EkeBus

A controller bus for handheld locomotive controllers on large model railway layouts

Technical Description

Revision: 1.0
Date: 2015-11-08

EkeBus

Technical Description

Revision History

Revision	Date	Update	Updated by
1.0	2015-11-08	First release.	Stefan Fjällemark

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1 Introduction

Today, digital control of model railways has established standards for the communication to locos, switches and other peripherals. The most common standard is *Digital Command Control* (DCC). On the other hand, there is no common standard for communicating with handheld locomotive controllers. Both cabling and protocols are often supplier specific, even if there are some protocols that are used by groups of suppliers. This forces model railroaders and clubs to select one controller protocol and limit the selection of controller equipment to those that support the selected protocol. To overcome part of this limitation Peter Ekelund has developed *EkeBus*. *EkeBus* supports LocoNet® and XpressNet on the same controller bus network.

The name *EkeBus* comes from the creator Peter Ekelund, nicknamed "Eke" by fellow model railroaders. Peter has a long experience with electronics hardware. With the arrival of ROCO's Z21, he saw an opportunity to create *EkeBus*, which has been successfully used for some years at module railway meetings in Sweden on quite large layouts.

EkeBus was first introduced at module meetings arranged by Modul Syd, which is a module railroader association for southern Sweden. During these meetings, EkeBus was tested and refined.

This document has been compiled by Erik Kuiper and Stefan Fjällemark, both active modular model railroaders and *EkeBus* users.

1.1 *EkeBus* in short

EkeBus supports controllers that communicates over the following protocols:

- LocoNet®, developed by Digitrax (USA)
- XpressNet, developed by Lenz (Europe)

EkeBus is not a new bus technology, but a repackaging of existing bus technologies. *EkeBus* cabling unifies one LocoNet®, two XpressNet and power to the controllers in one network. The main *EkeBus* cabling is standard RJ45 network cables.

To connect a controller to *EkeBus* a special adapter cable is required. These cables are both simple and cheap to make. Material for cables are about 50 SEK ≈ € 5 and with little experience of using a crimping tool you can make one yourself.

1.2 Why two XpressNet?

There are two limitations that led to having two XpressNet buses in *EkeBus*:

1. The first is that XpressNet has a limitation of maximum 30[1] connected controllers. In a large modular layout this can be a critical limit.
2. The other is that some controllers must have their address assigned manually, while other can automatically be assigned an address when they are plugged in. Unfortunately the two types of address assignment cannot be used on the same XpressNet.

The solution was to provide two XpressNet buses, one that could be used for ROCO controllers, which assigns its addresses automatically, and the other for controllers that need manual address assignment, e.g. Lenz. Having the option to use automatic address assignment reduces the administrative burden at module meetings. This use of the two XpressNets gives possibility to have maximum 30 ROCO and 30 Lenz controllers.

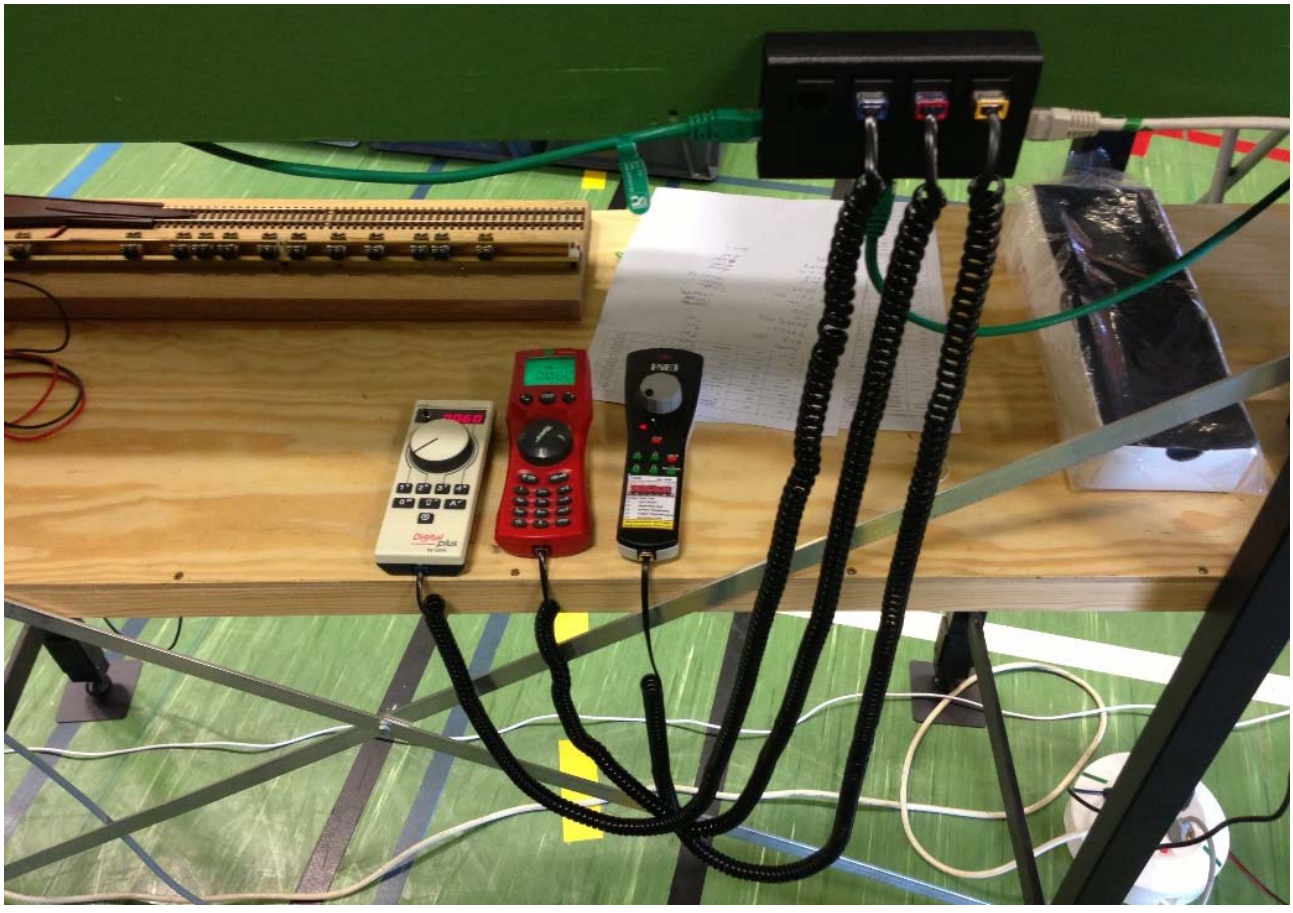

Fig. 1. The essence of EkeBus, connecting different controllers in the same connector

[1] Some central units supports 31 loco controllers on XpressNet.

1.3 Scope of Document

This document describes *EkeBus*, the technical design and the reasons behind it, the parts it consists of and how it set up for both large and small layouts. In addition, the document describes how *EkeBus* is connected to the Z21 central unit.

A description of how the DCC-signal can be distributed to the boosters on the layout is also provided.

1.4 Intended Readers

The two first chapters is for anyone interested of using their locomotive controller with *EkeBus*. Chapter 1 is this introduction and chapter 2 describes how the controllers should be connected to *EkeBus*.

The rest of the document is intended for persons setting up an *EkeBus* network.

2 Connection of a Controller to *EkeBus*

The main users of *EkeBus* are the train drivers moving around the layout, connecting and disconnecting their handheld controllers to the *EkeBus* jacks located on the layout. This chapter describes the details of the adapter cables required to connect different controllers to *EkeBus*.

2.1 Controller Connection to *EkeBus*

A controller is connected to an RJ45 jack, for example mounted on a panel like the one to the right. The panels are mounted around the layout at places where it is convenient for drivers to connect their controllers.

The jacks on a panel are wired according to the table below. Each jack provides one LocoNet®, two XpressNet and 12V power. Each type of controller has a special connection cable that provides it with the required signals.

The RJ45 connector has eight pins (see Fig. 2) that are wired as described in the table below. A detailed schema for each type of cable is presented in section 2.3.

Pin	Function	Comment
1	LocoNet® ground (0 V)	Dedicated to LocoNet® compatible controllers.
2	LocoNet® signal	
3	0 V loco controller power	
4	XpressNet 1b	Recommended for ROCO controllers with automatic address assignment.
5	XpressNet 1a	
6	+12 V loco controller power	
7	XpressNet 2b	Recommended for Lenz (and other) controllers with manual address assignment.
8	XpressNet 2a	

At module meetings, whether an XpressNet controller shall be connected to XpressNet 1 or XpressNet 2 is decided by the person responsible for the *EkeBus* setup. Please check with this person before connecting an XpressNet device to *EkeBus*.

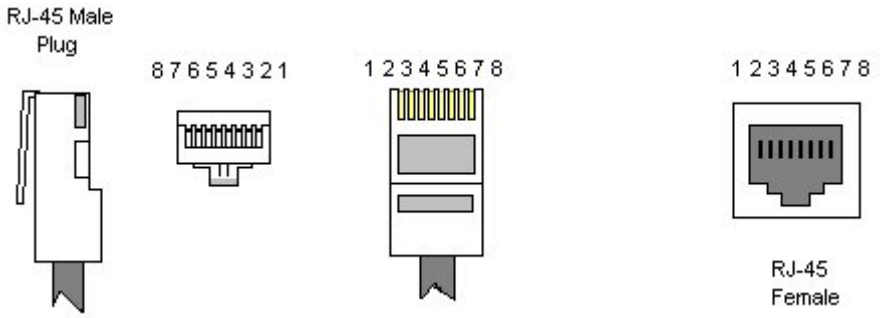

Fig. 2. RJ 45 connector

2.2 Supported Controllers

EkeBus supports all controllers that is supported by the central unit used for locomotive control. The controllers in the table below are supported by Z21.

Manufacturer	Model	Bus type	Note
Digitrax	DT300	LocoNet®	
	DT402	LocoNet®	
	UT4	LocoNet®	
Fleischmann	*multi*MAUS (grey)	XpressNet	Automatic XpressNet address assignment supported.
	Profi Boss	LocoNet®	
	Twin Control	LocoNet®	
FREMO	FRED	LocoNet®	Locomotive address assignment by dispatch from other device.
	FREDI	LocoNet®	
Lenz	LH30	XpressNet	Manual XpressNet address assignment only.
	LH90	XpressNet	
	LH100	XpressNet	
	LH200	XpressNet	
ROCO	LokMaus 2	XpressNet	Automatic XpressNet address assignment supported.
	LokMaus 3	XpressNet	
	*multi*MAUS (red)	XpressNet	
Uhlenbrock	Daisy	LocoNet®	
	Daisy II	LocoNet®	Supports wired only, not wireless.
	FRED	LocoNet®	Locomotive address assignment by dispatch from other device.
	IB-Control	LocoNet®	

2.3 Cabling for Controllers

This section describes the cables for connecting controllers to *EkeBus*.

A controller cable consists of an RJ-45 male connector in one end and an RJ-12 or RJ-14 connector in the other. The cable is a standard 4-wire telephone cable. The connectors shall have different colours depending on the type of controller.

For controllers with fixed cables, an adapter can be used.

2.3.1 Cable for LocoNet® Controller

Fig. 3. Example of cable for LocoNet® loco controllers

Fig. 4 shows the wiring for a standard cable for LocoNet® loco controllers except for Uhlenbrock Daisy, which is shown in Fig. 5. An *EkeBus* LocoNet® controller cable shall have yellow connectors.

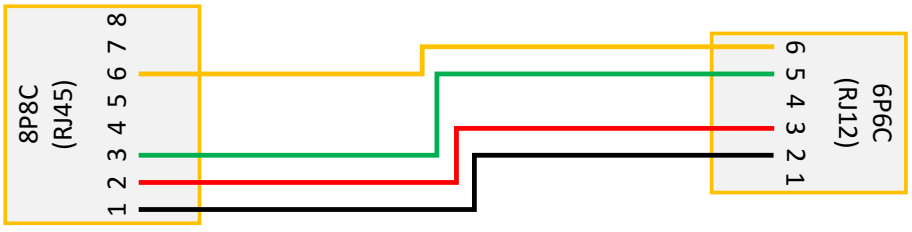

Fig. 4. EkeBus cable for LocoNet® handheld.

For Uhlenbrock DAISY, a special cable is required that connects the red wire to both pin 3 and 4 in the RJ-12 connector, see Fig. 5. However, this wiring also works for any other LocoNet® controller.

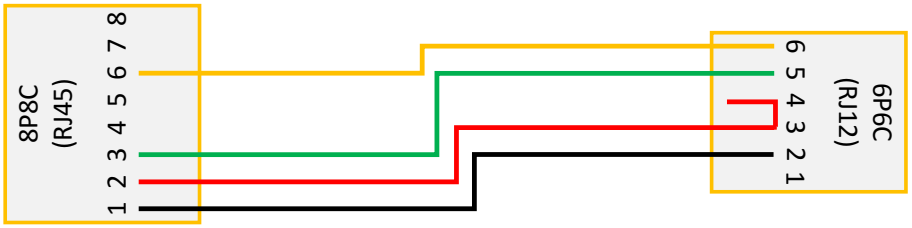

Fig. 5. EkeBus cable for Uhlenbrook DAISY

2.3.2 Cable for XpressNet 1 (ROCO) controller

Fig. 6. Example of cable for Roco loco controllers

Fig. 7 shows the wiring for an XpressNet 1 (ROCO) controller. An *EkeBus* XpressNet 1 controller cable shall have red connectors.

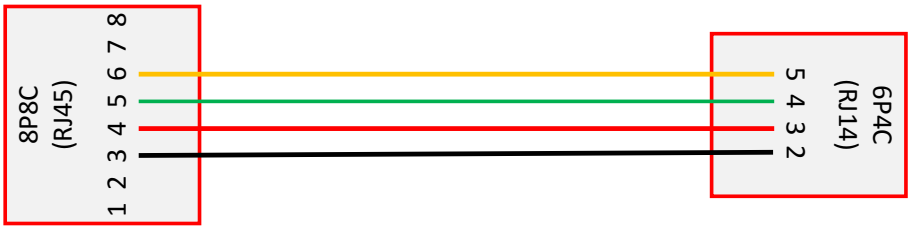

Fig. 7. EkeBus cable for XpressNet 1 (ROCO)

2.3.3 Cable for XpressNet 2 (Lenz) controller

Fig. 8. Example of cable for Lenz loco controllers

Fig. 9 shows the wiring for an XpressNet 2 (Lenz) controller. An *EkeBus* XpressNet 2 controller cable shall have blue connectors.

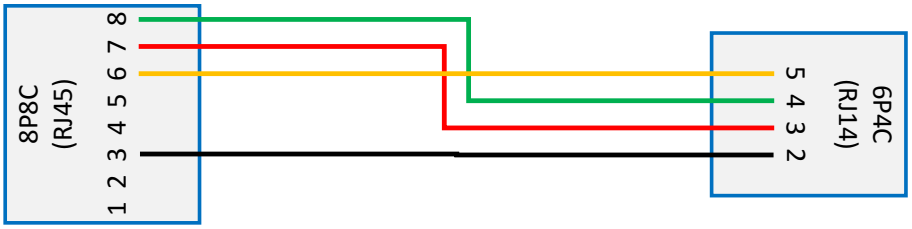

Fig. 9. EkeBus cable for XpressNet 2 (Lenz)

2.4 Adapters

2.4.1 Adapter for DIN 5-pin XpressNet to *EkeBus*

Fig. 10. Example of XpressNet 2 DIN adapter

Fig. 11 shows the wiring for an XpressNet 2 (Lenz) adapter cable to a 5-pin DIN XpressNet connector. The 5-pin DIN connector is shown from the soldering side. The connection between RJ45 pin 1 to DIN pin 3 is optional.

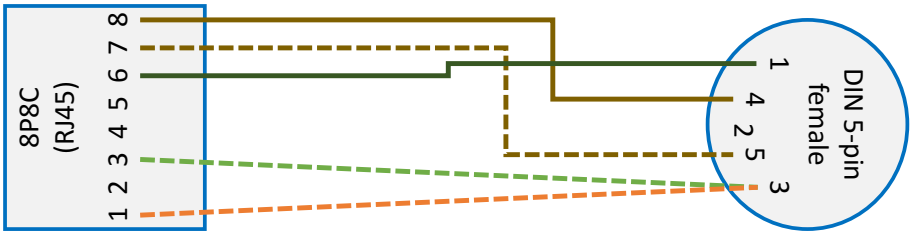

Fig. 11. EkeBus cable for 5-pin din adapter.

2.4.2 Adapter for Digitrax LocoNet® Controller to EkeBus

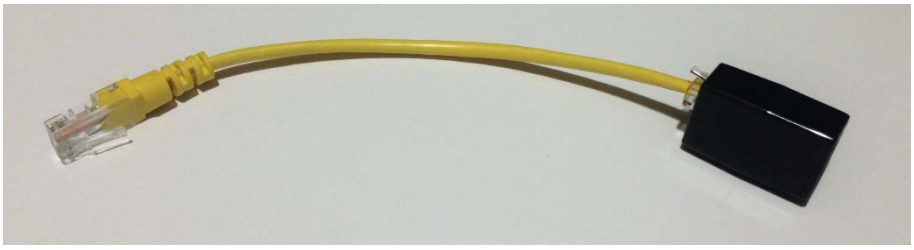

Fig. 12. Example of adapter for Digitrax controller

The connections are the same as the drawing in Fig. 4.

3 Technical Description

This chapter describes *EkeBus* in detail. The information presented her is primarily intended for the persons setting up *EkeBus*. A driver does not need to know the details presented here to use his handheld controller with *EkeBus*.

3.1 Colour Conventions

To simplify verification that everything is connected as it should, *EkeBus* has adopted some colour conventions. The use of different colours is described in the table below.

Colour	Description
Yellow	Identifies LocoNet® controller cables, special LocoNet® cables and special *EkeBus* network cables. No normal yellow RJ45 network cables shall be used in an *EkeBus* setup.
Red	Identifies XpressNet 1 (ROCO) controller cables and special cables for XpressNet 1.
Blue	Identifies XpressNet 2 (Lenz) controller cables and special cables for XpressNet 2.
Green	Identifies power cables.

3.2 Topology

LocoNet® and XpressNet have different requirements regarding network topology. LocoNet® should have a star topology while XpressNet should have a linear topology. *EkeBus* solves this by dividing the panels into linear sections. Each section has a separate LocoNet® and 12 V handset power supply, and the sections are connected together in series for XpressNet using *sectioning cables* (see section 4.3). The LocoNet® signal is distributed to the sections in a star network using separate RJ-12 cabling, and the two XpressNet signals are fed into the *EkeBus* from a *bus adapter* at one point. The basic *EkeBus* setup is illustrated in Fig. 13 below.

Digitrax, the owner of the LocoNet® protocol, recommends to not use Ethernet cabling for LocoNet®. With the *EkeBus* network topology the LocoNet® signals only uses Ethernet cabling for a short distance, and this has been proven to work in practice.

3.2.1 Sections

A section is a set of panels with controller jacks. The panels within a section are connected serially with standard RJ-45 twisted pair cables. Panels are described in section 4.8.

Between *EkeBus* sections where LocoNet® needs to be broken to not cause a loop, a *sectioning cable* is used. This *sectioning cable* also breaks the power feed. Only the four wires for the two XpressNets are connected. The *sectioning cable* is described in section 4.3.

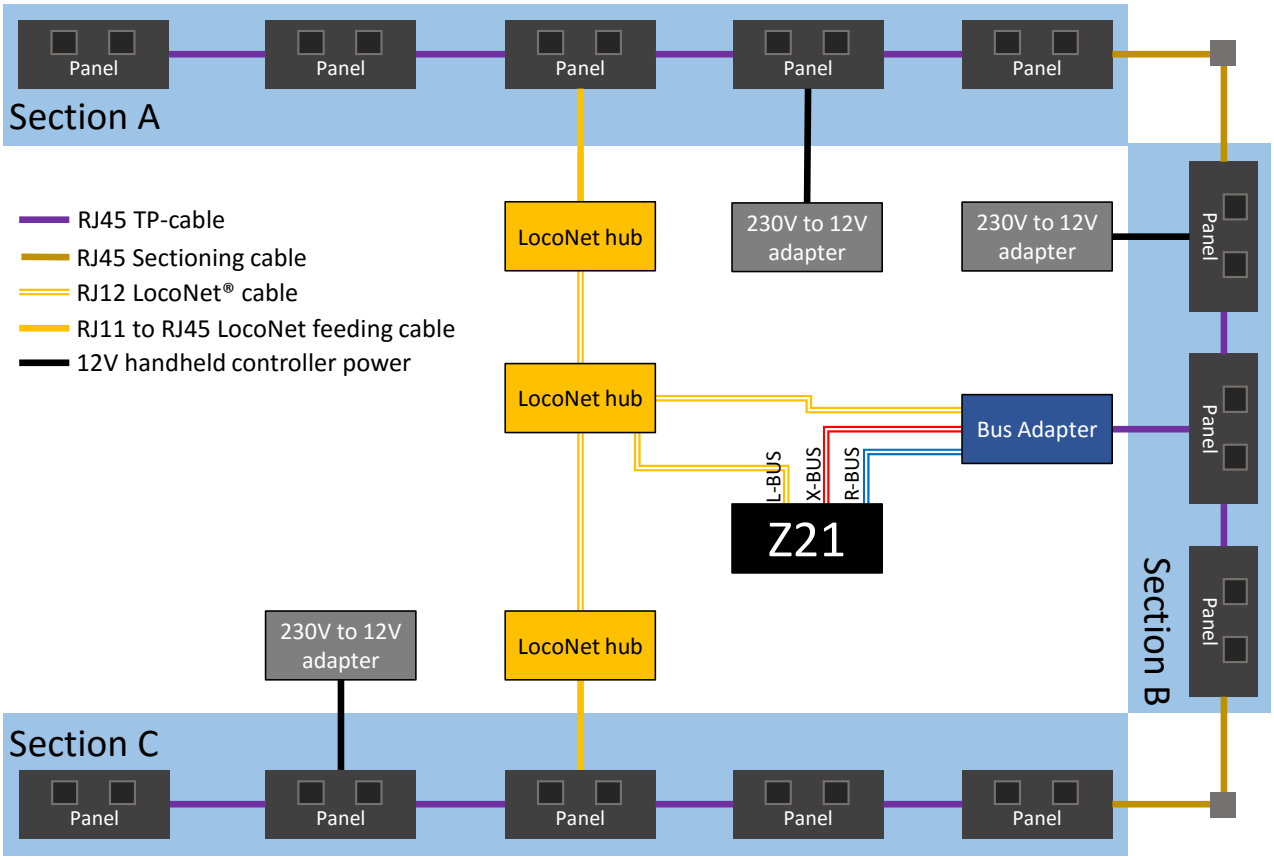

Fig. 13. EkeBus topology

3.2.2 LocoNet®

LocoNet® is distributed as a star network in separate RJ-12 cables to each section. The first LocoNet® hub is connected to the L-BUS on Z21. From that hub, cables are preferably drawn directly to the other hubs. From these hubs, the LocoNet® signal is fed into an *EkeBus* section using a *LocoNet® section feeding cable*. This cable is described in section 4.6.

3.2.3 XpressNet

The two XpressNet buses are fed through a *bus adapter* in one section, preferably the section near the middle of all of the *Ekebus* cabling. The *bus adapter* is described in section 4.2.

3.2.4 Central Unit

The Roco Z21 is the central unit that at the moment is the most suitable for *EkeBus*. However, one can also use other makes of central units with LocoNet® and/or XpressNet but then not use the full capacity of EkeBus. All descriptions in this document assumes that Z21 is used as central unit.

3.2.5 Power

EkeBus panels provides power to the controllers. Each *EkeBus* section is powered by a 230V to 12V adapter equipped with a special cable and connected to one of the panels using a RJ-45 connector. This ensures that the polarity is correctly connected. The power unit and cabling is described in section 4.5.

3.3 Wiring

Panels are usually mounted with small screw clamps on the layouts' sides.

For practical reasons, the wiring usually follows the edge and is placed under the layout. This minimises the risk to accidently break any connection.

If the wiring is parallel to normal electrical cables or the main track DCC cables, they should to be at some distance to avoid interference and disturbance.

3.4 Limitations

Practical use of *EkeBus* has given the following experiences of the network limits.

3.4.1 Length of sections

Sections with up to 11 panels with 3 meter CAT 5 TP-cable (33 meter), where LocoNet® and power is fed close to the middle of the section seem to work for all types of handheld controllers.

In most cases a section can be extended to 16 panels. When the sections are longer, some controllers may not work. The *Fleischmann Profi-Boss* seems to be the most sensitive controller.

Longer cabling and more connectors along the way degrades the LocoNet® signals and the power due to resistance in cables and contacts.

3.4.2 Length of LocoNet® cabling

LocoNet® is distributed to *EkeBus* sections using the recommended RJ-12 cabling. With 10 meter cables connected together with hubs, the distance from the central unit to the feeding point at the centre of a section can be at least 100 meters. With longer cables and fewer hubs it is possible to have even longer distances.

3.4.3 Topology of XpressNet cabling

In many cases, it is possible to divert from the linear structure of sections and use a star topology for XpressNet. However, a linear topology gives the best performance.

3.4.4 XpressNet terminators

EkeBus has been tested without terminators on the XpressNet on CAT 5 TP-cables up to 500 meters. However, it is recommended to terminate the two longest branches (counted from the Bus Adapter feeding point) with a resistor of 120 Ω between the A and B wire. Note that at most two terminators per XpressNet can be used.

3.4.5 Maximum number of controllers

On each XpressNet up to 30 or 31 controllers can be connected.

The upper limit of the number of controllers that can be handled by LocoNet® depends on a number of technical factors that are out of scope of this document. At least 30 concurrent LocoNet® controllers should be supported by most central units.

3.4.6 Maximum number of controlled locomotives

The central unit limits how many locomotives that can be controlled simultaneously. Please consult the technical documentation for the central unit for details.

3.5 *EkeBus* with other protocols

3.5.1 Wireless controllers

EkeBus is for wired controllers. Wireless controllers can be used in parallel with controllers connected to *EkeBus*. A wireless controller either communicates directly with a receiver in the locomotive or over wireless communication with the central unit.

3.5.2 Other types of controller buses

EkeBus does not support other types of buses, for example CAN buses. If the central unit supports additional bus types, these controllers can usually be used in parallel with *EkeBus*, but will require additional parallel cabling.

4 Equipment

This chapter presents in more depth the components used in setting up *EkeBus*.

4.1 Z21

The central unit that makes *EkeBus* practical is Z21 from ROCO/Fleischmann. Z21 supports both LocoNet® (L-BUS) and XpressNet, and can have two separate XpressNet buses. The second XpressNet is the R-BUS connector configured to be an XpressNet. This feature is available in Z21 from program version 1.25.

Fig. 14. Connectors on ROCO Z21 Central Unit

4.2 Bus Adapter

The *bus adapter* merges the three controller buses into one RJ-45 female connector, see Fig. 15 for an illustration. The three connecting cables should have the same colour as the controller cable for that bus, i.e. yellow for LocoNet®, red for XpressNet 1 and blue for XpressNet 2. The yellow cable is connected to a LocoNet® hub, the red cable is connected to the Z21 X-BUS and the blue cable is connected to the Z21 R-BUS. The wiring for a *bus adapter* is shown in Fig. 16.

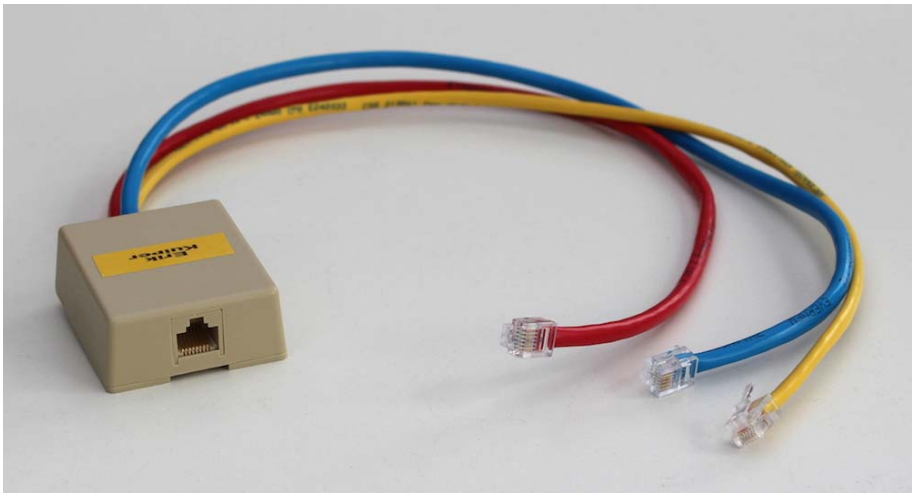

Fig. 15. Bus Adapter

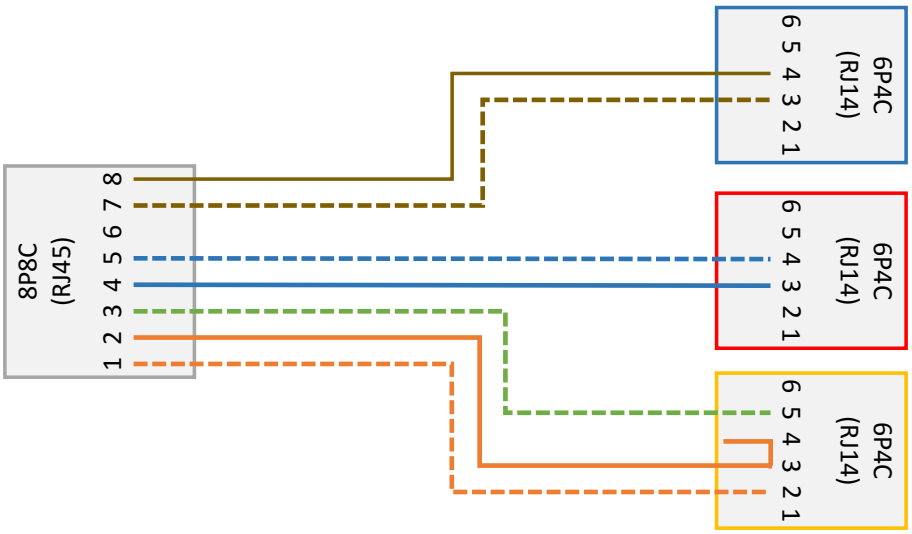

Fig. 16. Wiring of Bus Adapter

4.3 LocoNet® and Power Sectioning Cable

The *sectioning cable* is a standard RJ-45 twisted pair cable with leads for LocoNet® and power cut. This cable shall be yellow.

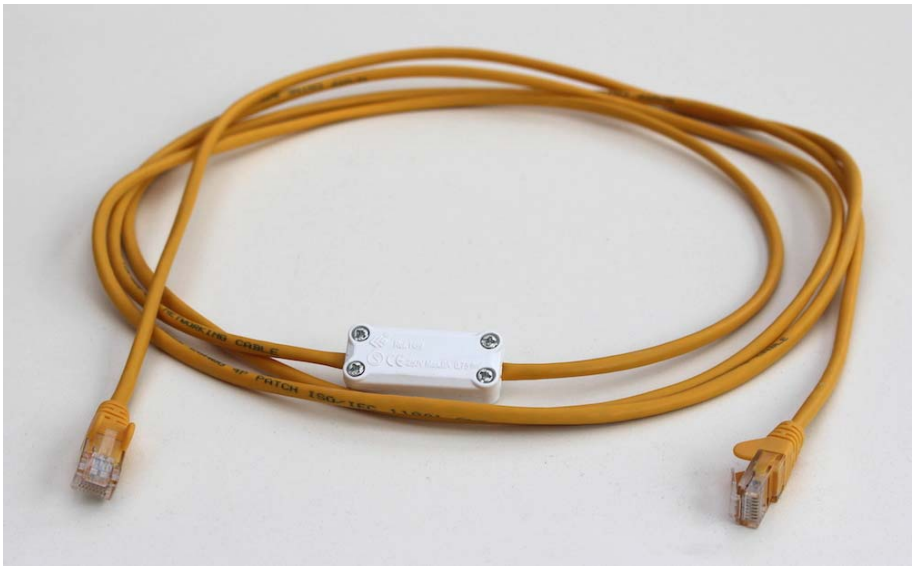

Fig. 17. EkeBus Sectioning Cable

A *sectioning cable* should be made of a standard RJ-45 twisted pair cable. In the middle of the cable, wires 1, 2, 3 and 6 are cut, and wires 1 and 3 from same connector are connected. The wiring of a *sectioning cable* is shown in Fig. 18.

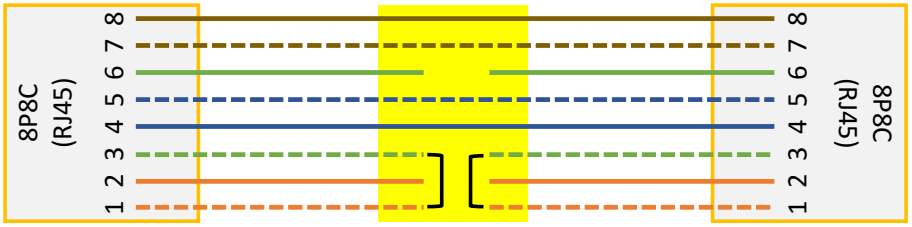

Fig. 18. Wiring of EkeBus Sectioning Cable

4.4 LocoNet® hub

A LocoNet® hub is simply a box with several parallel coupled RJ-12 female connectors. One example is the FREMO LN-BOX (see Fig. 19).

Fig. 19. FREMO LN-BOX

4.5 LocoNet® bus cabling

LocoNet® cabling should be 6P6C RJ-12 flat cabling as recommended by Digitrax. Best is to always use straight wiring (1-1, 2-2 etc.) and not crossed. This simplifies troubleshooting when a short circuits occurs. It also avoids damage to XpressNet devices if the cables are used for XpressNet.

4.6 LocoNet® section feeding cable

A *LocoNet® section feeding cable* is for connecting LocoNet® to an *EkeBus* section. The wiring for a *LocoNet® section feeding cable* is shown in Fig. 21. The red wire in the LocoNet®

feeding cable shall be connected to both pin 3 and 4 in the RJ-14 connector. A *LocoNet® section feeding cable* shall have yellow connectors.

Fig. 20. Example of LocoNet® section feeding cable

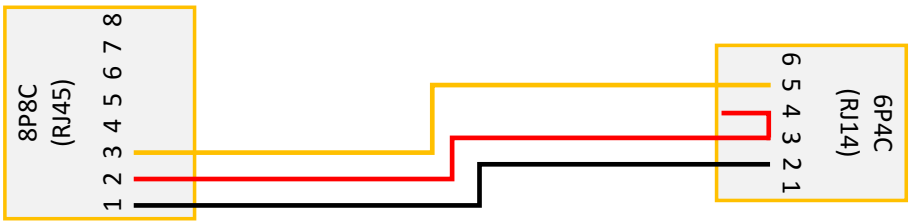

Fig. 21. Wiring of LocoNet® section feeding cable

4.7 Controller Power Supply

Each *EkeBus* section shall have a separate stabilised power of 12 Volt DC and 500 mA current. To minimize voltage loss within a section, the feed should be connected in the middle of the section.

Fig. 22. Power Supply for Loco Controllers

The power supply cable shall be connected according to Fig. 23. Both the black and red wire shall be connected to the minus (ground). The RJ45 connector in a power supply cable shall be green.

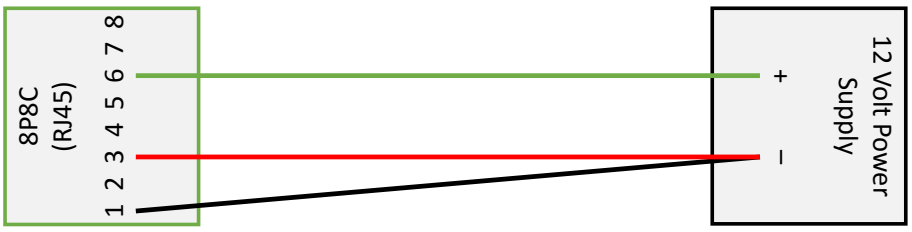

Fig. 23. EkeBus power supply cable[2]

[2] Wire colours is under consideration.

4.8 Panels

Panels can be designed with one to or more jacks for controllers. On the Swedish module meetings, panels with 1, 2 and 4 controller jacks are used. Panels with more jacks are often required at busy stations. The controller jacks shall be designed with the locking mechanism located downwards.

In addition to the controller jacks, three additional jacks are required to be able to connect the panels within a section to each other and to feed LocoNet® and power to the section. All jacks on the panel are wired in parallel. Additionally, pins 1 and 3 shall be connected by a jumper.

Fig. 24. Panel with two controller connectors

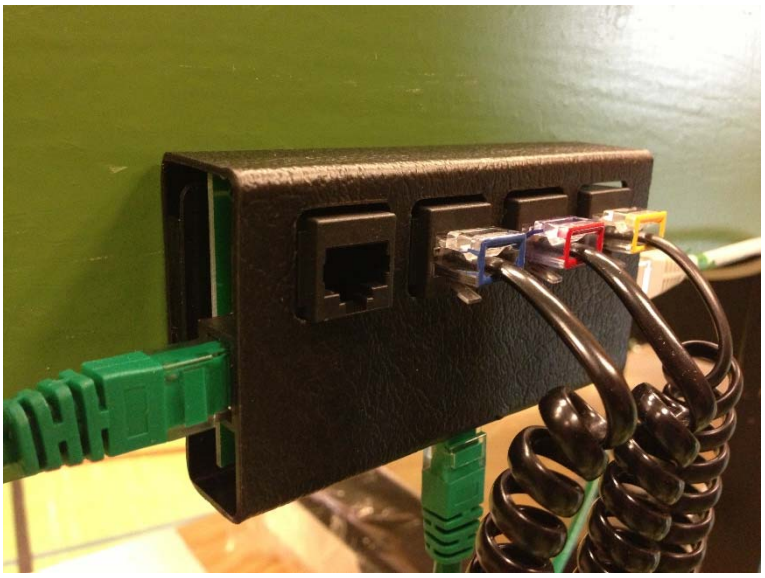

Fig. 25. Panel with four connectors and connected cables

5 Distributing DCC Signals over LocoNet®

The previous description of *EkeBus* does not deals with how the DCC-signal is distributed to the boosters around the layout. One option is to use separate cabling. Another option is to distribute the DCC-signal using the standard LocoNet® cabling.

In order to do so, the primary LocoNet® hub needs to be replaced by a *Rail Sync Current Limiting Device* (RSCLD). This device limits the maximum current of the DCC/RailSync signals in the LocoNet® network. This prevents damage to the LocoNet® cabling if a short circuit occurs. In most cases an RSCLD also acts as a LocoNet® hub where each branch is independently current limited. The DCC/RailSync signal needs to be fed to the RSCLD from a booster. The maximum DCC/RailSync voltage depends on the RSCLD. The DCC/RailSync current should not exceed 500 mA at a short circuit to prevent damages on the wiring.

Fig. 26 illustrates how the Z21 should be connected to an RSCLD and how the boosters are connected to the LocoNet® network. Normally up to five boosters can be connected to each LocoNet® branch.

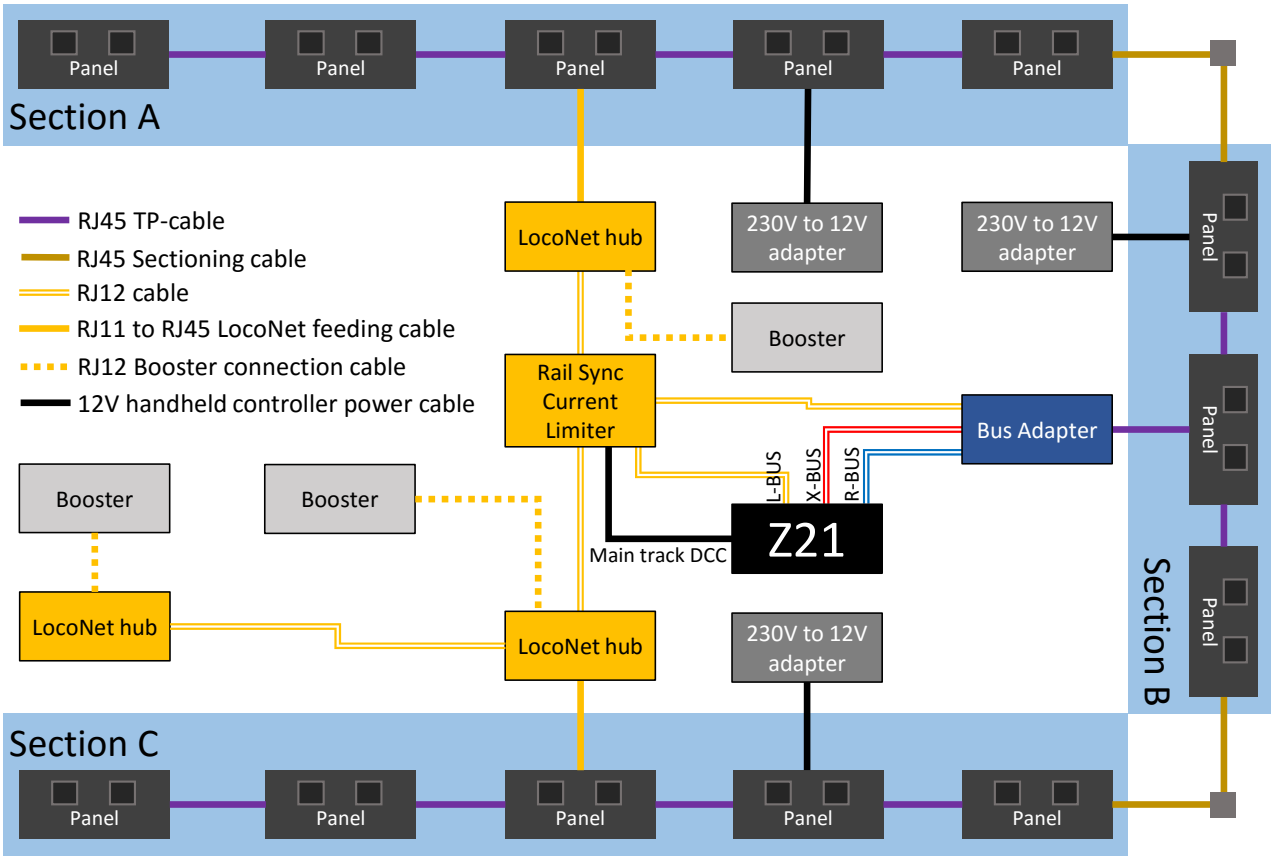

Fig. 26. EkeBus with booster feed over LocoNet®

5.1 Boosters

All boosters used on the layout need to have an optically isolated DCC/RailSync input, and they need to independently be able to shut down the power to the tracks in case of a short circuit.

Examples of boosters that meet these requirements are Lenz LV101 and TAMS B4.

Examples of boosters that cannot be used without modification are ROCO boosters.

How the DCC/RailSync signal should be connected to the boosters is booster type specific and not detailed in this document.

The wiring diagram below shows how boosters and EkeBus panels are connected to a LocoNet® hub. Note the jumper between pin 1 and 3 in the EkeBus panel and the jumper between pin 3 and 4 when connecting EkeBus to a LocoNet® hub. Note that LocoNet® is feed only to one panel in the middle of a section.

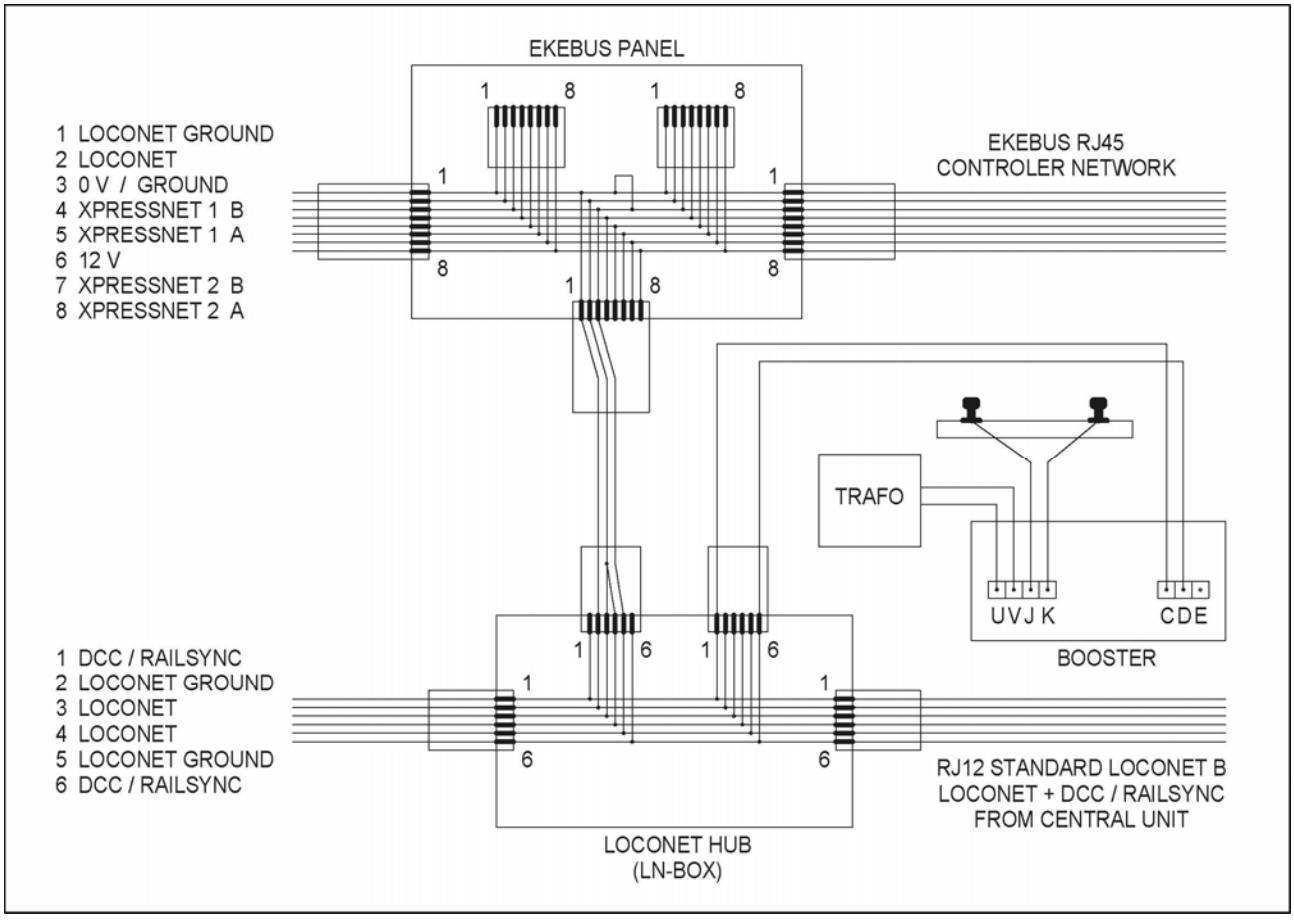

Fig. 27. Wiring of EkeBus panel, LocoNet® hub and booster connection.

5.2 Rail Sync Current Limiter Device

The *Rail Sync Current Limiter Device* (RSCLD) is from FREMO and used the same ways FREMO does. See Fig. 29 for an example schematic and section 7 References for additional information.

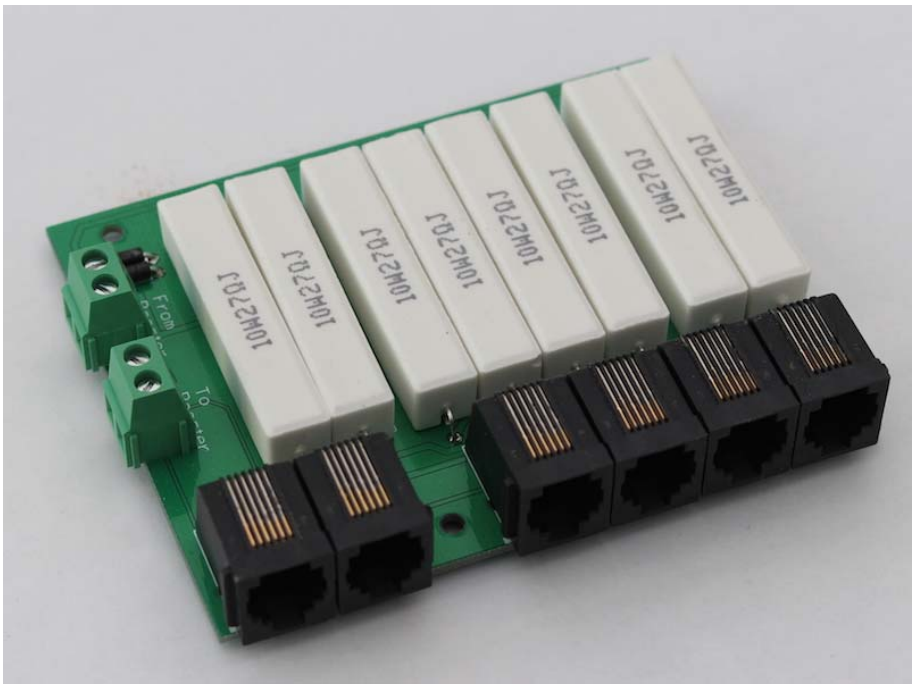

Fig. 28. Example of an RSCLD

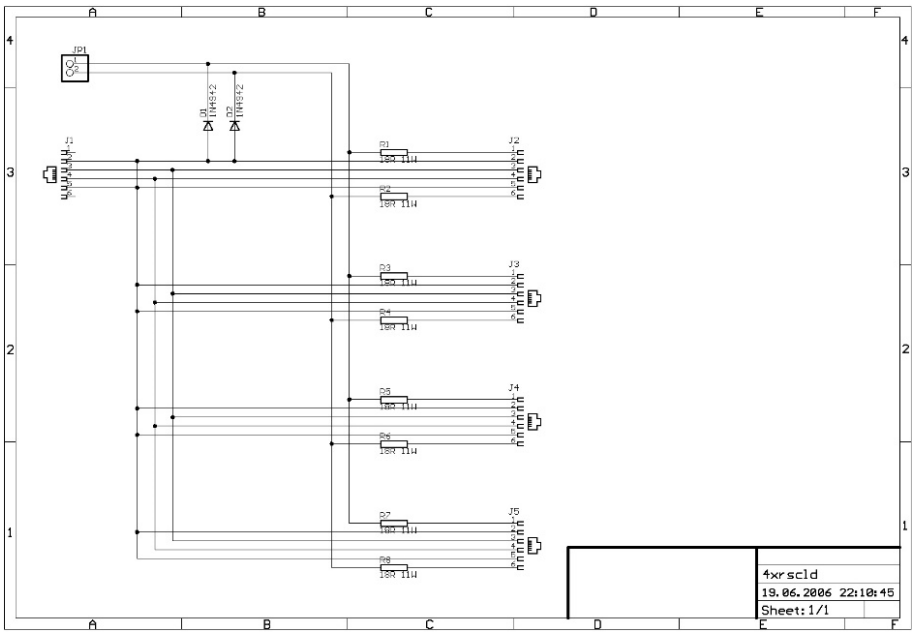

Fig. 29. Example of wiring of an RSCLD

6 Using EkeBus on Small Layouts

For small layouts, e.g. a home model railway, *EkeBus* can be set up much simpler. A small layout can be set up with only one *EkeBus* section where the Z21 feeds all signals to the single *EkeBus* section.

If the layout does not need to be separated into booster districts then the Z21 can feed the tracks directly. This eliminates the need for boosters, sectioning cables, LocoNet® hubs and 12 V adapters.

In the simple setup the bus adapter's all three cables are connected to Z21, and the Z21 feeds the main track directly. The power to the controllers is taken from an extra X-BUS jack on the Z21, see Fig. 31 for the schematic of the power cable. The power cable connectors shall be green. With this setup, it is possible to use all supported controllers on a home model railway.

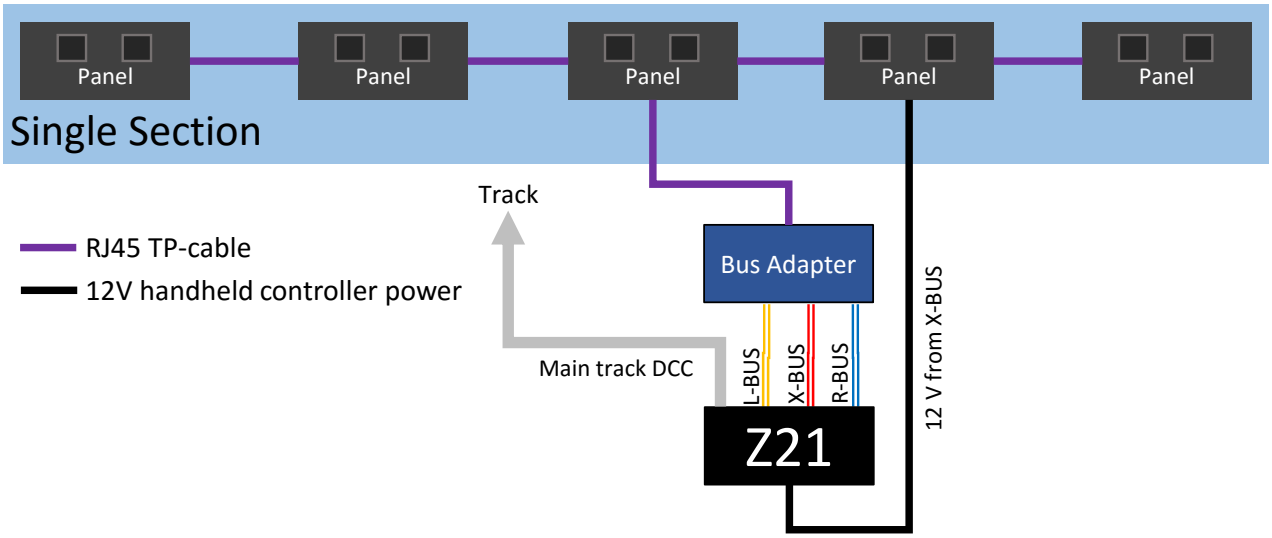

Fig. 30. Topology for single section EkeBus.

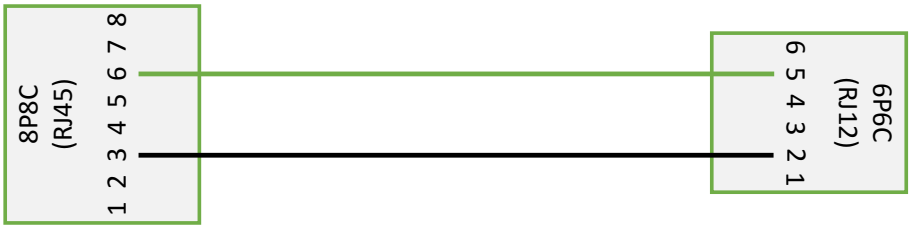

Fig. 31. Cable for 12 V power feed from X-BUS connector[3]

[3] Wire colours is under consideration.

7 References

Document	Description
LocoNet®	http://www.dccwiki.com/Loconet
XpressNet	http://www.lenzusa.com/1newsite1/XpressnetFAQ.html
Z21	http://www.Z21.eu
RSCLD	http://www.fremo.wisotzki.org/projekte/6fach_rscld/x_images/702_6fach_rscld_2sch.pdf http://www.mec-leonberg.de/4xrscld/4xrscld_schema.jpg http://www.mollehem.se/index.php/electronics/rscld-detail