where ever possible the trunking is hidden inside cupboards; where it is in plain view it can be painted the same colour as the rest of the interior so it is camouflaged.

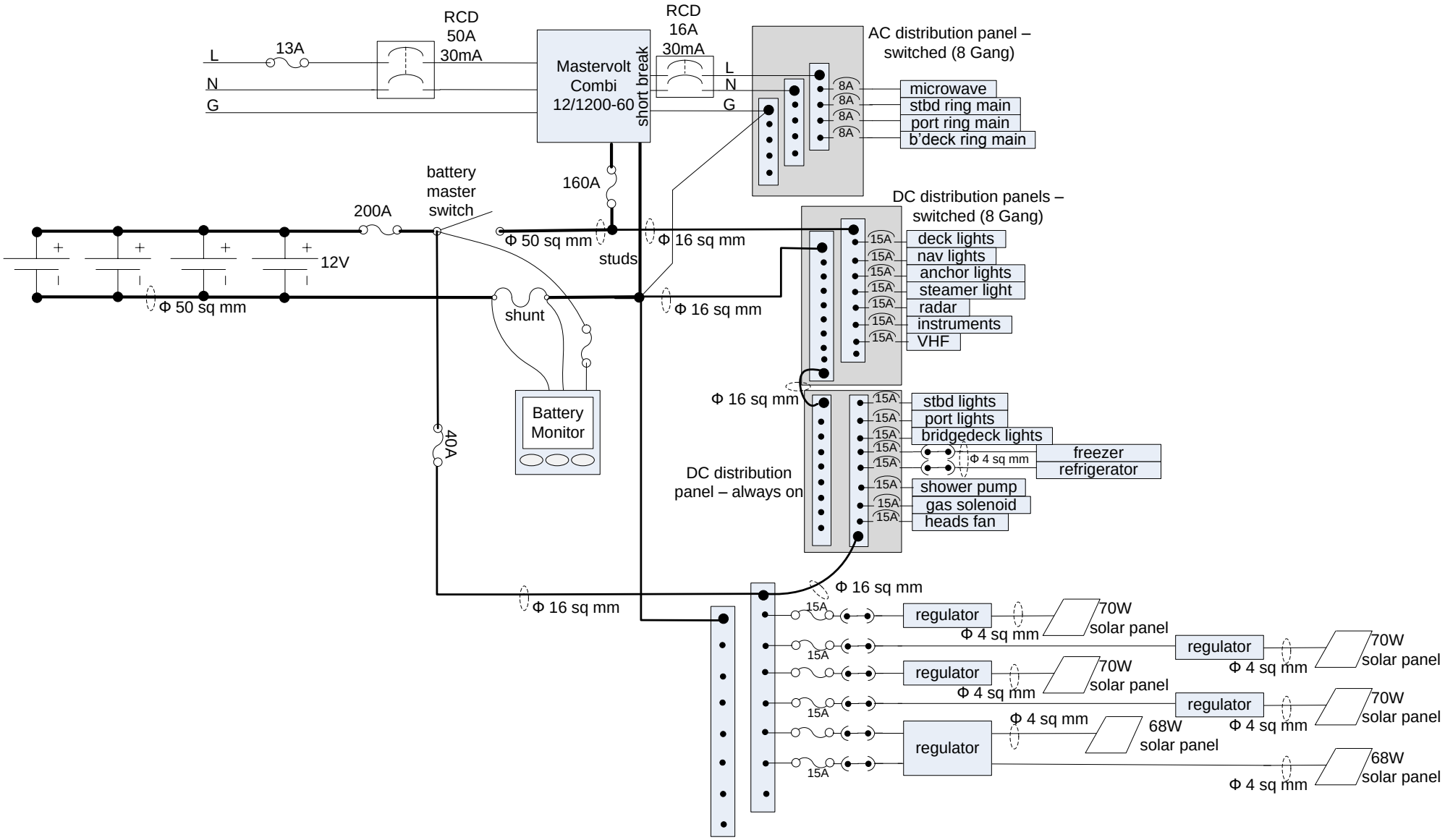


Figure 2: Power Distribution

Starboard Hull Wiring

The starboard hull contains the distribution panels for the electrical installation and the DC compressors for the fridge and freezer. There is also wiring for a gas solenoid valve, so the gas in the external locker can be turned off from inside the hull. There is also wiring for 2 solar panels and the starboard navigation light. See Figure 3 for details.

LED Lighting

For general lighting, there are 6 2.4W LED downlighters, giving 140lm, and 4 MR16, G5.3, 2.8W LED spots. All LEDs use SMD technology. That is a lot of acronyms, what do they mean?

- lm – lumen, a measure of the total amount of visible light emitted by a bulb.
- W – power in watts. Different bulbs have different efficiencies as measured in lm/W. For example incandescent bulbs produce about 15lm/W, halogen bulbs 20lm/W and LED 60lm/W.
- MR – Multifaceted Reflector. The number that follows refers to the bulb's diameter $1/8^{th}$ of an inch: MR16 has a diameter of 16/8=2in.
- LED – Light Emitting Diode, i.e. a semiconductor device.
- SMD - Surface Mount Diode, i.e. the LEDs are all mounted on a flat surface.
- G – stands for Glass, for historical reasons. The number that follows refers to the distance between the 2 pins of the bulb. For more detail see: http://en.wikipedia.org/wiki/Bi-pin_connector .

The LED lights seem to be brighter than the wattage would suggest. For example the 2.4W downlighters are roughly equivalent to a 10W incandescent bulb. This may not seem very bright but, because of the directional nature of the surface mount LED bulb, they appear much brighter.

Electro-Magnetic Interference

When installing the LED spot lights, the nearest one to the radio caused considerable electro-magnetic interference (EMI). The culprit was the switched-mode regulator, common to most LED bulbs, in the MR16 bulb. Another bulb gave the same result. This was irritating but also worrying since if it can interfere with an FM radio, it could surely interfere with a VHF radio, SSB radio or radar.

A forum thread which explains the phenomenon is: http://www.avforums.com/forums/dab-digital-radio-fm-radio/1330696-led-lights-interferes-dab-signal.html . Basically, the culprit is scant regard for the regulations that should prevent EMI by certain manufacturers wanting to shave a penny off the cost price.

Bulbs which are EMI free do exist, see: http://www.bedazzled.uk.com/ .

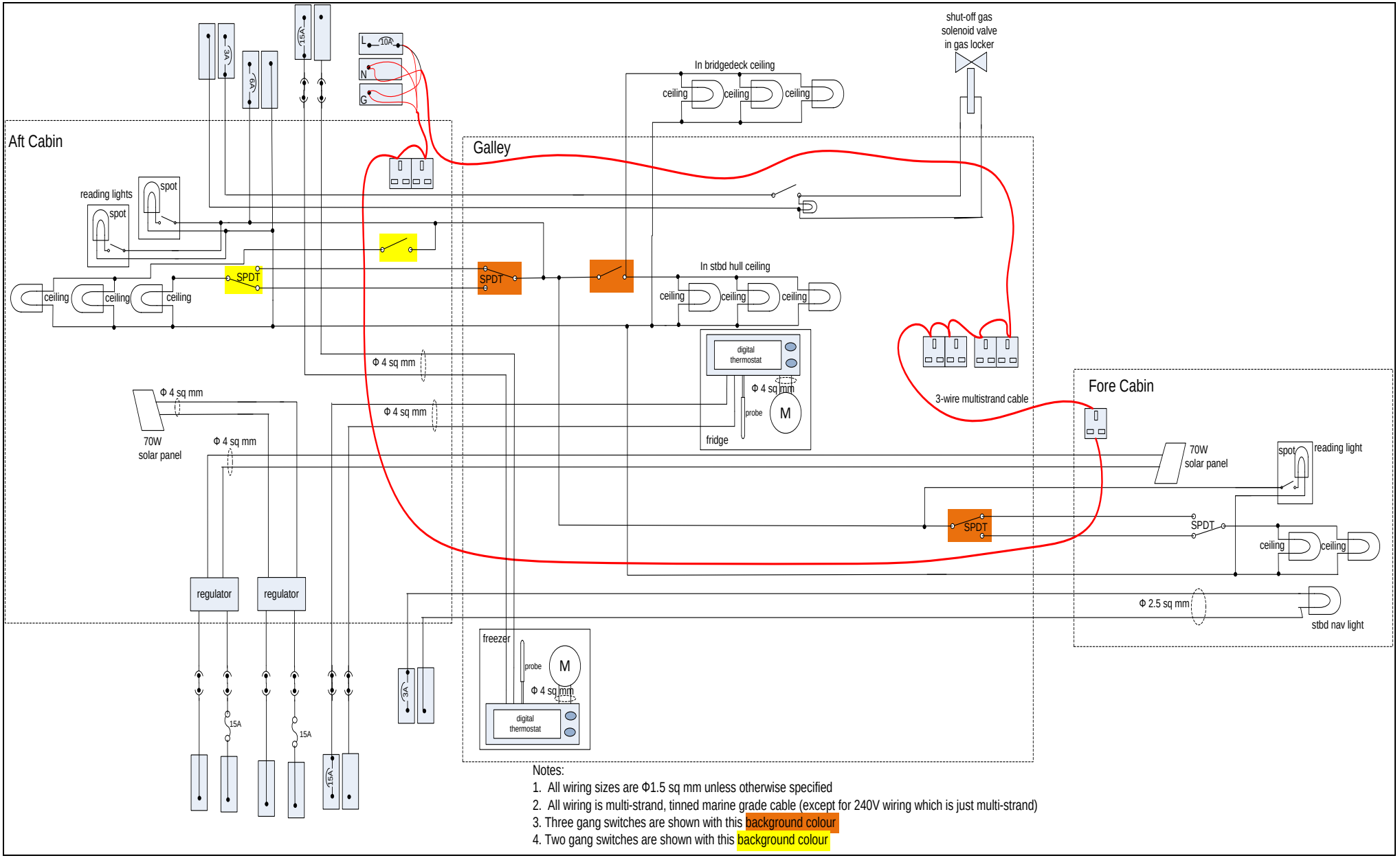
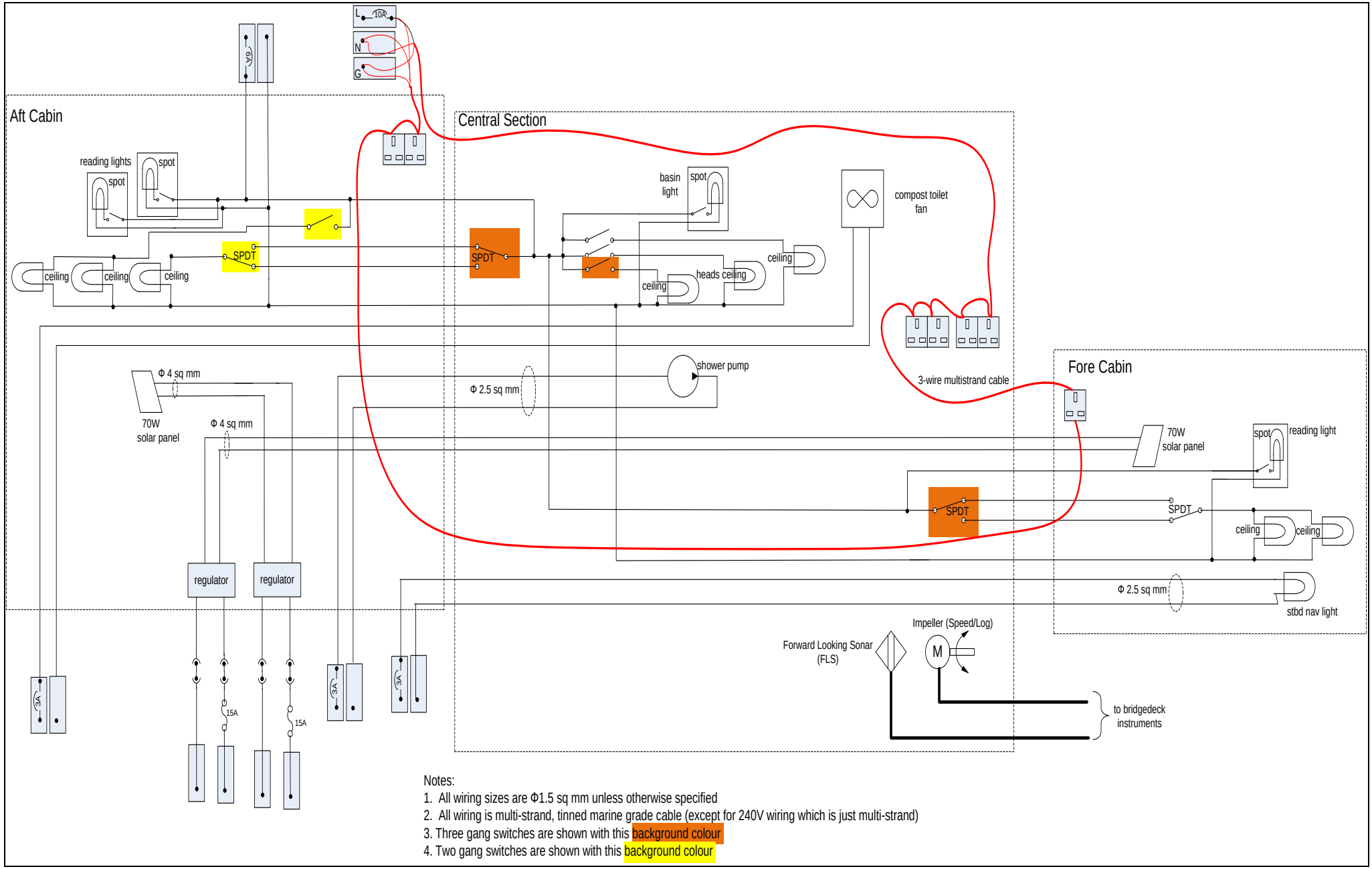


Figure 3: Starboard Hull Wiring

Port Hull Wiring

The port hull contains the fan for the compost lavatory, a shower pump and wiring to the Forward Looking Sonar (FLS) and log impellar. There is also wiring for 2 solar panels and the port navigation light. For general lighting, there are 6 2.4W LED downlighters, giving 140lm, and 4 MR16, G5.3, 2.8W LED spots. All LEDs use SMD technology. That is a lot of acronyms, for what they mean refer to the section on Starboard Hull Wiring.



Notes:

1. All wiring sizes are Φ1.5 sq mm unless otherwise specified
2. All wiring is multi-strand, tinned marine grade cable (except for 240V wiring which is just multi-strand)
3. Three gang switches are shown with this background colour
4. Two gang switches are shown with this background colour

Figure 4: Port Hull Wiring

Bridgedeck Wiring

TBD