

18th Edition

**Overload Protection of
RCCBs and Switches
within Consumer Units**

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Executive Summary

The rewriting of chapter 53 of BS 7671:2018 IET wiring regulations has highlighted some areas where designers will have to change their habits when it comes to the selection of consumer units with regard to the rated current of the consumer unit and the rated current(s) of any RCCBs or switches contained within the assembly.

Electrical designers in the UK have traditionally determined the rated current of residual current circuit breakers (RCCBs) and switches after taking into account diversity factors. This method is still the accepted practice. However, the wiring regulations tell us that RCCBs and switches provide no overload protection, therefore, they shall be protected by an overcurrent protective device. The wiring regulations also tell us that overload protection shall not solely be based on the use of diversity factors of the downstream circuits and that overload protection of RCCBs or switches shall be selected to according manufacturer's instructions.

The electrical manufacturers association (BEAMA²) provide two methods to determine the rated current of switches and RCCBs within an assembly with respect to their overload protection:

- Method 1 – ensure that the rated current of the sum of the downstream MCBs¹ do not exceed the rated current of the switch or RCCB when installed within the consumer unit (I_{nc}), or
- Method 2 – ensure that the rated current of the switch or RCCB in the related assembly circuit in the consumer unit (I_{nc}) stated by the assembly manufacturer, is not less than the rated current of the upstream overcurrent protective device (OCPD). For a domestic installation this is likely to be the cut-out fuse rated at 60 A, 80 A or 100 A.

Spare ways offer the potential for future additions to the installation, e.g. additional circuit(s) for electric vehicle charging, electric showers or hot tubs and therefore method 2 would generally be the most robust method to determine the rated current of the switch or RCCB in the related assembly circuit within the consumer unit. However even with method 2, consideration should also be given to the uprating of the supply fuse from 60 A to 80 A, or from 80 A to 100 A to accommodate potential additional circuits and related increased current demand.

Therefore, the most flexible solution would be a consumer unit with an I_{nA} 100 A and I_{nC} 100 A for each RCCB protected assembly circuit.

Introduction

Changes to BS 7671 18th Edition IET wiring regulations released July 2018 have drawn our attention to the specification of RCCBs and switches when incorporated into assemblies such as consumer units in relation to overload protection of these components. This report will highlight the impact of the changes to the regulations on installations, show methods which will allow compliance to be determined and provide robust product solutions.

Regulation 536.4.3.2 states that RCCBs and switches provide no protection against overload therefore they shall be protected by an overcurrent protective device (OCPD). The rated current of this OCPD shall be selected according to manufacturer's instructions. Regulation 536.4.202 also needs to be taken into account, this states that overload protection shall not solely be based on the use of diversity factors of the downstream circuits. Again manufacturer's instructions should be used when selecting the OCPD.

Where the changes to the regulations originate

A requirement for changes to the regulations was originally highlighted from within the electrical installation industry where it was argued that diversity cannot be used for overload protection. Also, a lack of overload coordination may be related to overheating and adverse effects upon the operating characteristics of RCCBs. These concerns were highlighted to the UK committee responsible for BS 7671.

The wiring regulations take account of the technical substance of agreements reached at CENELEC level in harmonised documents (HD). The technical intent of HD 60364-5-53 November 2015 was implemented into the 18th Edition which included Regulation 536.4.3.2 covering overload protection of an RCCB or switch.

Pre 18th Edition approach to rated current / overload protection of RCCBs and switches

Before the 18th Edition, the approach was to use the application of diversity factors to determine maximum demand / rated current and an assumption of overload protection for switches and RCCBs.

Rated Current derived from maximum demand and diversity.

Maximum demand is generally calculated with the application of diversity factors. A method to calculate the maximum demand and apply allowances for diversity can be found in Appendix A of the IET on site guide. This guidance gives methods for application to the demand current for individual circuits and also guidance for standard arrangements of final circuits from Appendix H which reads 100% of the current demand of largest circuit +40% of current demand of every other circuit.

In practice this could be a very difficult process for the electrical designer in residential applications as in many cases the actual load(s) are not fully known at the time of design and are likely to alter a number of times during the expected life of the installation. For example, on a new house the actual cooker which is to be installed may not have been selected at the time of design and is likely to be exchanged for a different cooker before the electrical system is updated. Hence it may be prudent to carry out calculations based upon the rated current of the final circuit protective devices e.g. MCBs¹.

Note: There is no change to the methods employed to calculate the maximum demand for an installation, diversity can still be taken into consideration.

Once the maximum demand has been established, the required rated current of the assembly (consumer unit) can be determined (I_{nA}).

I_{nA} – The rated current of an assembly (consumer unit). This is not necessarily the rating shown in amperes on the incoming device, and is required to be provided on the consumer unit designation label.

Where a split load arrangement of a main switch supplying two RCCBs is used in order to provide additional protection for a group of downstream circuits, the rated current of this group of circuits has the symbol (I_{nC}) and also needs to be taken into account in the same manner as for the complete assembly.

I_{nC} – The rated current of a section within an assembly (assembly circuit). This is not necessarily the rating shown in amperes on the specific devices within the assembly, and is required to be provided in the technical documentation supplied with the consumer unit.

Devices are manufactured to their individual product standards, when they are integrated into an enclosure to form an assembly the assembly (consumer unit) manufacturer carries out further verification of this assembly to determine and validate the rated values shown in their product information.

Overload protection

Generally, overload protection of RCCBs and switches has been related to the application of diversity.

What the regulations say

As can be seen from the introduction the 18th Edition IET wiring regulations clearly state that:

Regulation 536.4.3.2 states that devices including; RCCBs complying with BS EN 61008 series, switches complying with BS EN 60947-3 or BS EN 60669-2-4, impulse relays complying with BS EN 60669-2-2 and transfer switching equipment complying with BS EN 60947-6-1 are used to switch loads or circuits. None of these devices provide protection against overload, therefore they shall be protected by an overcurrent protective device (OCPD).

For overload protection of RCCBs and switches the rated current of the OCPD shall take account of manufacturer's information; in general, the OCPD is installed upstream of the RCCB or switch.

The rated current of a switch or RCCB may also be based on the application of diversity factors to the downstream circuits according to regulation 311.1 and the rated current of the OCPD shall be selected according to the manufacturer's instructions. See also Regulation 536.4.202

Regulation 536.4.202 states that overload protection shall not solely be based on the use of diversity factors of the downstream circuits. To achieve overload protection of RCCBs or switches, the rated current of the OCPD shall be selected according to manufacturer's instructions.

For most residential applications the OCPD will be the supply authority fuse. On multi-residential installations this may be a fuse or MCB¹ housed in a TP&N board, a fused distribution board, a switched fuse or similar assembly.

Hence RCCBs and switches shall be protected by an OCPD and that overload protection cannot solely be based on the application of diversity. Both of these regulations state that manufacturer's instructions (assembly manufacturer's instructions) shall be used to determine the rating of the OCPD.

The manufacturers of electrical distribution equipment are therefore required to instruct designers and installers on how to determine the rated current of the OCPD for both the assembly (I_{nA}) and the related assembly circuits (I_{nC}) within it. BEAMA the leading trade association representing manufacturers of electrical infrastructure products has provided some guidance to assist manufacturers, designers and installers.

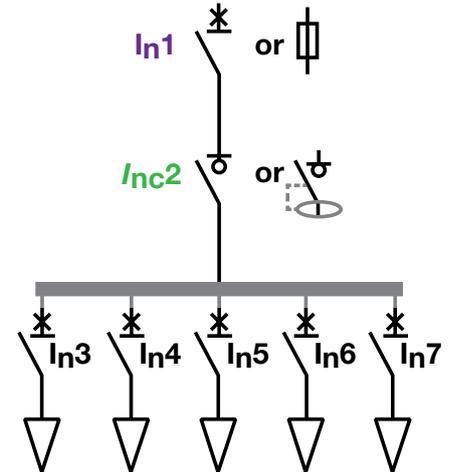
What the electrical product manufacturers association say

British Electrotechnical and Allied Manufacturers Association (BEAMA) offers guidance on the subject by providing two methods that can be utilised to establish the rated current for the RCCB or switch.

Method 1

The rated current in the assembly circuit $I_{nc}(A)$ of the switch or RCCB shall be greater than or equal to the sum of the rated current of all the associated downstream outgoing circuit OCPDs

$$I_{nc2} \geq I_{n3} + I_{n4} + I_{n5} + I_{n6} + I_{n7}$$

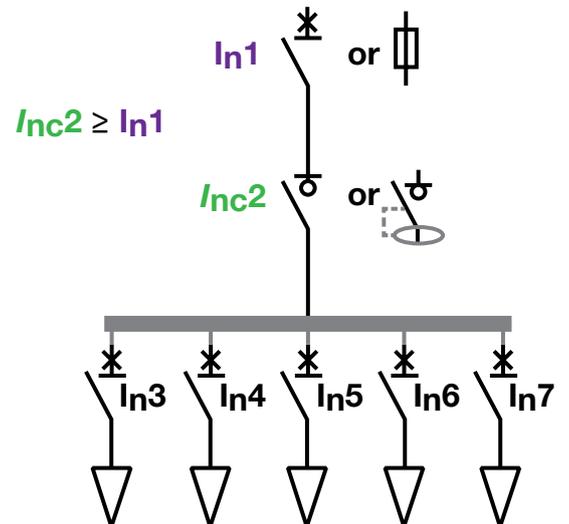


$$I_{nc2} \geq I_{n3} + I_{n4} + I_{n5} + I_{n6} + I_{n7}$$

Method 2

Have a rated current based upon diversity and a suitably rated overload protective device conforming to one of the following: a general-purpose type (gG) fuse to BS 88-3, a circuit breaker to BS EN 60898, a circuit-breaker to BS EN 60947-2 or a residual current circuit breaker with integral overcurrent protection (RCBO) to BS EN 61009-1.

$$I_{n1} \leq I_{nc2}$$



$$I_{nc2} \geq I_{n1}$$

Overload protection of RCCBs and switches when applied to consumer unit.

If we take a consumer unit application *fig 1* where typical circuits may include;

- 40 A Shower or Garage
- 32 A Socket Circuit 1
- 6 A Lighting Circuit 1
- 6 A Smoke Detectors Spare
- 32 A Cooker
- 32 A Socket Circuit 2
- 16 A Water Heater
- 6 A Lighting Circuit 2 Spare

Method 1

With the arrangement in *fig 1* and applying method 1, I_{nc2} refers to the rated current of the RCCB or switch controlling the assembly circuits contained within the consumer unit and I_{n3} , I_{n4} etc. refers the rated current of the MCBs¹ downstream of these devices.

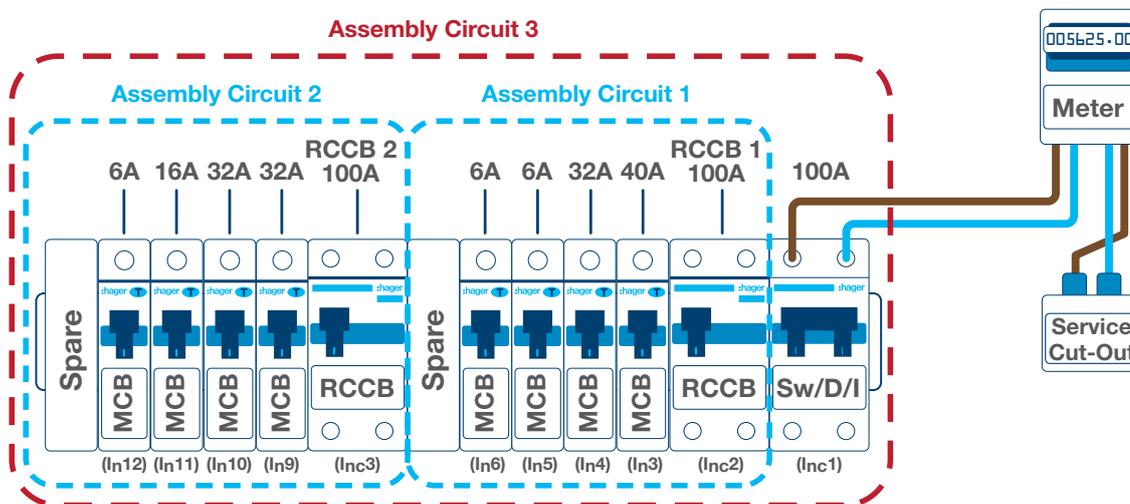


Fig 1: Method 1

Hence for assembly circuit 1 the rating of RCCB 1 should be equal to or greater than the sum of the downstream MCBs

$$I_{nc2} \geq I_{n3} + I_{n4} + I_{n5} + I_{n6}$$

$$100 \text{ A} \geq 40 \text{ A} + 32 \text{ A} + 6 \text{ A} + 6 \text{ A}$$

$$100 \text{ A} > 84 \text{ A}$$

For this arrangement method 1 meets the requirements for overload protection. However, an additional circuit to replace the blank should be considered.

This is then repeated for assembly circuit 2

$$I_{nc3} \geq I_{n9} + I_{n10} + I_{n11} + I_{n12}$$

$$100 \text{ A} \geq 32 \text{ A} + 32 \text{ A} + 16 \text{ A} + 6 \text{ A}$$

$$100 \text{ A} > 86 \text{ A}$$

For this arrangement method 1 meets the requirements for overload protection. However, the impact of an additional circuit to replace the blank should be considered.

The same methodology needs now to be applied to the main switch assembly circuit 3

$$I_{nc1} \geq I_{n3} + I_{n4} + I_{n5} + I_{n6} + I_{n9} + I_{n10} + I_{n11} + I_{n12}$$

$$100 \text{ A} \geq 40 \text{ A} + 32 \text{ A} + 6 \text{ A} + 6 \text{ A} + 32 \text{ A} + 32 \text{ A} + 16 \text{ A} + 6 \text{ A}$$

$$100 \text{ A} < 170 \text{ A}$$

For this arrangement method 1 cannot be used determine overload protection of the main switch. Method 2 should be considered.

Method 2

When looking at the consumer unit arrangement in *Fig 2* and applying method 2, I_{n1} refers to the service cut out fuse and I_{nc2} is shown as RCCB 1, however it applies equally to RCCB 2 (I_{nc3}) and the main switch (I_{nc1}).

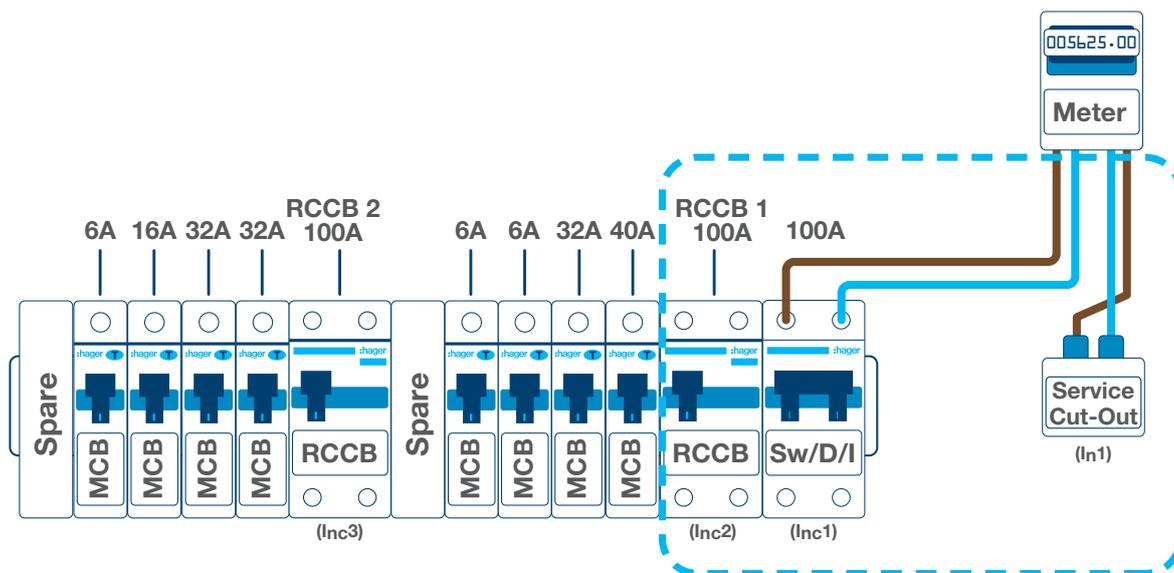


Fig 2: Method 2

$$I_{n1} \leq I_{nc2}$$

$$100 \text{ A} \leq 100 \text{ A}$$

For this arrangement method 2 can be used to determine overload protection. As the rated current within the assembly of both RCCB and the main switch are 100 A this method works for all of the assembly circuits. ($I_{n1} \leq I_{nc3}$, $I_{n1} \leq I_{nc1}$)

There are two types of supply authority service heads currently being used in the UK. The first type will incorporate a 60 A or 80 A cut-out fuse, whilst the second type will incorporate an 80 A or 100 A cut-out fuse. The challenge is to be sure which size of cut-out fuse is actually installed within the sealed fuse carrier. This could be achieved either by contacting the supply authority or by allowing for the highest rated current of the cut-out fuse (100 A).

For example with the arrangement shown in *Fig 3* with 100 A main switch and 100 A RCCBs, $I_{n1} \leq I_{nc2}$ will allow method 2 to be used for 60 A, 80 A or 100 A supply authority cut-out fuse.

Installations where the upstream protection is known.

Obviously there are occasions where the upstream protection of the consumer unit is known. Fig 3 is an example of where a consumer unit is utilised for such an application. To determine overload protection of the RCCBs and switch, the two methods shown already can be utilised.

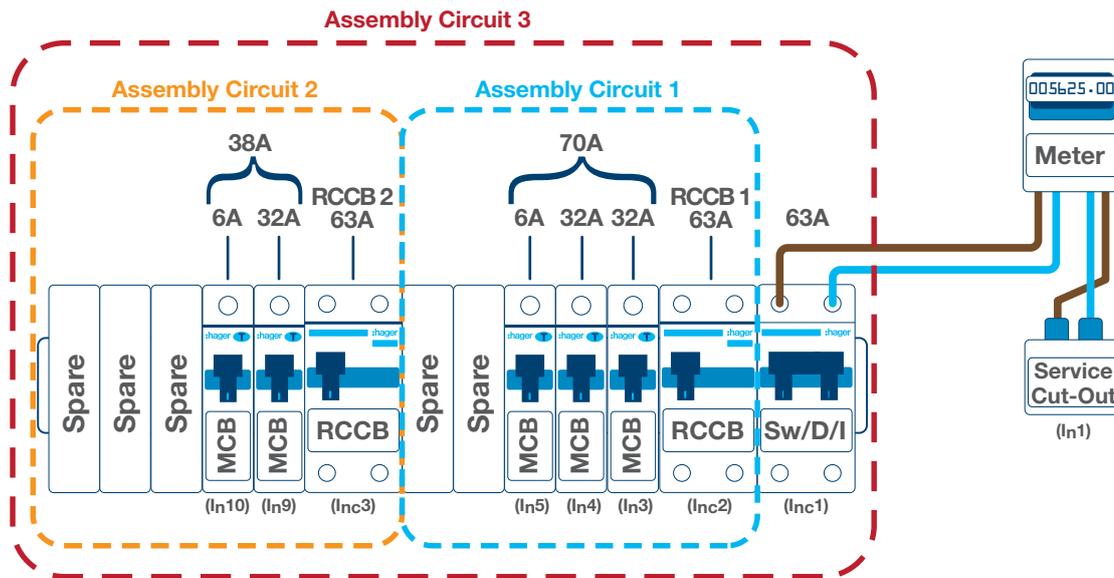


Fig 3

Method 1

RCCB 1 (Assembly Circuit 1)

$$I_{nc2} \geq I_{n3} + I_{n4} + I_{n5}$$

$$63 \text{ A} \geq 32 \text{ A} + 32 \text{ A} + 6 \text{ A}$$

$$63 \text{ A} < 70 \text{ A}$$

So method 1 cannot be used to determine overload protection for assembly circuit 1.

RCCB 2 (Assembly Circuit 2)

$$I_{nc3} \geq I_{n9} + I_{n10}$$

$$63 \text{ A} \geq 32 \text{ A} + 6 \text{ A}$$

$$63 \text{ A} > 38 \text{ A}$$

Method 1 can be used to determine overload protection of assembly circuit 2.

Main switch (Assembly Circuit 3)

$$I_{nc1} \geq I_{n3} + I_{n4} + I_{n5} + I_{n9} + I_{n10}$$

$$63 \text{ A} \geq 32 \text{ A} + 32 \text{ A} + 6 \text{ A} + 32 \text{ A} + 6 \text{ A}$$

$$63 \text{ A} < 108 \text{ A}$$

So method 1 cannot be used to determine overload protection of assembly circuit 3.

Again the presence of spare ways will have an impact on these calculations should extra circuits be added at a later date.

Method 2 ($I_{n1} \leq I_{nc2}$)

In this example the rated current of the cut-out fuse is crucial.

For a 60 A cut-out fuse method 2 can be used to determine overload protection, however, for an 80 A or 100 A cut-out fuse method 2 cannot be used to determine overload protection. This applies equally for an 80 A rated RCCB and main switch arrangement with an 80 A supply authority fuse.

If we look at the principles applied to conductors on the same installation. The current carrying capacity of a cable for continuous service under the particular installation conditions concerned (I_z) should be equal to or greater than the rated current or current setting of protective device (I_n) represented by the formula $I_z \geq I_n$. This is demonstrated for instance with the selection of meter tails to BS 6004 for a consumer unit, where a 60 A cut-out fuse is installed it is common for a 16mm² meter tail to be selected, however where a 100 A cut-out fuse is installed and the cables are clipped direct 25mm² meter tails would typically be installed. The sizing of these conductors for overload protection is determined by the upstream fuse and not by using the diversified downstream loads

Proposed Solutions

On installations where the designer is required to make so many assumptions in relation to the characteristics of the loads, along with the very real prospect of additional circuits in the coming years to provide for example for electric vehicle charging, ensuring the correct selection of consumer unit is essential.

As can be seen from the examples in the previous section, method 1 is difficult to implement where there is a possibility for an additional circuit(s) to be added. It is suggested that method 2 is a more robust method for anticipating future demands.

This suggests that the solution where the rated current of the consumer unit I_{nA} and the rated current of the related assembly circuits within the consumer unit I_{nC} are equal to or greater than the rated current of the upstream protection. On installations where the rated current of the cut-out fuse is not known, it would be prudent to design for the highest rated current of cut-out fuse i.e. a 100 A fuse resulting in the specification for the split load consumer unit being 100 A I_{nA} , with related RCCB assembly circuits 100 A I_{nC} to provide overload protection for RCCBs and switches in line with the 18th Edition IET wiring regulations.

Conclusion

With the introduction of the 18th Edition of BS 7671:2018 IET wiring regulations electrical designers will need to ensure that they specify the correct consumer unit rated currents with regards to overload protection of RCCBs and switches.

This paper has identified two methods which can be implemented to achieve overload protection for RCCBs and switches:

Method 1 – ensure that the sum of the rated current of the downstream MCBs do not exceed the rated current of the switch or RCCB. This method would need to consider the consequences of any spare ways and later additions.

Method 2 – ensure that the rated current of a switch or RCCB stated by the assembly manufacturer is not less than the rating of the upstream OCPD. In a domestic installation this could be a 60 A, 80 A or 100 A cut-out fuse.

Notes:

- 1 'MCB' is used as generic term for a circuit breaker to BS EN 60898.
- 2 BEAMA, British Electrotechnical and Allied Manufacturers Association.



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