Decoder "Standard connectors" and Stay-Alives...

A few pages from our DCC advice #12…

This document is taken from our DCC advice #12 and is covers the range of standard NMRA/ NEM compliant connectors… and details a few oddball choices made by Brands like Hornby and Bachmann in their UK prototype models. It also includes general "Stay Alive" data

Like wire colours, the American NMRA and European NEM standards also cover connections for DCC installations. … these are generally followed by loco makers, with a few odd and quite unnecessary and annoying exceptions which have been introduced by some UK brands for no sensible reason!

There are several approved connectors that you will come across.

- For N scale and some TT, OO and HO locomotives, the NEM-651 SIX pin connector
- For OO and HO scale (and On30) the NEM652 EIGHT pin connector
- For OO and HO the 21MTC 21 pin connector.
- For all scales, variants of the PLUX connector, which can be 8, 12, 16 or 22 pins.

The 6 PIN NEM651 or "Small NMRA connector":

The Small 6-pin connector was originally created for N scale but is now sometimes also used in EU for HO scale (mostly by Fleischmann) and in English OO in small locomotives by Bachmann.

It has a current rating of 0.5 Amp continuous, 0.75 Amp peak, so to be frank I believe Fleischmann may be in in error using it, as their heavy 3 pole motors are very capable of exceeding these levels!

This connector is unique in that it offers no BLUE wire for accessory functions. Accessories or lights must connect to the appropriate function wire plus either the red or black wires. This gives half-wave rectified power and not full power as with installations that use the blue positive ground wire.

The drawing below shows the pin-out numbering looking into the socket of the connection system, as you would see it if the loco is DCC ready: The images show you what it should look like.

Which way is up? Uniquely among connectors that meet the standards… This plug has no natural orientation: In general the TOP of the decoder should face you as you insert it.

On DCCconcepts Zen decoders that is the side with the Zen logo - on European decoders which very often have no heat-shrink on them… "which side is up" is not always very obvious.

Just try if you are not sure… nothing will work if it is upside down. Just reverse it if needed!

The NEM-651 connector (looking at the plug face)

A useful NEM-651 harness 6-pin male to 6-pin Female

Zen 6-pin ZN6D decoder

Decoder "Standard connectors" and Stay-Alives...

Continued…

Pin configuration for the 6-PIN NEM651 (small NMRA connector):

The colour codes for this connector are as follows:

- **ORANGE (1)** Motor wire (by convention, right or upper brush of motor). Often marked with a star.
- **GREY (2)** Motor Wire (by convention, left or lower brush of motor)
- **RED (3)** Track power pickup wire (By convention, this wire should be attached to the pickup wire etc. that collects power from the RIGHT rail)
- **BLACK (4)** Track power pickup wire (By convention, this wire should be attached to the pickup wire etc. that collects power from the LEFT rail)
- **WHITE (5)** Accessory - Always front Light, switchable usually by F0 by default. (White and yellow are usually also set up to act only in the direction of travel to act as front/rear lights automatically. With good quality decoders the function allocated can be changed if needed).
- **YELLOW (6)** Accessory - Always rear light, switched usually by F0 by default. The yellow wire is the negative in any circuit. (White and yellow are usually also set up to act only in the direction of travel to act as front/rear lights automatically. With good quality decoders the function allocated can be changed if needed).

You will note that the NEM-651 connector does NOT include the common positive blue wire!

This done to save space in N scale where the absence of one wire makes life much easier. It is less helpful in OO or HO though. If you want lights you either have to wire lights for half wave operation by connecting one side of the LED or bulb to the white or yellow and the other to the chassis….

Or:… You can use a DCCconcepts ZEN decoder. The blue wire that is attached to DCCconcepts ZN6D decoder to use with the Stay-Alive can double-up as a common positive function wire!

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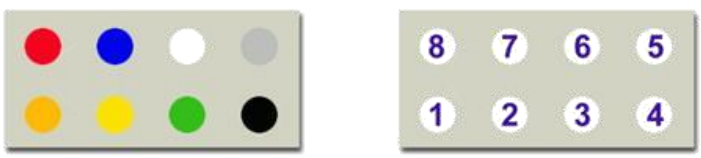
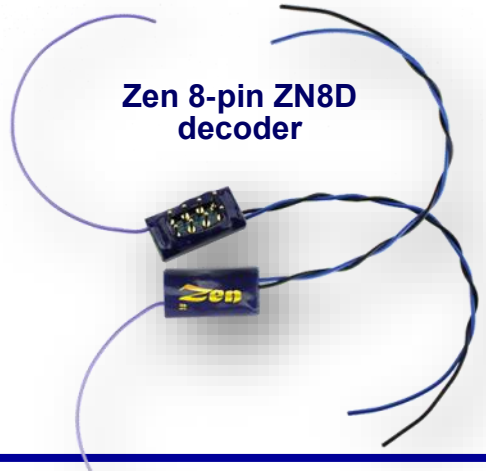
The 8-PIN NEM652 (Medium NMRA Connector):

This is the one most people call the NMRA Plug. it is also called the NEM 652 Medium connector for HO scale and larger. It is the most common of all connectors and is found across the world. It is configured with two rows of four pins spaced at 0.1" apart. It is suitable for applications up to 1.5-Amps continuous current applications with a 3-Amps peak.

The design is clever in that if you insert the plug backwards, then no harm will come to the decoder…. Its easy to know when you get it wrong - If your loco runs backwards instead of forwards and the lights do not work as you expect… you have it in backwards!

The drawing below shows the pattern and pin-out numbering as if you are looking down on to the socket or at the wires on the top of the plug. (the view you see on a DCC ready loco)





Inset at right… *the VERY small 4-function Zen direct decoder.*

The ZN8D is literally only the same size as the blanking plug.
It is the world's smallest 8-pin direct-plug decoder and we are sure that it will fit ANY 8-pin locomotive you may buy!
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Decoder "Standard connectors" and Stay-Alives...

Continued…

Pin configuration for the 8PIN NEM652 (medium NMRA connector):

The drawing above shows the face of the 8 pin socket:

The drawing shows the face of the socket for this connector, as wired to the loco. The decoder has the plug fitted to its harness. The drawing above shows the colour and number for each connector pin. Where there are other wires (commonly an additional free purple wire) this will need to be hard-wired.

The colour codes for this connector are as follows:

- **ORANGE (1)** Motor wire (by convention, right or upper brush of motor). Often marked with a star.
- **YELLOW (2)** Accessory - Always **rear light by default** (Usually controlled by F0 by default).

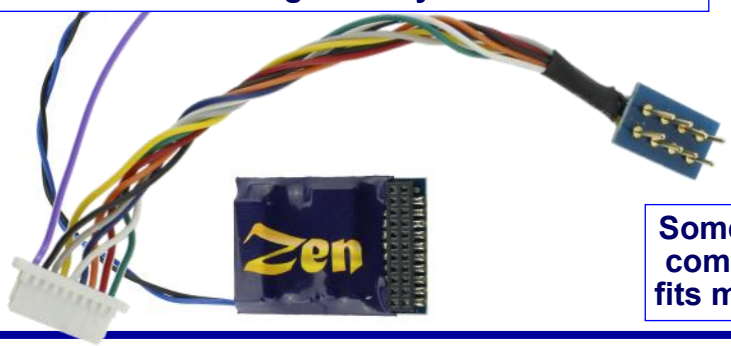
  The yellow wire is the negative in any circuit. White and yellow are usually also set up to act only in the direction of travel to act as front/rear lights automatically. With good quality decoders the way the light operates and which function it is controlled by can be changed if needed.
- **GREEN (3)** Accessory - Optional, and found only on decoders with more than two lighting functions. It is usually switched by the function 1 button by default.

  The green wire is the negative in any circuit. White and yellow are usually also set up to act only in the direction of travel to act as front/rear lights automatically. With good quality decoders the way the light operates and which function it is controlled by can be changed if needed.
- **BLACK (4**) this wire attaches to the pickups to transfer power from the track to the decoder. usually, the black wire is connected to the pickups that collect power from the LEFT rail (That is, left rail from the loco drivers point of view).
- **GREY (5)** Motor Wire (by convention, left or lower brush of motor)
- **WHITE (6)** Accessory - Always **front light by default** (Usually controlled by F0 by default).

  The yellow wire is the negative in any circuit. White and yellow are usually also set up to act only in the direction of travel to act as front/rear lights automatically. With good quality decoders the way the light operates and which function it is controlled by can be changed if needed.
- **BLUE (7)** This is the **Common POSITIVE for ALL accessory functions** of the decoder.

RED (8) this wire attaches to the pickups to transfer power from the track to the decoder. usually, the red wire is connected to the pickups that collect power from the RIGHT rail (That is, right rail from the loco drivers point of view).

The ZN218 decoder. It has a full NEM652 8-pin harness, but it also incorporates a full 21 pin MTC interface making it a very useful decoder!



Sometimes wires just get in the way. Zen360 is a compact direct-plug 8-pin NEM652 decoder that fits most locos irrespective of socket orientation.

Decoder "Standard connectors" and Stay-Alives...

Continued…

Pin configuration for the "21 pin MTC" Direct-plug Connector:

VCC	Controller internal VCC	12	11	NO Pin	Coding or registration
AUX 3	Output 5	13	10	LS	Loudspeaker Terminal B
AUX 2	Output 4	14	9	LS	Loudspeaker Terminal A
AUX 1	Output 3	15	8	FRONT LIGHT	Output 1 / Front Light
V+	Controller Plus (behind rectifier / Blue)	16	7	REAR LIGHT	Output 2 / Rear Light
MOTOR 3	Motor Output 3	17	6	TBDTA	Train BUS - Data Line
MOTOR 2 MR	Motor Output 2	18	5	TBCLK	Train BUS - Clock Line
MOTOR 1 MF	Motor Output 1	19	4	AUX 4	Output 6 / Pick-up control
GND	Controller GND (Behind rectifier)	20	3	HALL 3	Hall Sensor #3
TRACK LEFT	2 Railtrack Left/3 rail outside rails	21	2	HALL 2	Hall Sensor #2
Track Right	2 Railtrack Right/3 rail centre rail	22	1	HALL 1	Hall Sensor #1

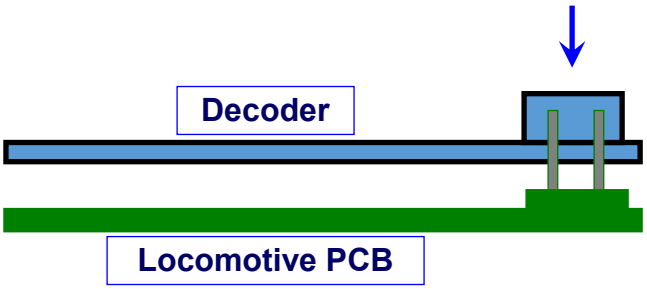
The drawing above shows the pin allocations of this connector, from above:

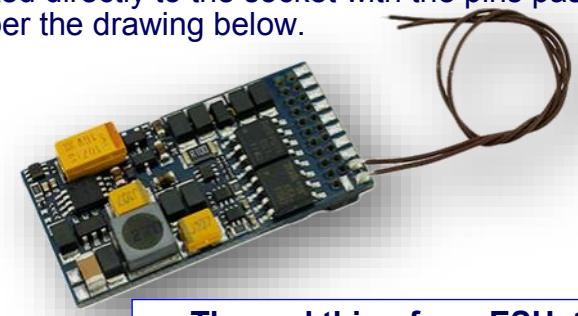
The drawing shows the face of a 21MTC connector as viewed from the top of the decoder. The purpose of each connector position is clearly indicated. To further clarify things, we've added coloured squares in appropriate wire colours to the pin positions.

The male 21MTC is always pre-fitted onto a PCB which is actually part of the locomotive itself and there are therefore NO wires to worry about with this connector, as the decoder is simply fitted directly to the 21MTC male plug that is part of the locomotives ex factory wiring.

Orientation of this decoder:

Note pin 11, which is a blank position with NO hole. (The red/blue circle) Look carefully at the loco and you will see there is no pin at the # 11 position. This "blanking position" establishes the orientation of the decoder in the locomotive. The 21MTC decoder is fitted directly to the socket with the pins passing through the Decoder PCB and up into the connector as per the drawing below.





The real thing from ESU, to show the 21 MTC connector

This connector allows for many more connections than most need:

Background of the 21MTC connector: This connector was never really planned for - It came about when ESU were creating a new Marklin decoder series (MFX) and Marklin needed also something with more pins to accommodate their 3 wire C-sine motor plus other functions.

It was quite quickly adopted by several other ESU clients including Bachmann, and can be found in all continents now - especially in UK and Europe where many brands use it. The 21MTC has gone global now and it is also used AU locomotives on occasion. In USA it appears in Bachmann and PCM.

This is the 21MTC logo

it should appear on the box of any locomotive that has this DCC connector installed.

Decoder "Standard connectors" and Stay-Alives...

Continued…

Summarising the 21MTC connector:

While not initially an approved connector, it was, after some discussion, added to the NMRA approved connector list and given formal NEM recognition, and is part of many locos in many brands, so it is very much "here to stay" for now.

The core concept of the 21MTC connector was good in that there are more digital control possibilities than the 8-pin plug allowed - but its application is not necessarily the best that could have been created as it has some shortcomings.

NMRA connectors are usually designed to "save" decoders and electronics if incorrectly used (the 8 and 6 pin for example can be inserted backwards with no loco or decoder damage - but the 21 pin cannot. If you force it in backwards, you WILL damage the decoder!

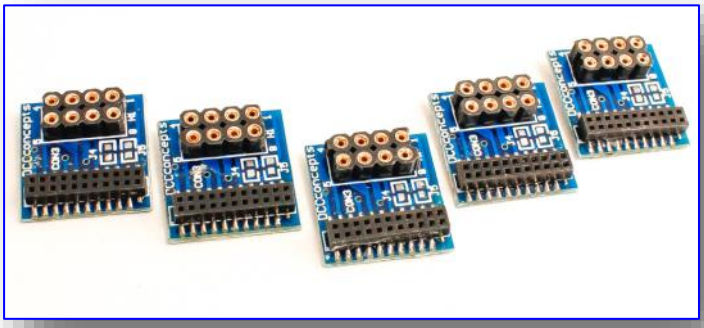
So… in time, this connector will possibly be superseded by the PLUX 22 that we review next. This is a connection structure which uses an almost identical with a differently placed "blanking pin" and quite different pin allocations designed to allow "sub-sets" of 22, 16, 12 or 8 pins to be used, depending on loco needs and decoder function availability.

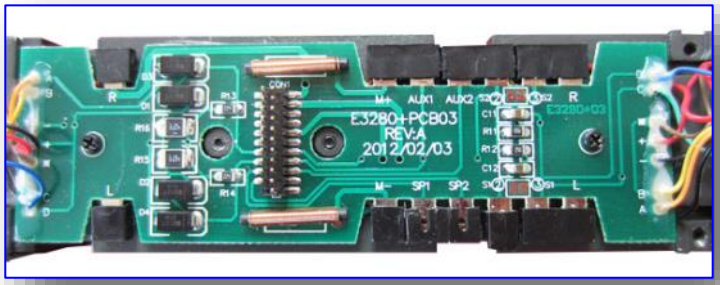
What do you do if you have a 21 pin locomotive and an 8 pin decoder you wish to use?

The 21 pin is a totally wireless concept, however if your loco is 21-pin and you have a favourite brand of decoder, you'll need an adapter.

DCCconcepts have therefore designed a simple , easy to use and economical 21 pin to 8 pin adapter. That connects up to 4 functions (sold in packs of 5)

Click on the image for more details! It simply plugs onto the loco 21 pin plug, and you then push the 8-pin plug into it, completing the installation.





A Diesel Loco PCB with a 21 pin connector.

You can also clearly see the 2 inductors here. They can be replaced with a bit of wire!

Please note the black rubber push-connectors on each side of the PCB. It is our experience that if you take the time to solder the wires to the PCB instead of relying on them, you will end up with a neater and more reliable installation!

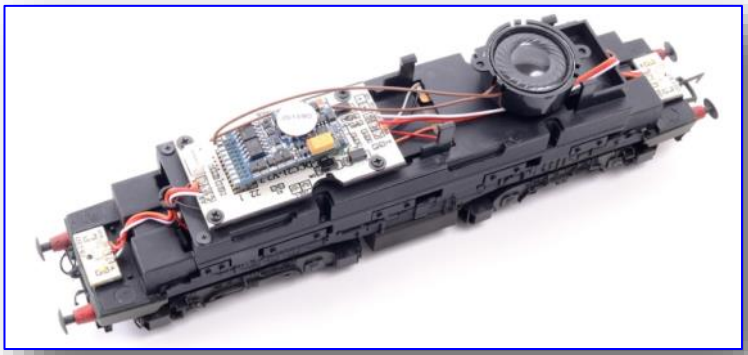
A Diesel Loco PCB with a 21 pin connector.

Another example, this time with decoder fitted.

I made comment earlier about the messy wiring we usually find in Hornby steam locomotives.

I also like to give credit when it is due and this Hornby loco's wiring is exactly the opposite

Neat, tidy and well put arranged. Really nice.



Decoder "Standard connectors" and Stay-Alives...

Continued…

PLUX 22 - The newest 22 PIN "recommended wireless NMRA and NEM Connector".

The size and shape of the PLUX - 22 connector is exactly the same as the 21pin MTC connector and it is simply placed on the PCB in the same way - with two big differences.

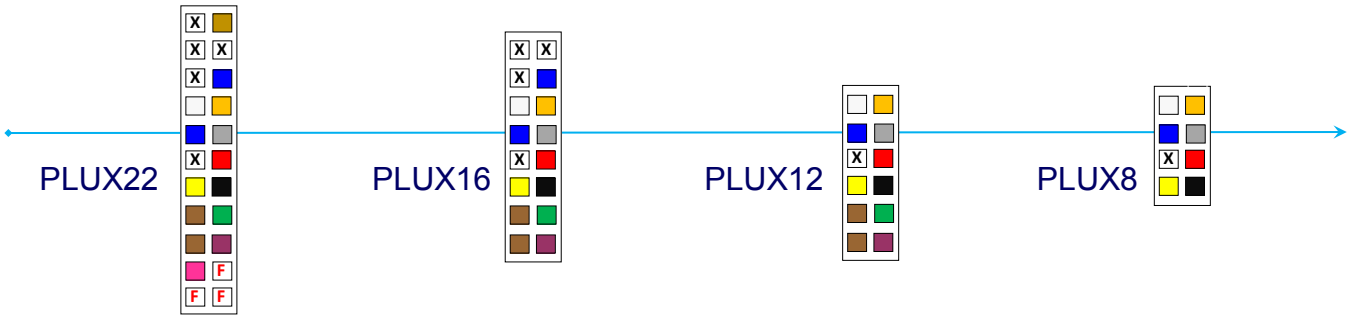
(1) There is NO blanking plug position.

(2) The connector in the loco is the socket. (21MTC has the pins in the loco)

However, as you can see from the images below, there is now a sensible set of combinations possible within the overall 22 pin geometry.

Left to right, we show 22 pins, 16, 12 and 8 pin variants, all "sub-sets" of the same connections. All have variants common positions for core functions, something that's impossible with a 21MTC connector.

It is out there now having been detailed several years ago, but its proliferation is actually quite slow.



Large loco with lots of functions and sound	medium loco with Functions & sound	average loco Sound is possible	N scale Loco only 3 functions

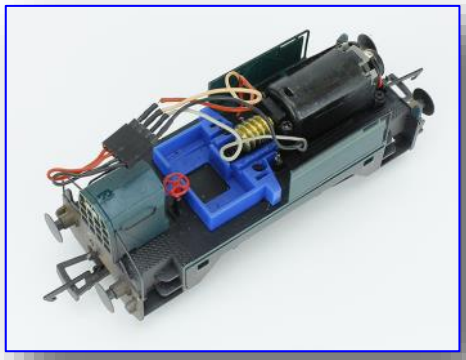
The "Pain in the Butt" Hornby 4-pin connector:

This is used in the sentinel and some other locos - I have no idea what Hornby were thinking about when they did this but it certainly wasn't their clients. A 6-pin NEM651 would have been ideal as a 6-pin decoder could then be fitted. We suspect Hornby just want to sell their own with a special harness!

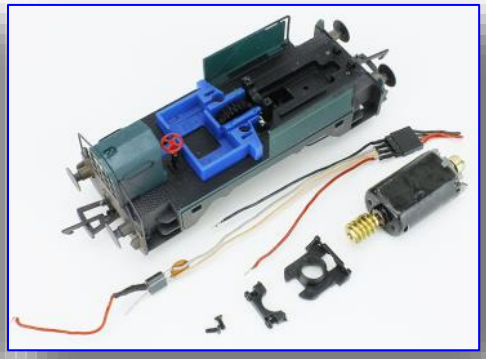
We'd considered making an adapter harness but when we opened it up, the wiring was... horrible!
How can they add so much untidy wiring inside a tiny loco that's already short of space!

So - we recommend just taking out ALL of Hornby's messy wiring and doing it as follows.
That will also be the quickest and easiest way for most modellers… as well as being tidier!

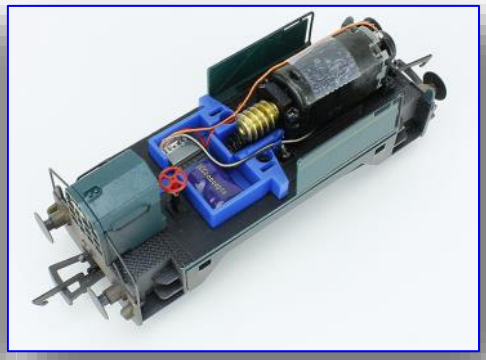
We used our Zen ZN6H decoder and an NEM651 harness for this job… easy! The photo's tell the story!



AS DELIVERED. Messy with wires much too long and a non-standard 4-Pin plug



90 seconds: All that it took to remove 4 screws, remove motor & messy wires!



10 minutes more: harness cut , soldered in, wires dressed and motor re-installed.

Decoder "Standard connectors" and Stay-Alives...

Continued…

If your locomotive does not have ANY form of socket, do not worry.

Just cut off the 8 pin plug, then simply follow the general wiring guides on Page 1 and hard-wire your decoder to your locomotive. Make sure that any joins in the wire are protected with fine heat-shrink (see pages 5+6)that will prevent short circuits that will inevitably cause damage to your decoders.

When hard-wiring your decoder it is best to trim all wires to the correct lengths, carefully strip, tin and trim to length before attaching. Work tidily and take your time!

It always seems a good idea to new DCC users… but don't! We do not recommend adding DCC sockets to locomotives that do not have them as it is unnecessary work and only adds to the potential for problems unless soldering skills are good.

It also needs a secure way to mount the socket, which takes a surprisingly large amount of room.

If you really, REALLY want to do it… there is an easier way. Many of our already have a separate harness with a plug-in socket at the decoder end, so the addition of a second socket really is unnecessary. (for example, take a look at the versatile ZN6H or ZN218).

Just cut off the loco-end plug and hard wire the harness in place, then plug it into the decoder! So - if you think about it - an additional connector is not needed! Common sense also says that hard-wiring a non DCC-ready loco will end up tidier and take less space, so why double up on the work?

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The DCCconcepts STAY - ALIVE™ and similar devices

What is a "Stay-Alive"?

"Stay-Alive" is the name used by DCCconcepts. They are also called "Current keeper", "Keep alive", Power pack" etc. by various decoder brands, in reality they are all similar types of devices designed to act as reserve power storage ready to act when your loco loses track power.

Are they all the same? No... there are both 3-wire and 2-wire types.

ESU and Lenz both make a 3-wire stay alive.

The device itself is slightly larger and much thicker than an average decoder. The 3 wires that come out of them are a ground wire, a main power wire for decoder motor drive and other circuits (sound and lighting) and a second power wire which only feeds the micro-processor of the decoder.

They can be difficult for the average modeller to install , as the 3 wires need soldering to 3 tiny solder pads on the decoder. Mistakes can be costly as, because you are soldering something to the PCB, there is NO warranty if you make a mistake. A bit of a catch-22 for the average modeller!

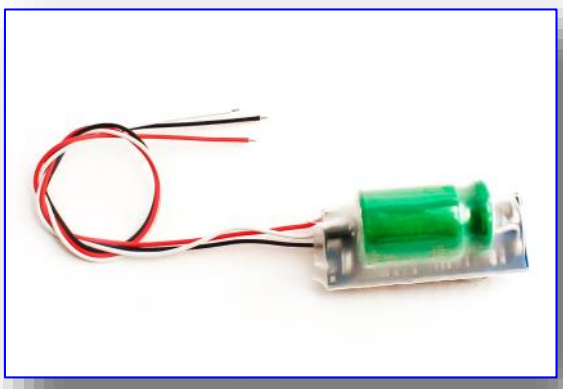
These are however the most sophisticated types and are as a result, very expensive. In both cases, the 3-wire stay-alive is actually MORE expensive than the high-end motor drive decoders sold by ESU and Lenz, so that sophistication has a very high cost indeed!

Do they work?

Yes, they do.

We often fit the ESU power Pack to ESU sound decoders that we install and it does work well, totally eliminating sound resets and preventing locomotive stalling.

However it DOES take care in installation, space can be hard to find especially in smaller locos and the cost is high… but they DO at least deliver what they promise.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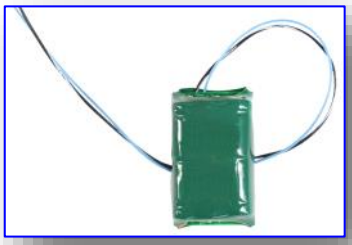
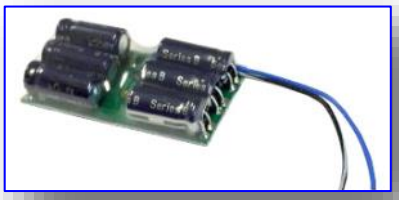
Decoder "Standard connectors" and Stay-Alives...

Continued…

Several Brands also make a 2-wire stay alive.

The two wires of this kind of stay-alive connect to the decoder PCB's "DC Negative" and the "Positive ground wire" which is the + DC terminal on the decoder-side of the rectifier.



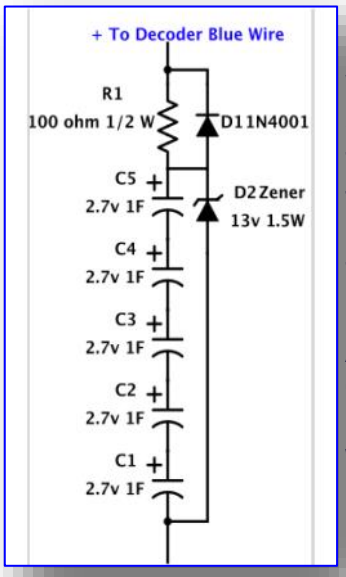


The + DC wire is easy as it is the same as the blue function common wire, however the DC - (negative) wire is harder… it must go to the anode of the two input diodes that are connected to the track input.

Get this wrong and you may end up with a dead decoder and of course, there will be no warranty, so be careful please.

Once you have it connected and the wires are in the right place… the "Stay-Alive" device is designed to store power ready for the moment that the locomotive fails to make good contact with the track.

When this happens, the decoder can draw on the stored power that is available in the "Stay-Alive" and keep operating properly.



There is a second, even MORE important thing Stay-Alives can do for running quality.

When a loco runs very slowly, you'll sometimes see that it starts to "cog" or stutter a little.

This is in part due to the cogging of the motor but this is not the whole story.

It is also in part due to constant "brown-outs" that turn the decoder on and off. This on-and-off power, in turn, makes the Back EMF reading inaccurate and creates tiny surges that are visible in the loco movement.

Adding a "Stay-Alive" will smooth this out, and adds greatly to the smoothness of locomotive running at slow speeds. We at DCCconcepts think that this "brownout prevention" is the biggest and best advantage of adding Stay-Alives.

What is a Stay-Alive made from?

Structurally, a Stay-Alive is formed of several parts all neatly arranged on a tiny PCB so that it takes up very little space and so there is always somewhere you can find to install it in all but the tiniest of locomotives.

The image above / at left shows a basic Stay-Alive circuit diagram. In this case, a number of 2.7v 1 farad "Super capacitors" are used in series to give it enough voltage tolerance to use on DCC.

By all means have a go at creating your own - but please DO be quite careful. If you do get it wrong, the electrolytic capacitors can explode quite suddenly and with nearly as much energy as a small bullet!

How long should a Stay-Alive power the locomotive?

Other brands make Stay-Alives that WILL run locos for a couple of seconds, however because they use super-capacitors, they ARE expensive - about the same price as the average Decoder.

DCCconcepts feel that cost matters to you, pickups should be adjusted properly and track wired properly, with live-frog points used everywhere to give best performance. For this reason we generally make our Stay-Alives with the primary purpose of eliminating brown-outs at slow speed. Therefore, the Stay-Alives we pack with our decoders use high end ceramic capacitors to keep the Stay-alive small and of course smooth our running beautifully, but they will only run the motor for fractions of a second.

HOWEVER - DCCconcepts DO listen to customers and for those who have asked us to also make a larger "Stay-Alive" there's good news - we have! Click here for the DCD-ZNSSA-1 !