

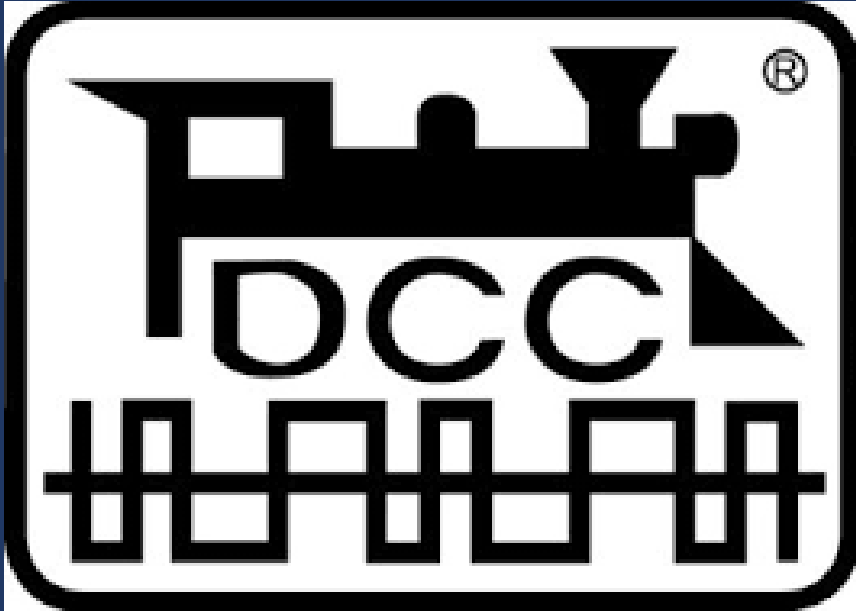


Understanding DCC

25th October 2023



1988: Lenz 2 rail digital control system



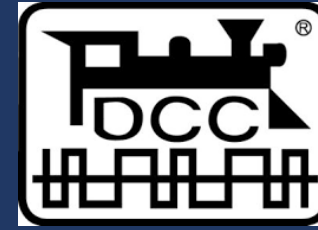
1993: NMRA announced new DCC format which was based upon the Lenz system.

The very first DCC control system was the Digitrax Challenger which was first shown that year.

1994-1996: Further enhancements were approved for the DCC standard.

NMRA : National Model Railroad Association ~ founded in the United States in 1935.

DC



Variable dc voltage to track.

One loco only controlable on each track or section.

Need to create isolated sections of track.

Dead frogs on points.

Not easy to add lighting.

Constant voltage to track.

Control as many locos as you wish at the same time.

All parts of the track remain live all of the time.

Live frogs on points.

Simple to add lighting.

DC

Dead frog

Insulfrog

Insulated frog

Unifrog

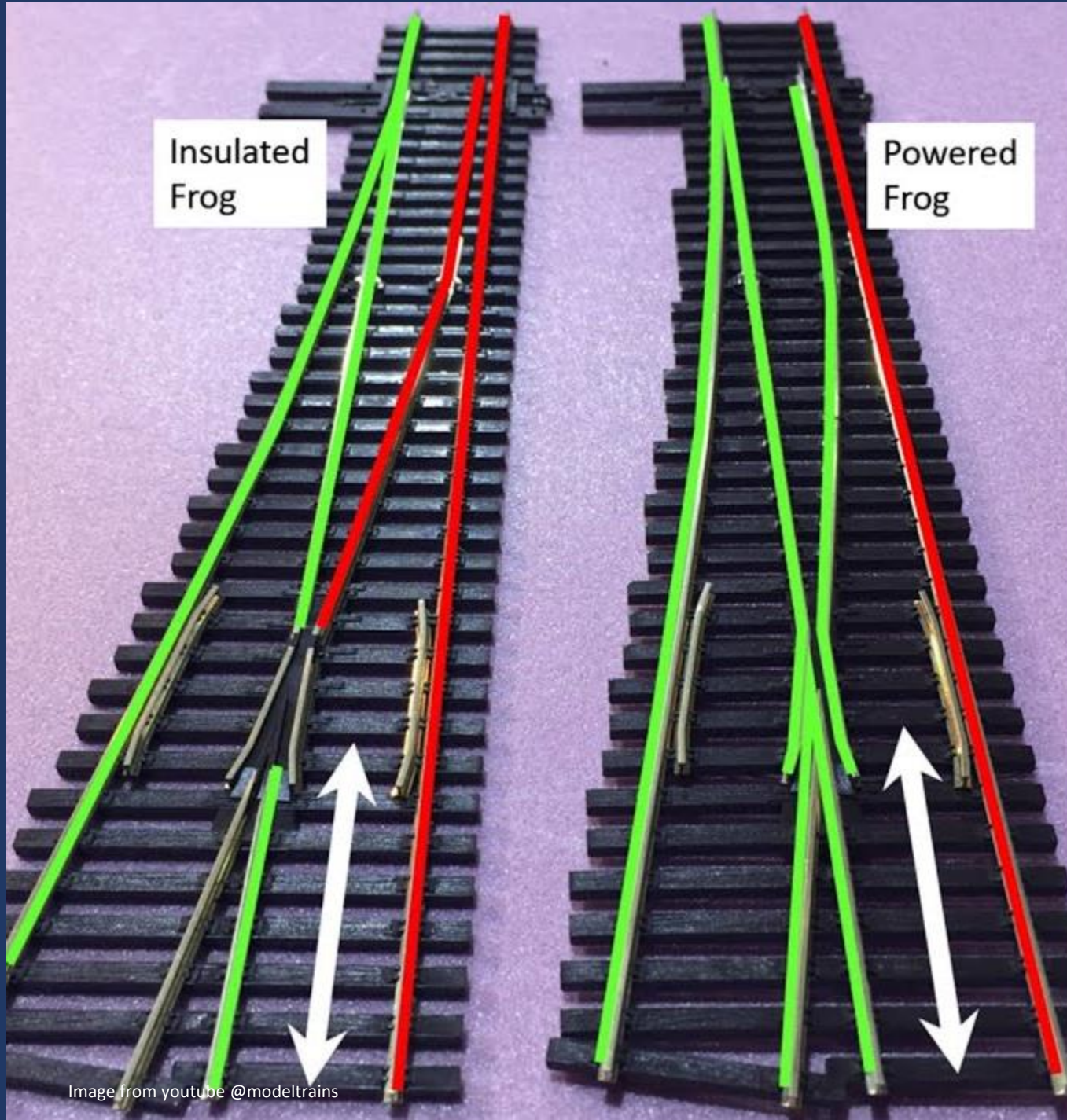
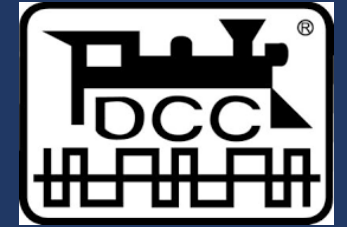


Image from youtube @modeltrains



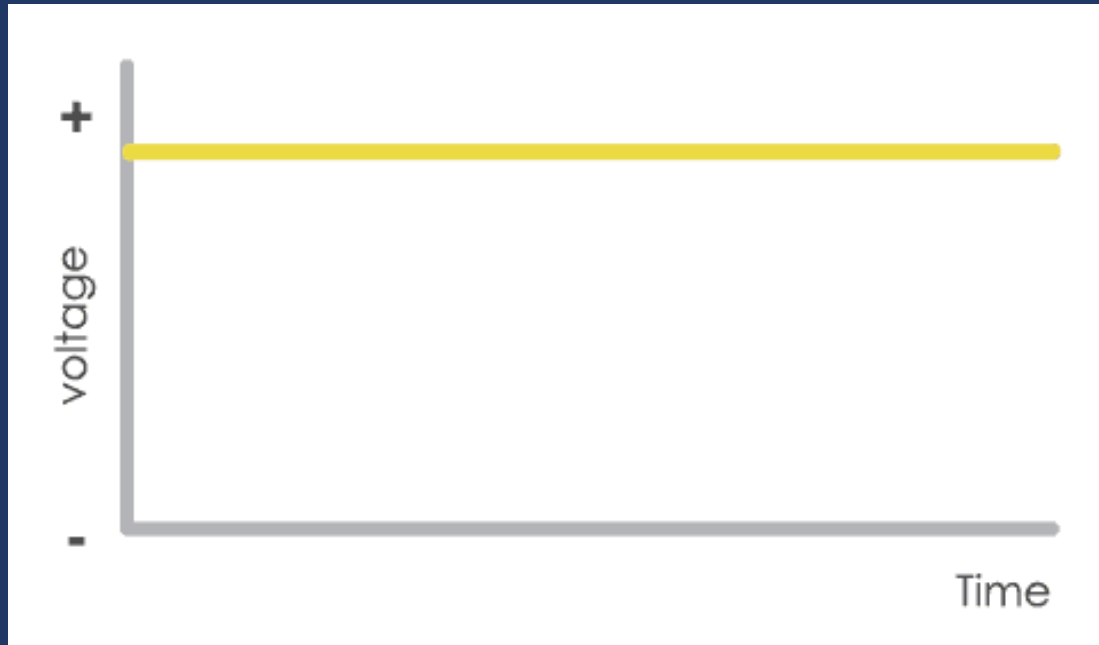
Live frog

Electrofrog

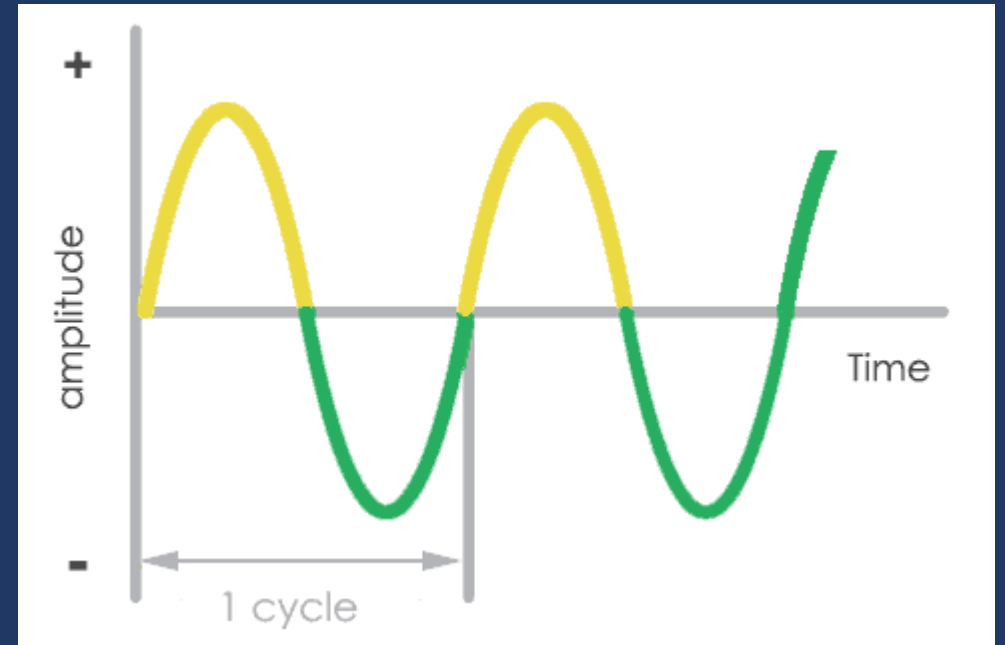
Powered frog

Unifrog

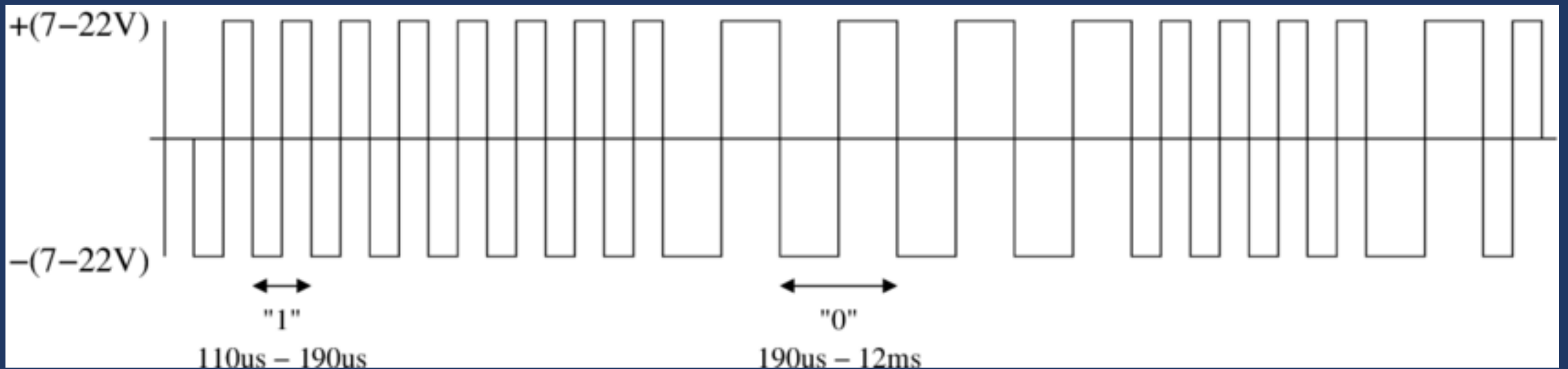
DC Power



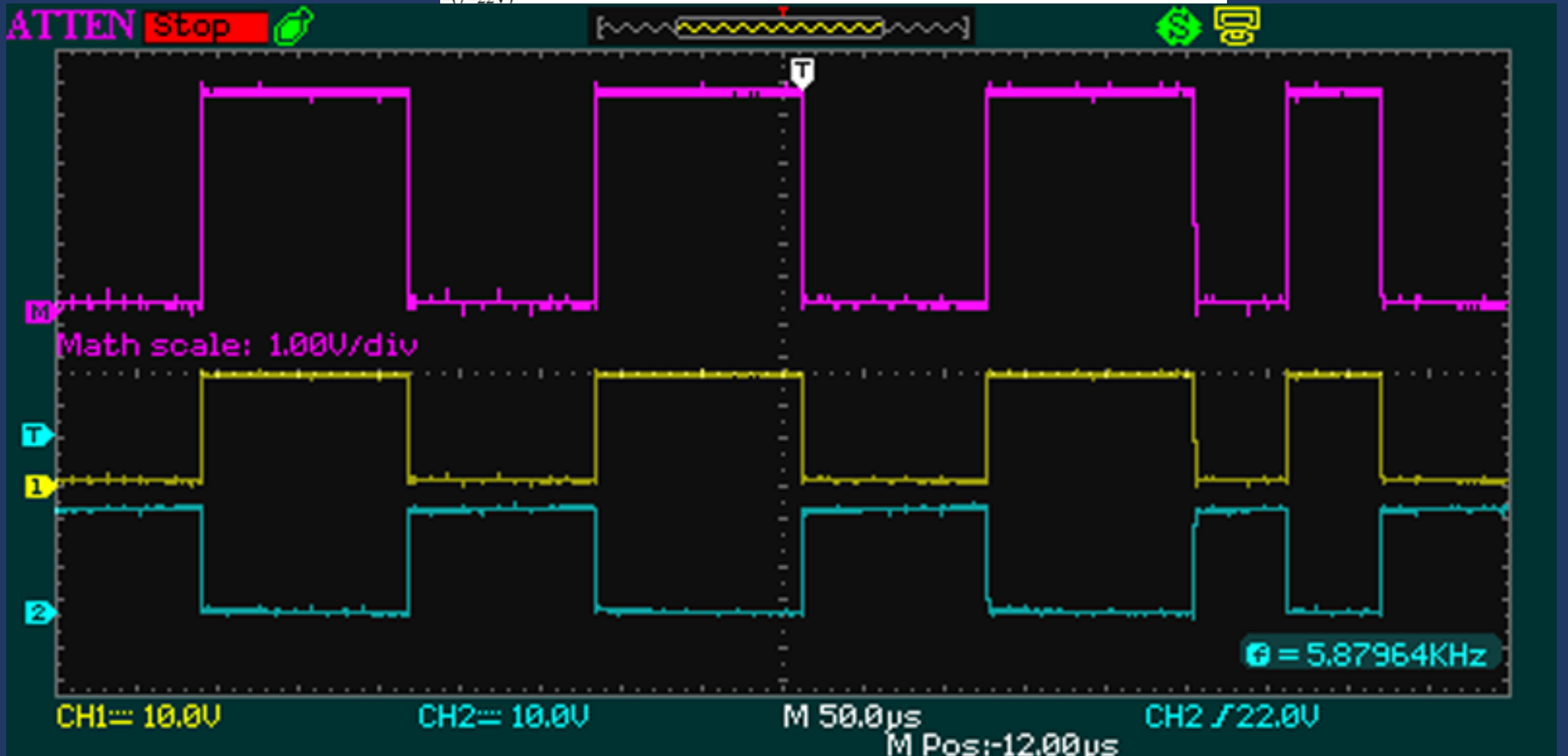
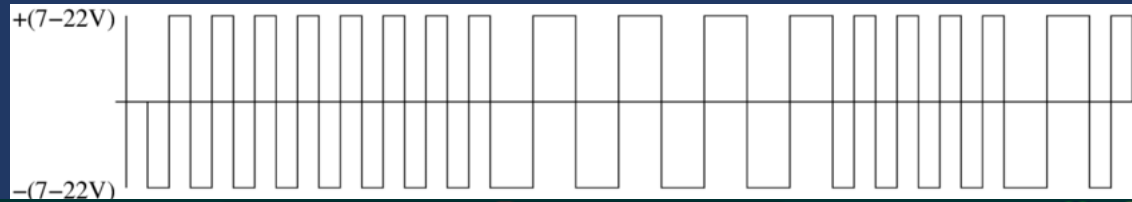
AC Power (uk 230v mains power @ 50 cycles per second)



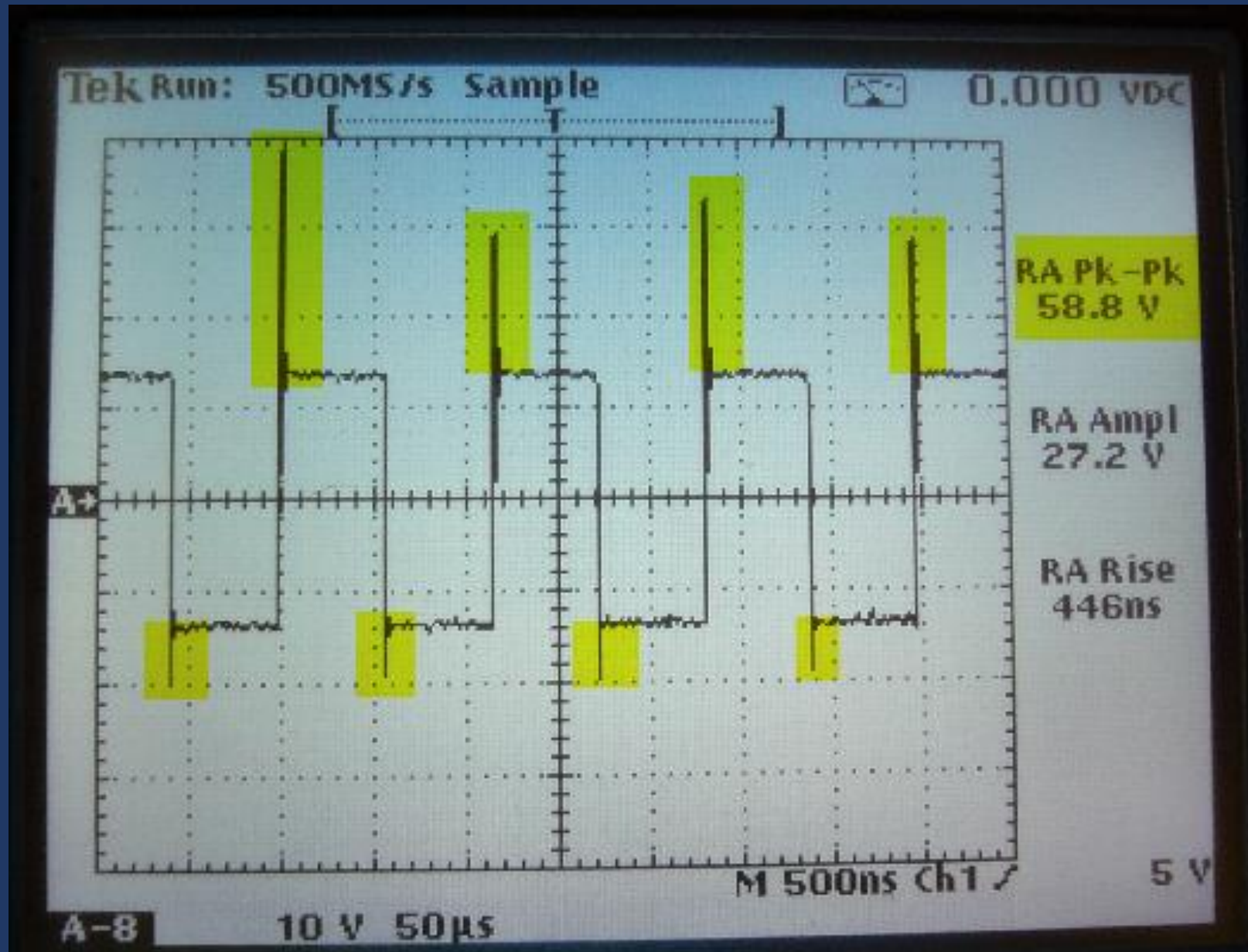
DCC Power: 6,000 to 9,000 pulses per second



DCC Power



Ringing

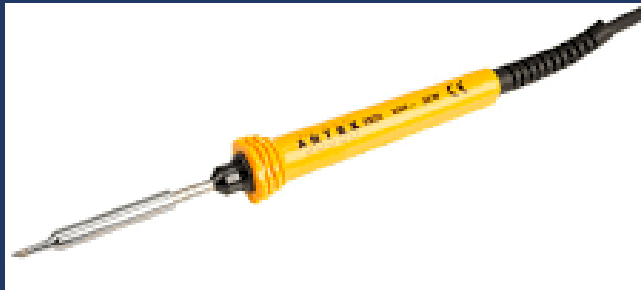


Restrict Ringing & Minimise Impedance



Bus Wire:

- > Use larger size cable for bus
- > Run bus wires close together
- > Solder joints wherever possible
- > Use connectors in preference to screw terminals



Remember this from school?

Denary (decimal) numbers

Base 10

98765432

Binary numbers

Base 2

10101010

Denary numbers

Base 10

98765432

Binary numbers

Base 2

10101010

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0
128	64	32	16	8	4	2	1

8-BIT

BINARY NUMBERS

7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1
128	64	32	16	8	4	2	1

$$\begin{array}{r} \mathbf{1101} \\ = \mathbf{13} \end{array}$$

7	6	5	4	3	2	1	0
0	0	1	1	0	1	1	0
128	64	32	16	8	4	2	1

$$\begin{array}{r} \mathbf{110110} \\ = \mathbf{54} \end{array}$$

7	6	5	4	3	2	1	0
1	1	1	1	1	1	1	1
128	64	32	16	8	4	2	1

$$\begin{array}{r} \mathbf{11111111} \\ = \mathbf{255} \end{array}$$



DCC CONTROLLER OR COMMAND STATION



DCC CONTROLLER OR COMMAND STATION



DCC DECODER FITTED TO LOCO



DCC CONTROLLER OR COMMAND STATION

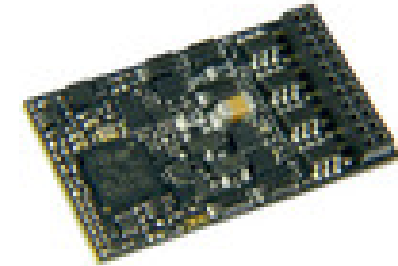
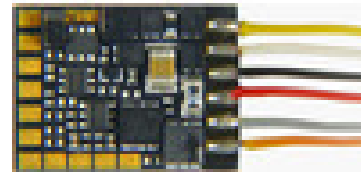
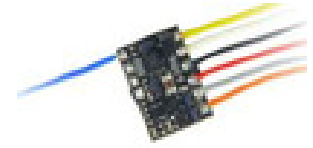
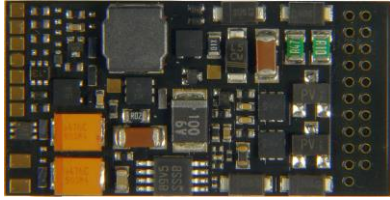


DCC DECODER FITTED TO LOCO



DC POWER TO DRIVE MOTOR OR LIGHTS ETC.

DECODERS



Decoders and Accessory Decoders

6-pin, 8-pin, 18-pin, 20-pin 21-pin, 22-pin and with wires.

Function outputs: 1, 2, 4, 6.

Some wired to pin outputs, some on solder pads.

Some with analogue outputs some with logic outputs.

All parameters in a DCC decoder are stored in **CONFIGURATION VARIABLES**

which we refer to as **CV**s

Each decoder can store up to 1024 CVs

However . . . some controllers can only program up to CV255

CV values are entered sometimes as decimal numbers in the range 0-255
but sometimes the decimal number is converted from binary so as to act as 8
'bit' switches.

Note that whilst the NMRA specifies the standard for DCC, the standard is quite limited in defining CVs.

Only CVs 1, 7, 8 & 29 are mandatory

CVs 2, 3, 4 & 11 are strongly recommended

All others are optional and can be deployed as decoder manufacturers choose.

CV8

Reading CV8 will return a number which relates to the manufacturer of that decoder.
You cannot change the value of CV8

**CV8 is also used to perform a factory reset of all CV values.
By writing a specific value to CV 8 the decoder will be reset
(but the value of CV8 will not change).**

CV8 = 8

**is the most common value used to perform a reset
BUT beware not all manufacturers are the same**

**eg for Lenz it's CV8=33, for AE, Lais, Dapol Imperium, Rails etc. it's CV8=4
and occasionally there are others used too.**

Plus some manufacturers offer different types of reset with other values.

Read the decoder manual if you aren't sure.

CV29

decoder configuration register

www.2mm.org.uk/articles/cv29%20calculator.htm

Insert Web Page

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Please enter the URL below.

`https://`

Note: Many popular websites allow secure access. Please click on the preview button to ensure the web page is accessible.

Setting the address

SHORT ADDRESS CV1

1 to 127 or sometimes only 1 to 99

or having remembered to set bit 5 of CV29 on (+32)

LONG ADDRESS CV17 & CV18

1 to 9999 or sometimes 0001 to 9999

Setting the address

SHORT ADDRESS = CV1 = 1 to 127

Setting the address

SHORT ADDRESS = CV1 = 1 to 127

LONG ADDRESS = CV17 & CV18 for example address 4705

First: convert 4705 to a 16 digit binary number = 0001001001100001

Split into half to make two 8 digit numbers = 00010010 + 01100001

Replace the first two digits of the first number with 11 = 11010010

Convert the first binary number to decimal to get CV17: 11010010 = 210

Convert the second binary number to decimal to get CV18: 01100001 = 97

or . . .

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Please enter the URL below.

Note: Many popular websites allow secure access. Please click on the preview button to ensure the web page is accessible.

For our Class 153 loco
let's set it to address **1531**



CV17 = 197

CV18 = 251

and

in CV29

Bit 5 on (+32)

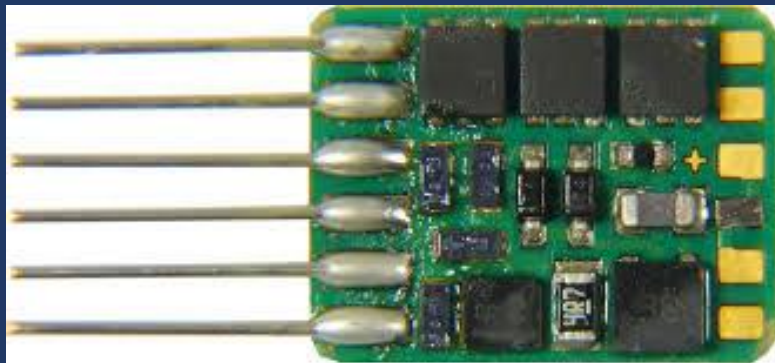
in this case it will be
CV29 = 43

Functions and loco lights etc.

Typically, a decoder will have 2, 4 or 6
'accessory outputs'

which can be used with **FUNCTIONS** to switch lighting
or other accessories

Some of these may be wired to pins and others may only be
used by direct wiring to solder pads.



NMRA Function Mapping

Function key on the cab	CV	Function outputs						Function outputs							
		14	13	12	11	10	9	8	7	6	5	4	3	2	1
F0 f	#33							7	6	5	4	3	2	1	0●
F0 r	#34							7	6	5	4	3	2	1●	0
F1	#35							7	6	5	4	3	2●	1	0
F2	#36							7	6	5	4	3●	2	1	0
F3	#37				7	6	5	4	3	2	1●	0			
F4	#38				7	6	5	4	3	●	1	0			
F5	#39				7	6	5	4	3●	2	1	0			
F6	#40				7	6	5	4●	3	2	1	0			
F7	#41	7	6	5	4	3	2●	1	0						
F8	#42	7	6	5	4	3●	2	1	0						
F9	#43	7	6	5	4●	3	2	1	0						
F10	#44	7	6	5●	4	3	2	1	0						
F11	#45	7	6●	5	4	3	2	1	0						
F12	#46	7●	6	5	4	3	2	1	0						

DEFAULT SETTINGS:

CV33 = 1 (F0f switches output 1)

CV34 = 2 (F0r switches output 2)

CV35 = 4 (F1 switches output 3)

CV36 = 8 (F2 switches output 4)

CV37 = 2 (F3 switches output 5)

CV38 = 4 (F4 switches output 6)

Also see options:

ZIMO alternative mapping (simpler)

SWISS mapping (much more complex)

Lenz decoders default to their own mapping table so read the manual.

Function Mapping

FOR EXAMPLE:

Dapol Class 153
(Next18 Decoder)

- Output 1 - front white lights
- Output 2 - front red lights
- Output 3 - rear white lights
- Output 4 - rear red lights
- Output 6 - coach lighting

- CV33 = 1 default
- CV34 = 2 default
- CV35 = 4 default
- CV36 = 8 default
- CV38 = 4 default

so

- F0f turns on front whites
- F0r turns on front reds
- F1 turns on rear whites
- F2 turns on rear reds
- F4 turns on coach lighting

BUT:

to operate in the same way as is usual on an 8 or 6 pin decoder with front and rear lights directional switching on F0

- CV33 = 9
- CV34 = 6
- CV35 = 32
- CV36 = 0
- CV38 = 0

then

- F0f turns on front whites and rear reds
- F0r turns on rear whites and front reds
- F1 turns on coach lighting

Function key on the cab	CV	Function outputs							
		8	7	6	5	4	3	2	1
F0 f	#33	7	6	5	4	3	2	1	0
F0 r	#34	7	6	5	4	3	2	1	0
F1	#35	7	6	5	4	3	2	1	0
F2	#36	7	6	5	4	3	2	1	0
F3	#37	4	3	2	1	0			
F4	#38	4	3		1	0			
F5	#39	4	3	2	1	0			
F6	#40	4	3	2	1	0			
F7	#41	1	0						
F8	#42	1	0						
F9	#43	1	0						
F10	#44	1	0						
F11	#45	1	0						
F12	#46	1	0						

Function Mapping

Function key on the cab	CV	Function outputs							
		8	7	6	5	4	3	2	1
F0f	#33	7	6	5	4	3	2	1	0●
F0r	#34	7	6	5	4	3	2	1●	0
F1	#35	7	6	5	4	3	2●	1	0
F2	#36	7	6	5	4	3●	2	1	0
F3	#37	4	3	2	1●	0			
F4	#38	4	3	●	1	0			
F5	#39	4	3●	2	1	0			
F6	#40	4●	3	2	1	0			
F7	#41	1	0						
F8	#42	1	0						
F9	#43	1	0						
F10	#44	1	0						
F11	#45	1	0						
F12	#46	1	0						

FOR EXAMPLE:

Dapol Class 153
(Next18 Decoder)

- Output 1 - front white lights
- Output 2 - front red lights
- Output 3 - rear white lights
- Output 4 - rear red lights
- Output 6 - coach lighting

CV33 = 9

CV34 = 6

CV35 = 32

CV36 = 0

CV37 = 0

F0f turns on front whites
and rear reds

F0r turns on rear whites
and front reds

F1 turns on coach lighting

HOWEVER,

This is a ZIMO decoder
(and the same applies to Lenz and
some other decoders)
which means that
FUNCTION OUTPUT 5 & 6
on the decoder are set up to
output a SUSI signal
instead of 12v dc.

SUSI =

Serial User Standard Interface

To disable SUSI and change the
output to 12v dc:

CV124 = 128

Function Mapping

FOR EXAMPLE:

Dapol Class 153
(Next18 Decoder)

- Output 1 - front white lights
- Output 2 - front red lights
- Output 3 - rear white lights
- Output 4 - rear red lights
- Output 6 - coach lighting

- CV33 = 1 default
- CV34 = 2 default
- CV35 = 4 default
- CV36 = 8 default
- CV38 = 24 default

so

- F0f turns on front whites
- F0r turns on front reds
- F1 turns on rear whites
- F2 turns on rear reds
- F4 turns on coach lighting

BUT:

to operate in the same way as is usual on an 8 or 6 pin decoder with front and rear lights directional switching on F0

- CV33 = 9
- CV34 = 6
- CV35 = 32
- CV36 = 0
- CV38 = 0

then

- F0f turns on front whites and rear reds
- F0r turns on rear whites and front reds
- F1 turns on coach lighting

Function key on the cab	CV	Function outputs							
		8	7	6	5	4	3	2	1
F0f	#33	7	6	5	4	3	2	1	0●
F0r	#34	7	6	5	4	3	2	1●	0
F1	#35	7	6	5	4	3	2●	1	0
F2	#36	7	6	5	4	3●	2	1	0
F3	#37	4	3	2	1●	0			
F4	#38	4	3	●	1	0			
F5	#39	4	3●	2	1	0			
F6	#40	4●	3	2	1	0			
F7	#41	1	0						
F8	#42	1	0						
F9	#43	1	0						
F10	#44	1	0						
F11	#45	1	0						
F12	#46	1	0						



MOTOR CONTROLS

BEMF

Back EMF

Back Electro-Motive Force

CV controls for BEMF vary amongst decoder manufacturers

For example, with ZIMO

CV9 = 55 & CV56 = 55

default medium sampling for standard 00 Gauge 12v motor

for a N Gauge standard motor this might be better at

CV9 = 95 & CV56 = 55

for an O Gauge coreless motor this will be better at

CV9 = 11 & CV56 = 111

MOTOR CONTROLS

CV2 : start up speed step

CV5 : maximum speed step

CV6 : mid point speed step

CV3 : rate of acceleration

CV4 : rate of deceleration

Speed Curves

Remember in CV29 we have set:
bit 1 on (+2) for 128 speed steps
bit 4 off (0) to NOT set complex curves

**This means that our speed curve is created automatically
over 128 steps by setting**

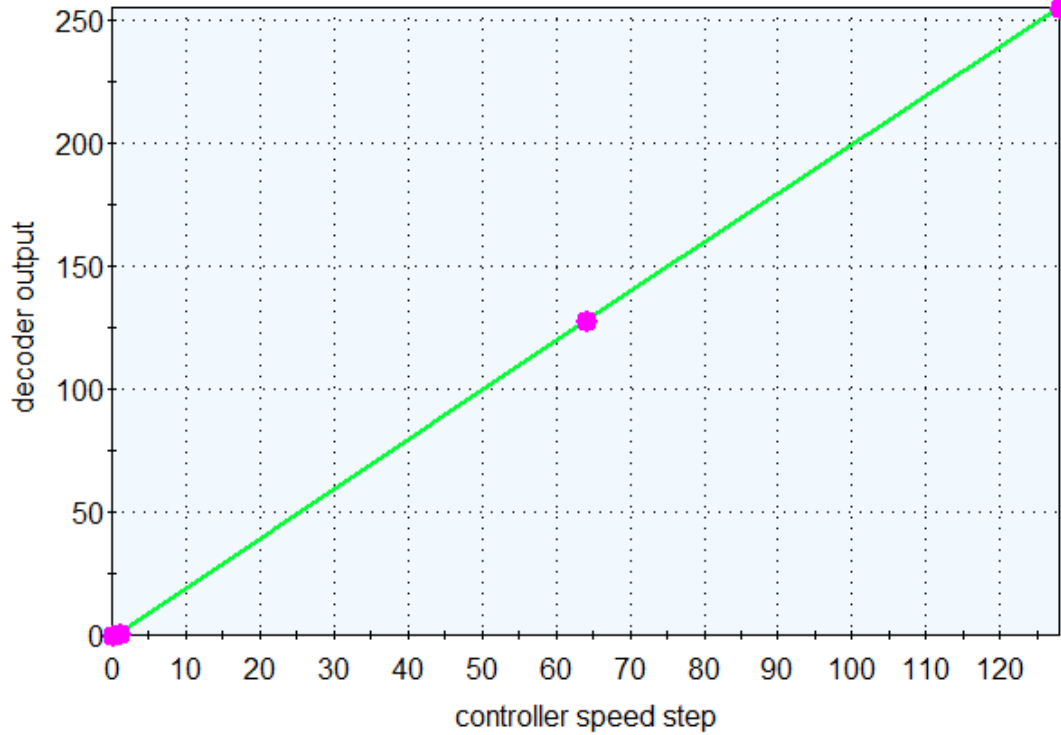
a start point = CV2

a mid point = CV6

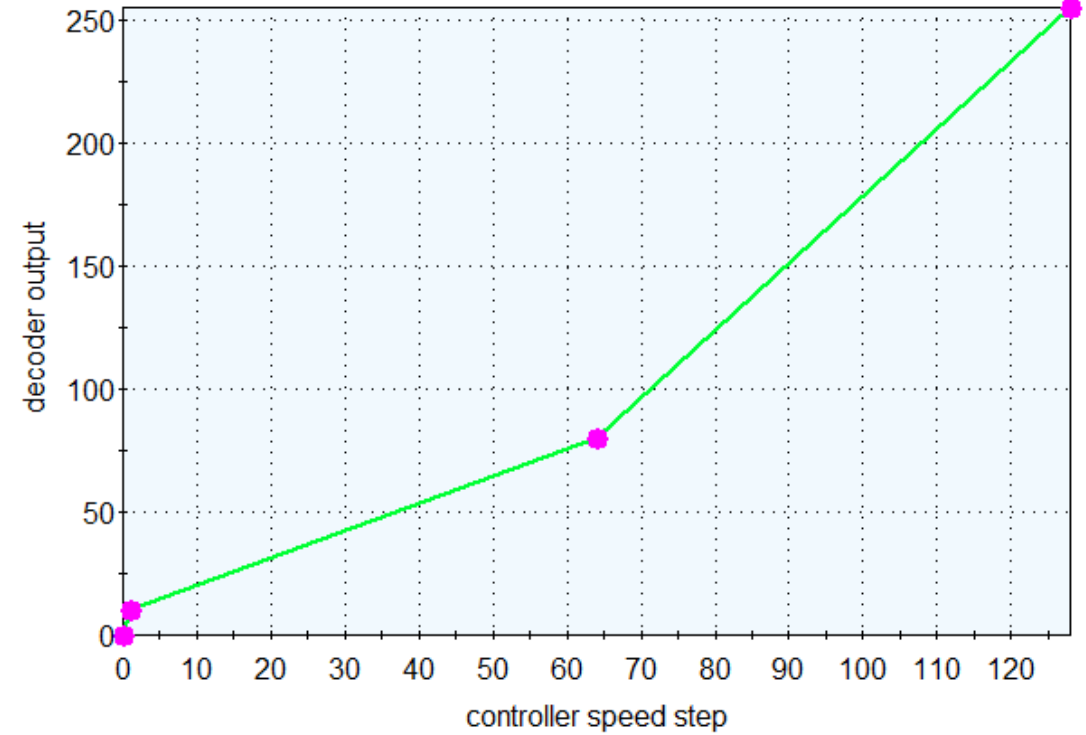
a top speed = CV5

Speed Curves

like this:

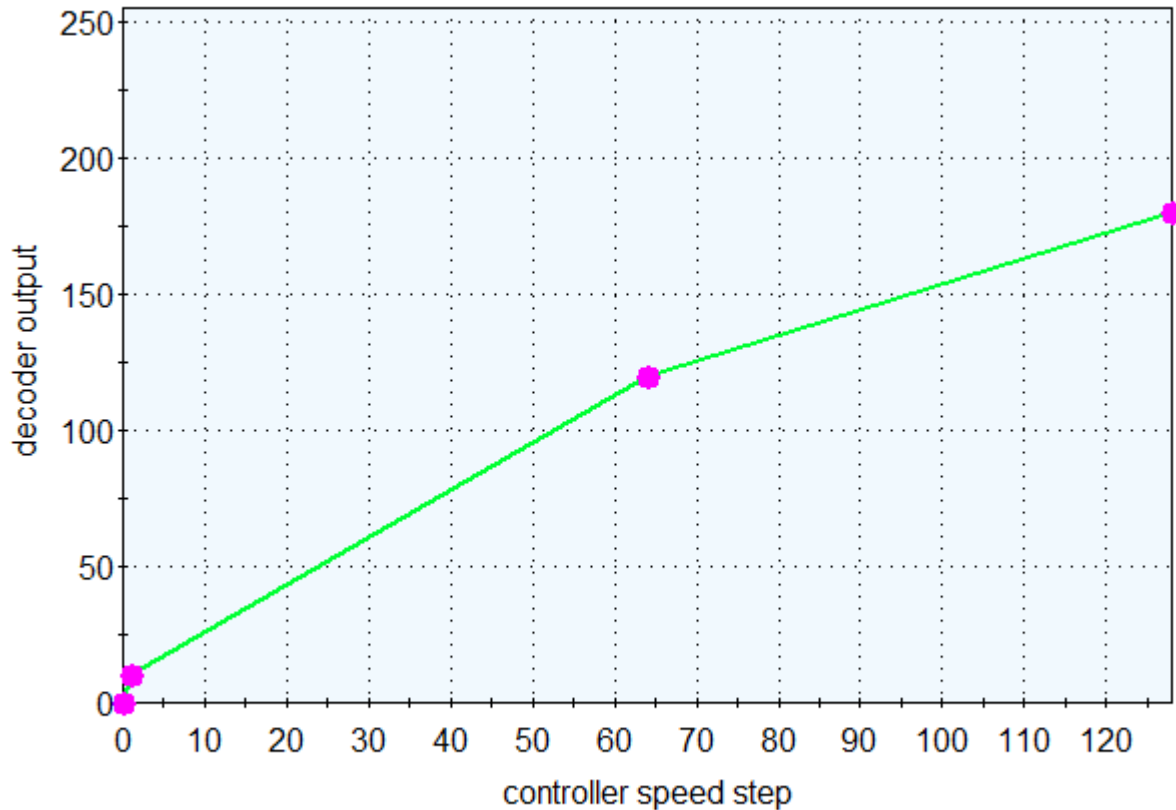


or



Speed Curves

or

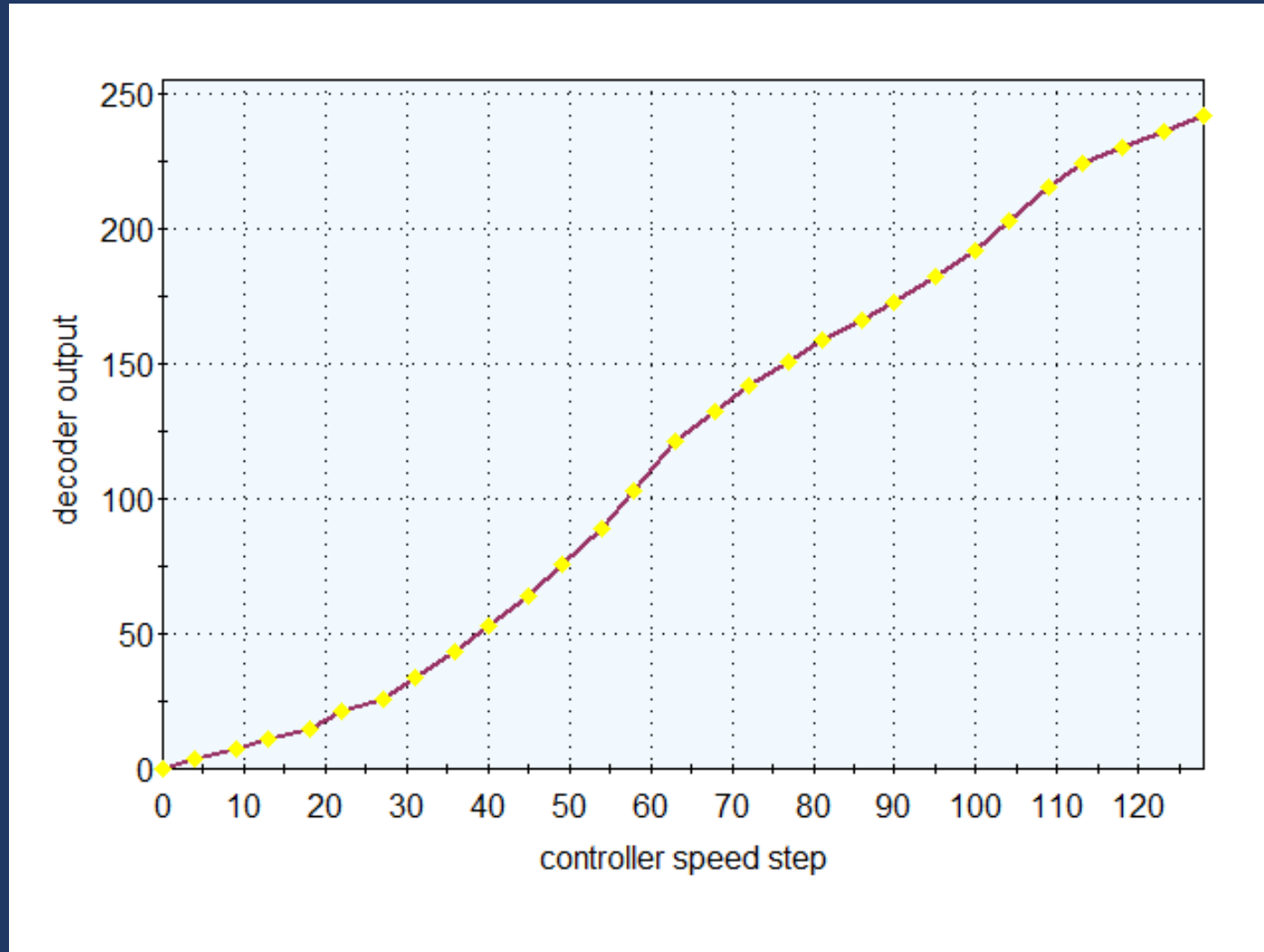


Where the top speed has been reduced to CV5 = 180

In this case the mid-point CV60 has been set at 120 which is two thirds of the top speed – a good starting point.

Speed Curves

Or you can create your own 'complex' speed curve of 28 steps in CV67 to CV94
Remembering to set bit 4 of CV29 on (+16) – CVs 2, 5 & 6 will then be ignored



CV2

**Sets the startup voltage output at speed step 1
described as Vstart
(on a scale of 1-255)**

The default is usually CV2 = 1

**If that works fine there's no need to change it.
If the loco needs a bit more power to pull away
try changing up a little to CV2 = 5
and then adjust up or down as required**

CV5

Sets the maximum voltage output at full speed described as V_{high} (on a scale of 1-255)

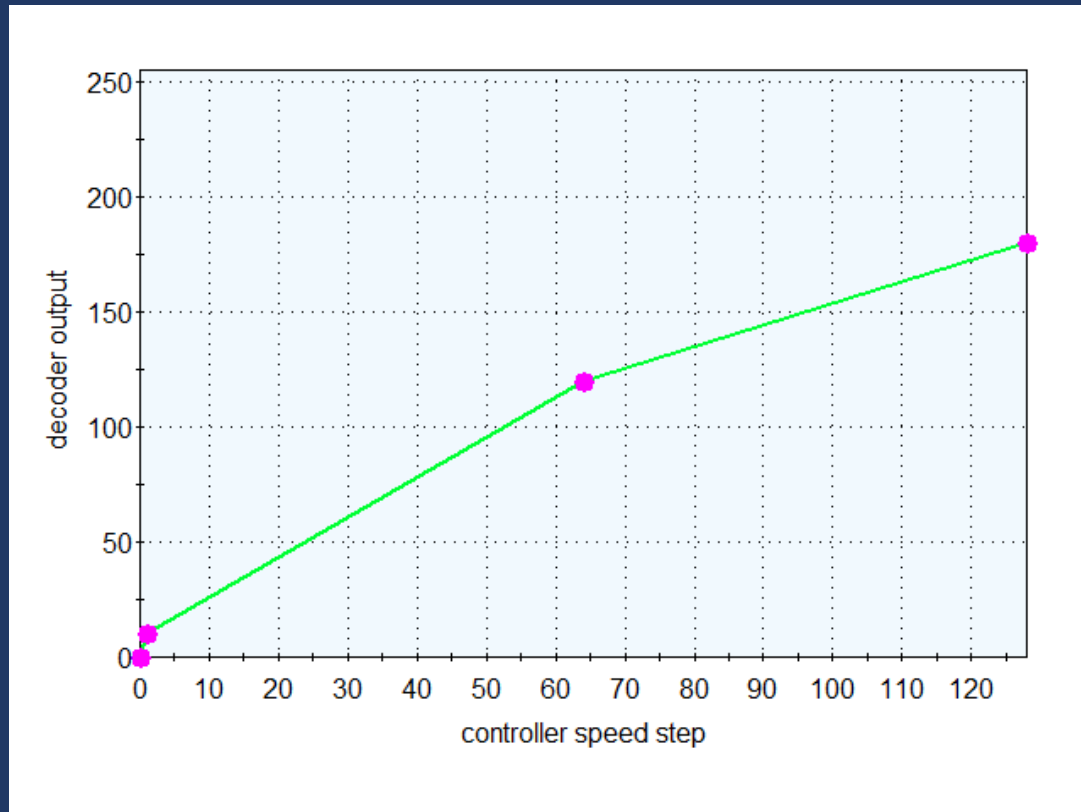
The default is usually $CV5 = 255$ (or 1 which = 255)

You'll probably want to adjust this to set a realistic maximum scale speed.

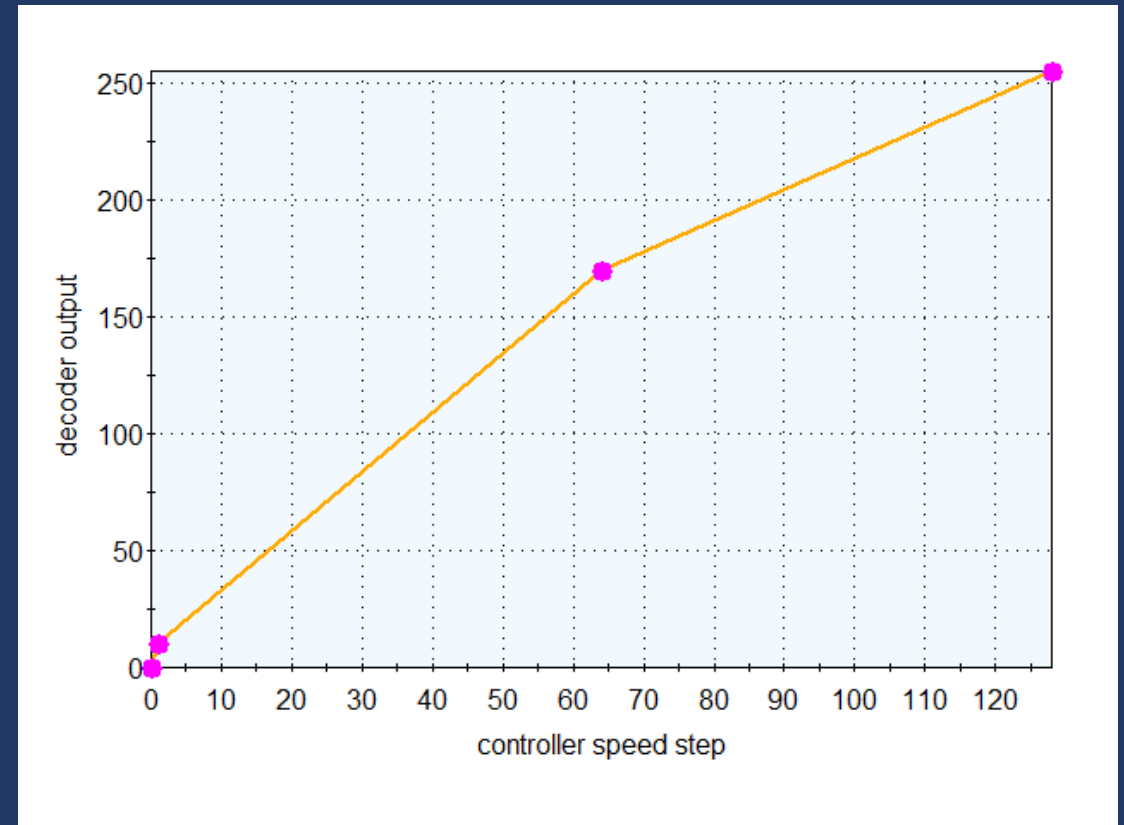
If you have a Zimo decoder then there's another, better, way of doing this using CV57 which limits the voltage output to the motor.

Speed Curves

Reducing CV5 to lower top speed



Or the same result with a Zimo decoder but reducing the value of CV57 instead of CV5



Speed Calibtation

You can reduce the top speed by reducing the value of CV5
start by trying a value of 180
then adjust up or down using trial and error.

If you have a Zimo decoder you can reduce the maximum voltage applied to the motor using CV57 instead.

This has the advantage that it retains the range of 0-255 on the output side of the speed curve.

To work out what is a realistic scale speed see this helpful calculator at
www.modelbuildings.org/scale-speed-calculator

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CV6

**Sets the mid curve voltage output
described as Vmid
(on a scale of 1-255)**

The default may vary between different decoders.

**Perhaps start by setting this to a value of
two thirds of the value of CV5.**

(Some default settings are less than this.)

Then adjust up or down as you wish.

CV3

Sets the rate of acceleration

most work within a range of 1 – 255
but this can vary so check the decoder manual

e.g. with Zimo it is 1-255 where the value $\times 0.9$
is the seconds it will take to accelerate from stop to max speed
i.e. CV3=15 will take 13.5 seconds to accelerate from stop to full speed

with Lokommander II the range is 0 - 63

The default value is usually low (2 in Zimo)
but this will be different in a sound decoder.

CV4

Sets the rate of deceleration

This works in the same way as CV3 but for slowing down.

The default is usually low (1 in Zimo) but this will be different in a sound decoder or if “Active Braking” has been activated.

(NB Active braking is not available in all decoders)

Other common configurations:

“ACTIVE BRAKING”

This is where a Function Key, usually F2, is used to increase the rate of deceleration or braking. Often used with sound decoders.

It is only available on some decoders.

The rate of deceleration or braking is set in CV4 to a fairly long period.

Then in CV349 a much shorter braking period is set.

For example: CV4 = 20 and CV349 = 6

So, when the loco receives the command to stop from the controller it will take around 18 seconds to come to a halt. But if the operator presses the F2 button that stop time will reduce to around 5 seconds.

The F2 button or any other Function key is set in CV 309

Other common configurations:

“Consist” where two locos are coupled and operate together.



Essentially set up using CV19 to enter consist address but other methods and additional configurations (how functions are controlled etc.) may apply with different decoders.

Some DCC controllers also offer a means of setting up and controlling a consist.

Other common configurations:

“SHUNTING MODE”

When a specific Function Key is activated the loco goes into shunting mode.

It is only available on some decoders.

The maximum speed available is reduced to 50%

Acceleration and deceleration rates (set in CV3 and CV4) are typically reduced by 75% or can be set to zero

CV124 is the main CV for enabling this mode with CV155, CV156 & CV157 used to set up parameters including which Function Key will be used to activate it.

Sound decoders may already have this configured as part of the sound project.

**There are many things you can do with DCC
even before you start to consider sound.**

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**Read the instruction manual for your decoder.
Not all decoders are the same.**

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When buying a new loco buy “DCC Ready” and fit a decoder of your own choice.

If you buy “DCC Fitted” the decoder supplied may not do everything you want it to.

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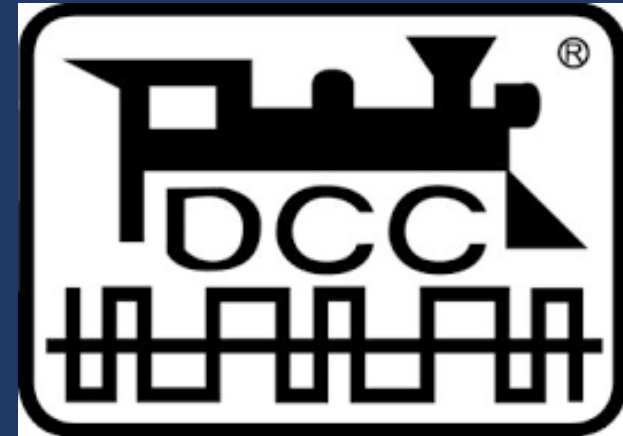
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If you buy “DCC Fitted” the decoder supplied may not do everything you want it to.

Some decoders work better ‘out of the box’ than others and will require less setting up time.

Enjoy using DCC

and if you just want to set an address and use it with its default configuration that’s fine too.



www.sidmouthmrg.com