



TCS Comprehensive Programming Guide

2014

(Revised 6/5/2014)

Decoder Configuration with CV 29 and CV 61	Page 2
BEMF Type and Keep-Alive™ Enabling using CV 182	Page 3
Decoder Addressing	Page 4
Decoder Lock, Version Number, and Date Codes	Page 5
Lighting Features and Programming	Page 6
Random Flicker and Constant Dim	Page 8
Ditch Lights	Page 9
Mars, Gyra, and Rotary Beacon Adjustment	Page 10
Strobes and Flashers	Page 11
Rule 17 Dimming	Page 12
Consist and DC Lighting Control	Page 13
Function Remapping	Page 14
BEMF	Page 15
Button Control of Motor and Dither	Page 17
Button Control of Braking and Trolley Features	Page 18
Motor Trim	Page 19
Momentum (Acceleration and Deceleration)	Page 20
Variable Momentum or 3-Point Momentum	Page 21
3-Point Speed Curves	Page 22
User Loadable Speed Tables	Page 23
Quick Presets	Page 24

Train Control Systems
Phone: 215-453-9145
Email: tcs@tcsdcc.com
URL: www.tcsdcc.com

Configuration CV's 29 and 61

Decoder Configuration: CV 29

CV 29 Configuration

	Value	Features
A	1	Reverse the direction the engine runs.
B	2	Use 28/128 speed step mode.
C	4	Enable analog (DC) operation.
D	16	Make the User Loadable Speed Tables active.
E	32	Make the decoder address 128 or higher. (Four-Digit Addressing)
CV 29		Program the sum of the value you choose into CV 29

CV 29 Configuration:

CV 29 is the primary configuration CV in all DCC decoders and can be used to make basic setting changes. To set-up CV 29 select the features from above that you want to use and tally up the corresponding values. For instance, if you would like to use 28/128 speed step mode, User Loadable Speed Tables, and Four Digit Addressing you would select the corresponding values of: 2, 16, and 32, and add them together. Take the sum: $2 + 16 + 32 = 50$ and program that sum (50) into CV 29.

Decoder Configuration: CV 61

	Value	Features
A	(1)	Enable BEMF
B	2	Enable Button Controlled BEMF
C	8	Button Control of Braking (Trolley)
D	16	Headlights Dim When Stopped (Rule 17 enabled)
E	32	Opposite Headlight Dim
F	64	Manual Button Control of Motor
G	68	Automatic Button Control of Motor
H	128	Button Control of Brake Lights (Trolley)
CV 61		Program the sum of the values you choose in CV 61

CV 61 Configuration:

CV 61 is used to configure a host of features including BEMF, Light Dimming and Button control of features. You will see references to CV 61 throughout this manual. Use the above table to assist in determining the value of CV 61 that gives you the features desired. Each of these features is better explained in the following chapters.

BEMF Type and Keep-Alive™ Enabling: CV 182

CV 182 Configuration:

CV 182 not only enable Keep-Alive™ with TCS decoders that are Keep-Alive™ ready, it also determines the type of BEMF in your decoder. Use the table below to determine which setting is right for you. The DEFAULT value for CV 182 is 2 which enables Keep-Alive™ and uses the standard Automatic BEMF settings.

Note: When Keep-Alive™ is enabled using CV 182 the “Stop on DC” feature is disabled to keep the loco from running away when the decoder sees the DC from the Keep-Alive™ on a bad piece of track.

	Value	CV 182 Features (BEMF and Keep-Alive™)
A	0	Automatic BEMF - Stop on DC Enabled (No Keep-Alive™).
B	1	Special BEMF setting for 3-Pole Motors
C	(2)	Automatic BEMF - Stop on DC Disabled - Enable Keep-Alive™ with Keep-Alive™ ready decoders. (DEFAULT)
CV 182		Program the sum of the values you choose into CV 182

NOTE: CV 182 is set to a value of 2 in all WOWSound decoders and is not adjustable.

Decoder Addressing

2-Digit Address

2-Digit Address	CV 1
-----------------	------

2-Digit Addresses (any address between 1-127) are the base address for the decoder. All decoders ship from the factory with a base address of 3 which is programmed into CV 1. To modify this address simply program CV 1 to a different value between 1-127.

NOTE: CV 1 cannot be programmed in OPS mode (programming on the main line) and is the ONLY CV which cannot be modified in OPS mode.

4-Digit Address

4-Digit Address (High Byte)	CV 17
4-Digit Address (Low Byte)	CV 18
Enable 4-Digit Address	CV 29

4-Digit Addressing (addresses between 128-9999) are used frequently as they allow the user to address the decoder with the locomotive number. Calculating the values to put in CV 17 and CV 18 is a bit daunting for most users so TCS provides a 4-Digit Address calculator on it's website under the DCC Tools section. This allows you to simply enter the address you wish to use and have the calculator return the corresponding CV 17 and 18 values.

NOTE: Most DCC Systems today will make these calculations automatically when Programming the 4-Digit Address.

Once the derived values have been programmed, enable the 4-Digit Address by adding a value of 32 to CV 29. CV 29 has a default value of 6, so to enable the 4-Digit Address just add a value of 32 and program the resulting value of 38 into CV 29

Consist Address

Consist Address	CV 19
-----------------	-------

Consist Addressing is similar to 2-Digit Addressing in that it can accept values from 1-128. However, Consist Addressing differs in that it allows for a second address to be applied to a decoder specifically for use when the locomotive is being operated in a Consist or "MU" train. The second differing feature of the Consist Address is that if you add a value of 128 to whatever address you plan to use the locomotives forward and reverse will be swapped. This allows for consists that have locomotives running back to back.

For example, if you are setting up a 2 unit Consist with the address of 12 and an "A" unit travelling in the normal directions and a "B" unit running reversed you would program a value of 12 into CV 19 on the "A" unit and a value of 140 into CV 19 on the "B" unit.

Decoder Lock, Version Number, and Date Codes

Decoder Lock

Unlocked Decoder	CV 15
Decoder Lock Number	CV 16

CV 15	All Unlocked = 0	Decoder to unlock = 1 - 6	All locked = 7			
CV 16	Mobile = 1	Sound = 2	Light Only = 3	User Defined = 4	User Defined = 5	User Defined = 6

Decoder Lock is used when a locomotive has 2 or more decoders in it. By default both decoders in the locomotive will be programmed together when placed on the programming track. This can cause problems as you try to set up different features on each decoder. To compensate for that the NMRA has created the feature known as “Decoder Lock” which is implemented here.

CV 16 is used to store a key number. This number typically is: 1 for motor and light decoder, 2 for sound decoders, and 3 for lighting only decoders. However, if you would like to have more than one decoder of the same type (motor and light, sound, or lighting only) the CV 16 value can be modified to a value between 1 and 6. NOTE: all modifications to CV 16 should be done before installing the decoders to avoid rewriting CV 16 on all of the decoders.

With the CV 16 values defined you are ready to lock and unlock each decoder. To unlock a decoder simply put the locomotive on the programming track and program CV 15 to whatever value the decoder you want to program has in CV 16. For instance if you have a locomotive with a lighting only decoder (CV 16 = 3) and a motor decoder (CV 16 = 1) you would program a value of 1 into CV 15 to lock the lighting only decoder and ready the motor decoder for programming. To switch to programming the lighting only decoder simply program a value of 3 into CV 15. Decoder Lock only effects programming, and so the values in CV 15 and 16 are not important for running your locomotive. Values of 0 and 7 are reserved for: all unlocked (0) and all locked (7).

Version Number

Version Number	CV 7
----------------	------

When major bug fixes or upgrades are done to the software in the decoder the version number is updated. For troubleshooting tech support representatives at TCS may ask for the version number which can be read out of CV 7.

Date Code

Month Programmed	CV 250
Day Programmed	CV 251
Year Programmed	CV 252

Each decoder that is programmed has the date it is programmed stored in CV’s 250, 251, and 252. If you contact TCS with a software related glitch or concern reading out the date code can help us identify when your decoder was made and more succinctly diagnose the problem.

Lighting Effects

An overview of each

Constant Bright: Full bright lighting effect, common for headlights and reverse lights this feature produces a no-frills, on/off only light.

Constant Dim: Much like the constant bright, the constant dim can be turned on/off but does not pulse, blink, flicker, or otherwise change brightness during operation. With one CV for adjusting, lights operated by the constant dim effect will remain at a brightness from completely to dim to full bright based on the setting used.

Random Flicker (fire box): Accurately capturing the flicker of flames from a lit fire box or other burning light source, the random flicker effect creates a warm, organic flame pattern.

Mars Light: Implemented as a signal-safety light the original “Mars Light” rotated the lighting module in a figure 8 pattern creating a distinctly recognizable pulsing pattern that alerted everyone to oncoming/outgoing locomotives. Due to the figure 8 pattern the resulting light would pulse in a: “dim-dim-bright” configuration which has been accurately replicated with this lighting feature.

Flashing Light: This lighting feature simply turns on and off the light function for adjustable durations of time in a loop. Typically it is on for close to a half second, off for the same amount of time and right back to on again. Similar to the flashing “road-work” lights this lighting feature finds its way into many stationary applications.

Single Pulse Strobe: A simple on/off strobing effect, the single pulse strobe spends 75%-80% of its light cycle off and only flashes at full brightness for the last portion of second in its light cycle. Perfect for a F.R.E.D. or any other simple strobe device where a regular, short blink is required.

Double Pulse Strobe: The double pulse strobe takes the same basic on/off blink approach of the single pulse strobe, but adds a second bright flash to every cycle. The blink pattern appears as: “bright-bright-dim” where each “bright” is a separate flash of its own.

Rotary Beacon: Use a safety-signal light the rotary beacon is typically on the top of a locomotive and is used to raise awareness in 360 degrees. By rotating in a full circle this light ramps from 50% brightness to full brightness and back again in a steady even pattern.

Gyra Light: Similar to the rotary beacon the Gyra light also pulses back and forth from two points though with the Gyra it is typically from full bright to fully off. Gyra lights can still be found today on commuter trains typically right at the top of the front and rear. This lighting feature makes a perfect addition to a passenger train layout.

Rule 17: While Rule 17 dimming is not one specific lighting feature, it is a series of train guidelines for handling lights in various operational states (stopped, moving forward, and moving reverse). These feature can be set to dim the light when the locomotive stops or to dim the opposing light when travelling down the rails. This means that if the train is heading forward the headlight will be on, and the reverse light will be dim (dim, not off). When the locomotive changes direction so to the reverse light will become bright and the forward light will go dim.

Ditch Lights: Ditch lights project from the left and right side of a locomotive on the front end and are used both to provide light and to alert others to the presence of a train. During typical operation both the left and the right ditch light will be full bright when travelling down the rails and blink in an alternating, fading patten when passing over a road or other potentially occupied area. When utilized, this feature will allow your ditch lights to remain on at full brightness until a function button is pressed which begins the alternating pulse cycle.

Auto-Mars Light: This lighting feature will remain at full brightness until the locomotive is decelerating below 36% speed at which point it will switch to the mars light pattern. When the locomotive accelerates over 36% speed it will again return to a full brightness light.

Brake Lights: Operating much like the brake lights on cars, the brake light function is ideal for trolleys. With the brake light feature enabled whenever the locomotive is slowing, or the brake is applied the light function will illuminate.

Lighting Effects and Functions

Setting up a light function

Lighting Feature*

	fwd	rev	both
Constant Bright Light	0	16	32
Mars Light	2	18	34
Flashing Light	3	19	35
Gyra Light	7	23	39
Rule 17 Dimmable	8	24	40
Ditch Light (Left or Right)	10	26	42
Ditch Light (Other Side)	11	27	43
Auto-Mars	13	29	45
Single Pulse Strobe 1	4	20	36
Single Pulse Strobe 2	15	31	47
Double Pulse Strobe 1	5	21	37
Double Pulse Strobe 2	64	80	96
Constant dim 1	12	28	44
Constant dim 2	66	82	98
Constant dim 3	67	83	99
Constant dim 4	68	84	100
Random Flicker 1	1	17	33
Random Flicker 2	65	81	97
Rotary Beacon	6	22	38
Brake Lights	14	30	46

Lighting Function**

CV 49	F0F	White Wire	
CV 50	F0R	Yellow Wire	
CV 51	F1	Green Wire	
CV 52	F2	Purple Wire	
CV 53	F3	Brown Wire	
CV 54	F4	Pink Wire	
CV 55	F5	Pink/Purple	
CV 58	F6	Green/Brown	

* All new TCS decoders (with light functions) will include all of the light features listed. Lighting features are not included or removed based on price ranges or decoder lines.

** Not all of the TCS decoders have all 8 light functions. Check your decoder's literature to determine how many of the above lighting functions you have.

Programming a Light Function:

1st. Select the lighting feature you wish to use from the feature table above.

2nd. Determine whether you would like your light to operate when travelling in the forward, reverse, or both directions.

3rd. Take the value that corresponds to the feature and directionality you decided on from the red table above.

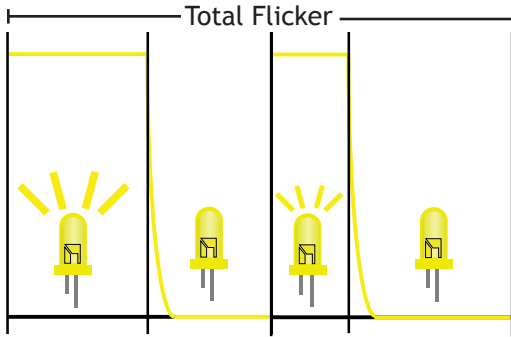
4th. Enter that value into the blue table above in the row for the light function you want to apply the feature to.

5th. When you have decided on all of your light features program the CV's found in the yellow column with the values you wrote into the blue column.

6th. Turn on your light functions and enjoy!

Modifying Lighting Effects

Random Flicker



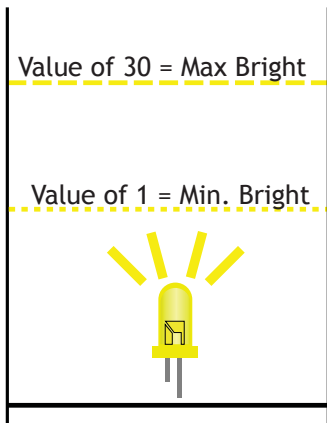
Random Flicker Modification:

Each TCS decoder includes two Random Flicker generators which allows for two different random flicker rates.

For each Random Flicker generator the overall speed of the flicker can be adjusted from 1-255 (1 being the fastest and 255 being the slowest).

	Speed of Flicker
Random Flicker 1	CV 135 (16)
Random Flicker 2	CV 152 (16)

Constant Dim



	Brightness Setting
Headlight Dim	CV 156 (0)
Reverse Light Dim	CV 157 (0)

Constant Dim 1	CV 64 (6)
Constant Dim 2	CV 153 (5)
Constant Dim 3	CV 154 (5)
Constant Dim 4	CV 155 (5)

Constant Dim Modification:

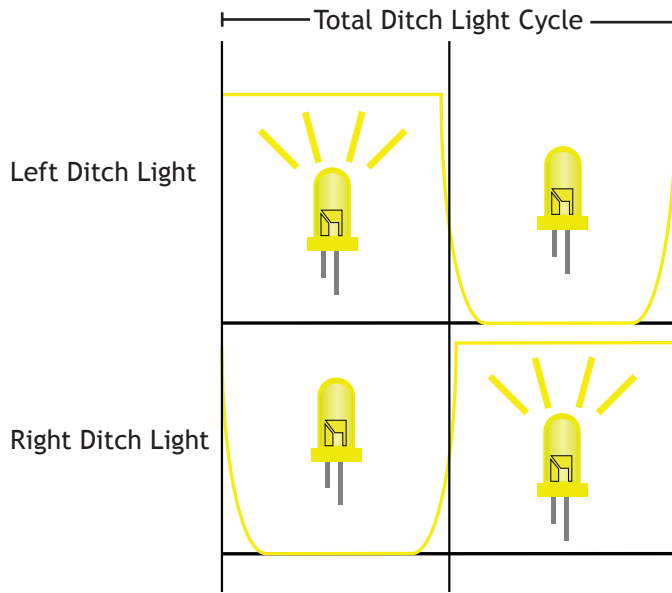
Each TCS decoder includes 6 Constant Dim generators which allows for 6 different Brightness settings. The first two work with the existing Headlight and Reverse light.

Headlight and Reverse light must be set to the "Constant Bright Light" feature for this dim adjustment to work.

The other four are used as separate lighting features and can be assigned to any function output.

For each Constant Dim light the values can be adjusted between values of 1-30 (with 30 being full brightness and 1 being least bright). Typically values between 2-6 are best for LED's and values between 12-18 are ideal for bulbs, but from light source to light source the results will vary and some degree of trial and error is required.

Ditch Lights



Ditch Light Modification:

Each TCS decoder includes a Left and Right Ditch Light which are controlled by a Single Ditch Light generator.

The overall speed at which the ditch lights alternate can be adjusted with CV 117 by entering values from 1-255. The lower the number slower the alternation, and the higher the number the faster they blink.

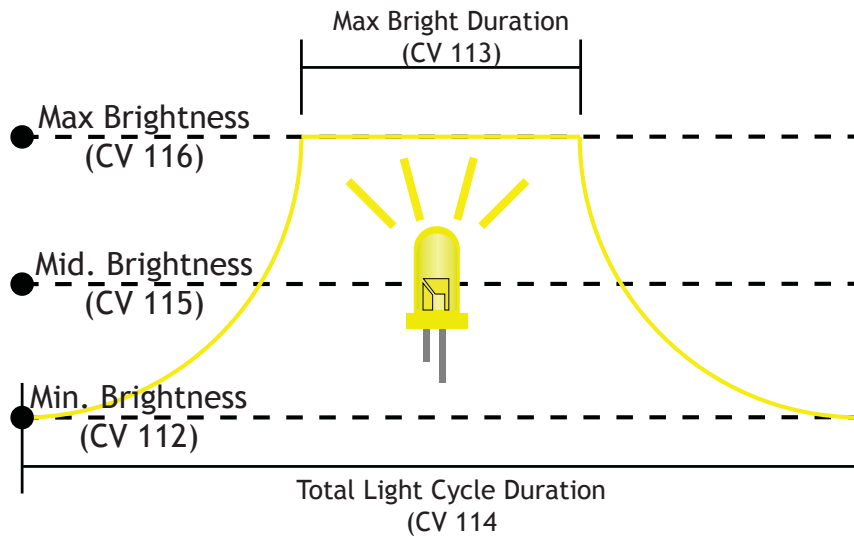
The Blink Holdover setting defines how long the lights will continue to alternate before returning to constant bright. Values of 1-255 can be used in CV 63 with lower values specifying a shorter holdover and high numbers causing a longer holdover.

See Quick Presets on page 24 for an easy way to setup Ditch Lights

Ditch Lights:	
Alternation Rate	CV 117 (213)
Blink Holdover	CV 63 (100)

Modifying Lighting Effects

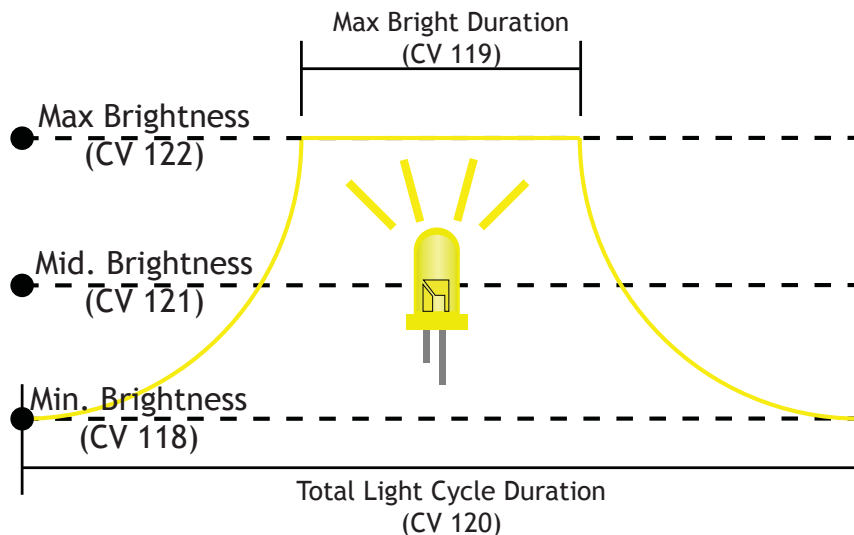
Mars/Gyra Light Adjustment



Mars/Gyra Adjustment CV's

Functionality	CV	Values
Max Bright Duration	CV 113	1-255 (9)
Total Light Cycle	CV 114	1-3 (2)
Max Brightness	CV 116	1-25 (11)
Mid. Brightness	CV 115	1-25 (8)
Min. Brightness	CV 112	1-25 (7)

Rotary Beacon



Beacon Adjustment CV's

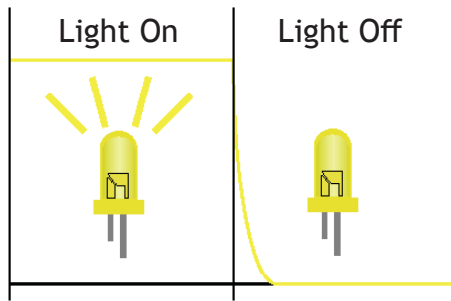
Functionality	CV	Values
Max Bright Duration	CV 119	1-255 (5)
Total Light Cycle	CV 120	1-3 (1)
Max Brightness	CV 122	1-25 (25)
Mid. Brightness	CV 121	1-25 (15)
Min. Brightness	CV 118	1-25 (25)

Mars Light, Gyra Light, and Rotary Beacon Modification:

- Note: The Mars and Gyra light use the same light pattern generator which means they cannot be used simultaneously.
- All of the above lighting features allow for 3 points of brightness adjustment, as well as 2 timing related CV's.
- The Total Light Cycle adjustment is a multiplier with increasing values (2 and 3) increasing the length of each light cycle.
- The Max Bright Duration dictates how long the lighting feature will remain at full brightness. The Total Life Cycle value will act as a multiplier on the Max Bright Duration and increase the length of time at max bright.
- When adjusting the brightness values keep these tips in mind:
 - All values must be above 0.
 - All three values (Min., Mid., and Max) cannot be the same.
 - Min. brightness must always be lower than (or equal to) mid. brightness, and mid. brightness must be lower than (or equal to) the max brightness

Modifying Lighting Effects

Single Pulse Strobe (SPS)



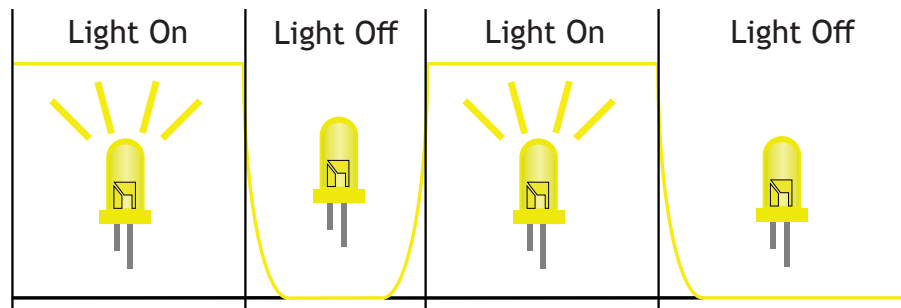
Single Pulse Strobe Modification:

Each TCS decoder includes two Single Pulse Strobe generators which allows for two different pulse patterns.

For each SPS generator the length of time the light function is on and the length of time it is off is adjustable with the CV's identified on the left. Values between 0-255 are accepted (the larger the value, the longer the light will remain in the specified state).

	Light On Duration	Light Off Duration
SPS 1	CV 141 (5)	CV 140 (5)
SPS 2	CV 143 (4)	CV 142 (124)

Double Pulse Strobe (DPS)



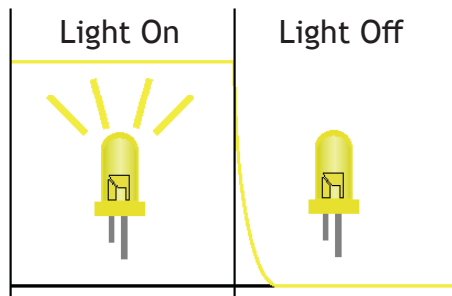
	1st Light On Duration	"Short" Off Duration	2nd Light On Duration	"Long" Off Duration
DPS 1	CV 147 (5)	CV 148 (16)	CV 147 (5)	CV 146 (112)
DPS 2	CV 150 (5)	CV 151 (16)	CV 150 (5)	CV 149 (117)

Double Pulse Strobe Modification:

Each TCS decoder includes two Double Pulse Strobe generators which allows for two different pulse patterns.

For each DPS generator the length of time the light function is on, the length of time the light is off between pulses, and the length of time it is off before starting the pattern again is adjustable with the CV's identified on the left. Values between 0-255 are accepted (the larger the value, the longer the light will remain in the specified state).

Flashing Light (FL)



Flashing Light Modification:

Each TCS decoder includes one Flashing Light generator.

For the Flashing Light generator the length of time the light function is on and the length of time it is off is adjustable with the CV's identified on the left. Values between 0-255 are accepted (the larger the value, the longer the light will remain in the specified state).

	Light On Duration	Light Off Duration
FL	CV 144 (144)	CV 145 (48)

Rule 17 and Opposite Dim

Explanation and application.

Rule 17 Explained:

Rule 17 (or as it is known in modern train guidelines: Rule 5.9.1-5.9.4) specifies operational instances where one or both lights should dim to avoid blinding workers or interfering with another trains operation. Some of the most common times this is used are: when a train is stopped at a station its lights should be dimmed, when a train stops on the mainline in an unsignaled region, and when passing a train on an adjacent track. To that end we have included several Rule 17 style lighting effects which can be used independently or collectively to achieve prototypical results.

Rule 17 Usage:

Rule 17 Dimming implemented by TCS includes three different types of functionality: Opposite Dim (when travelling forward the reverse light is on dimmed, and when travelling in reverse the forward light is on dimmed), Dim when stopped (when a locomotive comes to a complete stop the light(s) dim), and button controlled dimming.

By default button controlled dimming is in place any time a lighting function is assigned the Rule 17 lighting effect, however, Opposite Dim and Dim when Stopped must be enabled in CV 61 before they will effect the decoders operation. See the table on page 2 for more information on enabling these two effects.

Once you have selected the features you would like to use you must program the light functions which you wish to have Rule 17 active on with the Rule 17 Lighting Feature (See Lighting Features and Functions for more information). Please note that will Dim when Stopped will work on any function output Opposite Dim can only be used with the White or Yellow Wires (FOF, FOR).

As mentioned before, button controlled Rule 17 Dimming is always enabled so if you program a light function to the Rule 17 lighting feature and press the Rule 17 button (by default button 4) any light using the Rule 17 feature will dim. Please note that the dimming value is controlled by CV 64 which also effects the dimming of the Constant Dim 1 lighting feature.

A Note regarding CV 61: CV 61 controls the use of BEMF as well as the Rule 17 lighting. **Use the table on Page 2 to program CV61 properly.** Select the features that you want then add up the corresponding values and program the result of that summation in CV 61. If you program an even number in CV 61 BEMF will be disabled which may significantly effect the slow speed performance of your locomotive.

Please note that the dimming value is controlled by CV 64 for the dimming of the Front and Rear Headlight if the Rule 17 feature is selected.

Brake Lights, Consist Lighting, and Lights on DC

Brake Lights

Brake Light Off Delay	CV 138 (16)
-----------------------	-------------

Acceptable values range from 0-255

To adjust how long the brakes light remain on after applying the “brakes” change the value in CV 138. The higher the number the longer the lights will remain on (up to 13 seconds) and the lower the number the less time they will remain active.

Brake Lights:

The Brake Lights lighting feature operates much like the brake lights on a car. When the locomotive decelerates the brake lights will remain on until the locomotive: levels out its speed, comes to a complete stop, or begins accelerating.

Typically found on trolleys, this lighting feature can be adjusted for how long the brake lights will remain after the “brakes” are no longer being applied will the brake lights remain on. This can be adjusted from as much as 13 seconds to an instant off as outlined in the table to the left.

Note: Button Control of Braking, and trolley braking features are covered in the motor control section of this manual.

Consist Lighting

Green F(1)	1
Purple F(2)	2
Brown F(3)	4
Pink F(4)	8
Pink/Purple Wire F(5)	16
Green/Brown Wire F(6)	32
CV 21	

White Wire F(0)F	1
Yellow Wire F(0)R	2
CV 22	

Consist Lighting Control:

By default the decoder light functions will only respond to the base 2/4 Digit Address regardless of whether the locomotive is currently being controlled through the consist address. However, all of the lighting functions can be controlled by modifying CV's 21 and 22. CV 21 controls F(1) through F(6) and CV 22 controls F(0)F and F(0)R.

Simply select the lighting features on the left that you would like to control while in a consist, add up the corresponding values from the right column and program the resulting value in the CV listed at the bottom of each table.

DC Light Operation

White & Yellow Wire (F0F and F0R)	1
Green Wire F(1)	2
Purple Wire F(2)	4
Brown Wire F(3)	8
Pink Wire F(4)	16
Pink/Purple Wire F(5)	32
Green/Brown Wire F(6)	64

Add the corresponding values from the right hand column of the table above and program that value into CV 13.

Enabling Lights on DC:

By default all of the light functions in TCS decoder will operate (with directional operation) on DC. This is accomplished by the default value of 255 in CV 13. To limit the functions that will operate in DC mode select the light functions from the table on the left , add the corresponding values for each function together, and program that value into CV 13.

Function Remapping

Button	Fwd 0 Rev		1	2	3	4	5	6	7	8	9	10	11	12
Value	1	2	4	8	16	32	64	128	4	8	16	32	64	128

CV	Default Value	Function	Your Value
CV 33	1	White Wire F(0)F	
CV 34	2	Yellow Wire F(0)R	
CV 35	4	Green Wire F(1)	(7-12) CV 37
CV 36	8	Purple Wire F(2)	(7-12) CV 38
CV 39	16	Brown Wire F(3)	(7-12) CV 41
CV 40	32	Pink Wire F(4)	(7-12) CV 42
CV 43	64	Pink/Purple Wire F(5)	(7-12) CV 45
CV 44	128	Green/Brown Wire F(6)	(7-12) CV 46
CV 134	2	Automatic Button Control of Motor Circuit (0-6)	
CV 123	32	On/Off for Rule 17 Dimming (0-6)	
CV 124	8	To Make the Ditch Lights Blink (0-6)	
CV 136	2	Button control of BEMF	
CV 139	128	Brake Button	

Remapping Functions

Remapping a Lighting Button Controlled Function:

1st. Determine which wire (function) you would like to program, and select the CV specified above for that function. If you will be using buttons 7-12, select the CV listed in the blue column which corresponds to the lighting function, otherwise (if the button is 0-6) select the CV in the red column.

2nd. Find the function button you would like to use in the grey row from the table above.

3rd. Enter the value found in Step 2 into the CV found in Step 1. Now you can control the lighting function with the function button selected.

Quick Reference Ditch Light Remapping

By default the green wire comes on with button one. To make the purple wire come on with button one as well enter the value 4 (the button one value) into CV 36 (the 0-6 CV from the red column for the purple wire).

Now your ditch lights will come on in forward direction when function button one is turned on and blink when button two is pressed.

Back EMF (BEMF-Back Electro Motive Force)

An overview of its purpose and how to implement it

BEMF Explained:

Friction, binds in the motor, out of round wheels, slop in the gears, poor gearing, and many more drive train variables prevent most decoders from creeping from a dead stop into ultra-slow speeds (1 tie per second). Typically to break through the friction and binding the motor must be given extra power which creates a lurching start where the locomotive moves very quickly for a moment and then backs off its speed. However, this method of overshooting does not provide the slow (heavy) acceleration of a real locomotive.

Even those decoders with BEMF, Dither, Start Volts, and other methods for allowing a locomotive to creep along they all must be carefully adjusted and calibrated to reach peak performance. Once the low speed has been carefully perfected though, many times the mid range and upper range of speed steps can be grossly inaccurate.

ALL THIS is where the TCS Auto-Adjusting BEMF comes into play. Built to intelligently and automatically adjust the motor RPM to create the most prototypical operation available. At slow speeds the TCS BEMF will adjust for friction and motor hiccups that cause stuttering operation and at high speeds it will allow for constant speeds regardless of grades on hills and heavy loads. This allows operators to use User Loadable Speed Tables, Speed Curves, Motor Trim, and Momentum to create the ideal speed range for a given locomotive and enjoy the accurate and even movement that replicates a full size locomotive.

BEMF Usage and Adjustment:

All TCS decoders ship with BEMF enabled though for some consists or for users who have standardized their locomotive speeds without BEMF disabling it all together may be preferred. However, the TCS BEMF allows for three different forms of disabling BEMF providing the most benefit with the least complexity. The three options for BEMF control are:

Programmed ON/OFF-

Programmed On/Off simply refers to turning on or off BEMF by adjusting CV values. To disable BEMF simply set CV 61 to the next smallest even number. For instance, if CV 61 has a value of 17, programming a value of 16 will disable BEMF.

Button Control of BEMF-

Turning on and off BEMF with a button is sometimes considered ideal when carrying heavy loads up a hill where BEMF would kick and keep the locomotive at pace in spite of the additional strain on the locomotive. Some users prefer to temporarily disable BEMF to accurately replicate the slowing of a locomotive when competing with situational challenges.

To enable Button Control of BEMF a value of 2 should be added to the value in CV 61. Being that CV 61 has a default value of 1 adding a value of 2 and programming the resulting value of 3 into CV 61. **By default after enabling button control of BEMF turning on and off function button 6 will turn on and off BEMF.** To remap button control of BEMF select the function button from the table below and program the selected value into CV 136.

Function Button	5	6	7	8	9	10	11	12
Value	1	2	4	8	16	32	64	128

BEMF Cutout-

BEMF Cutout automatically disables BEMF once a user-defined speed is reached. This option is sometimes found beneficial when running locomotives in consist as (when improperly speed matched) the two locomotives may begin to fight each other at high speeds. Using 'Cutout' to disable BEMF after breaking through the especially sticky slow speeds allows the locomotive to perform prototypically at slow speeds and still respond well in a consist.

To enable BEMF Cutout simply enter a value into CV 10 that is between 1 and 128. The value entered into CV 10 directly correlates to the speed step at which it will cut out. That is to say if you wish to disable BEMF at speed steps above speed step 50 enter a value of 50 into CV 10.

NOTE: “Programmed ON/OFF”, “Button Control of BEMF”, and “BEMF Cutout” are not available on the TCS WOWSound decoders. BEMF is critical for the correct operation of the sound features and cannot be turned off.

BEMF and 3-Pole Motors-

Some locomotives come equipped with a less efficient 3-pole motor installed. Even with the TCS automatic BEMF some jerky operation will be unavoidable. To remedy this as much as possible TCS decoders have a 3-pole motor setting for the BEMF. When turned on, this has a very aggressive algorithm for the first 3 speed steps to get the 3-pole motor turning as smoothly as possible. This is turned on using CV 182.

	Value	BEMF Features
A	0	Automatic BEMF - Stop on DC Enabled (No Keep-Alive™)
B	1	Special BEMF setting for 3-pole motors
C	2	Automatic BEMF - Stop on DC Disabled - Enable Keep-Alive™ with Keep-Alive™ ready decoders (DEFAULT)
CV 182		Program the sum of the Values you choose into CV 182

Button Control Of Motor and Dither

An overview of their purpose and how to implement them

Button Control of the Motor Explanation and Usage:

For certain operations (controlling a smoke unit, turntable, drawbridges, etc.) one might want to use a TCS decoder and control said functionality with nothing more than a button press. For this type of operation included in every TCS motor decoder is a feature known as “Button Control of the Motor Circuit”. This allows the motor speed to be defined in a CV and then with a simple button press the motor circuit will be powered at the voltage defined by the user.

Button Control of the Motor has two forms: Automatic (direction of motor spin determined by the direction command sent to the decoder) or Manual (direction of motor spin determined by which button is pressed).

Automatic Button Control of Motor:

To enable Automatic button control add a value of 68 to whatever value is found in CV 61. By default CV 61 has a value of 1 so simply program a value of 69 into CV 61. Now when button 0 is pressed the motor will run at full speed in the direction identified on the handheld. To remap the button used visit the Function Remapping section of this manual.

Manual Button Control of Motor:

To enable Manual button control add a value of 64 to whatever value is found in CV 61. Once this is completed the decoder will spin it's motor in the forward direction when button 2 is enabled and in reverse when button 3 is enabled.
(NOTE: Manual Button Control of Motor is hard coded and cannot be mapped to other buttons)

In both cases to set the speed/voltage of the motor adjust the value of CV 133 (values ranging from 0-128 which correspond to the 128 speed steps).

Dither Explanation and Usage:

While most modelers will use BEMF to achieve slow speed starts and maintain even operation throughout the speed range some users still prefer to use the older Dither functionality to start their locomotive “creeping” at very low speeds. Dither works by adding micro pulses (when properly adjusted these pulses are invisible to the human eye) of a higher voltage to the motor to break through static friction and keep the motor from binding at very low speeds.

To enable Dither one must only disable BEMF by programming an even number into CV 61. For instance if CV 61 has a value of 17 simply subtract a value of 1 and program the resulting value of 16 into CV 61. With BEMF disabled Dither automatically kicks in and can then be adjusted for optimal performance.

CV 56 (3)	Dither Frequency (1 being the lowest frequency and 255 being the highest frequency).
CV 57 (10)	Dither Voltage (1 being the lowest and 255 being the top voltage).

To adjust Dither the values of CV's 56 and 57 must be modified. CV 56 controls the frequency (the number of micro-pulses in a given period of time) and CV 57 controls the voltage (the power of each micro-pulse).

To tune Dither begin by increasing the value of CV 57 by values of 5 until the locomotive in question is able to move at speed step 1. Next adjust the value of CV 56 by 1 value at a time until the locomotive is able to creep slowly and the operation still appears smooth and even.

Button Control Of Braking and Trolley Features

An overview of their purpose and how to implement them

Button Control of Braking

Button Control of Braking	CV 61 (1)
---------------------------	-----------

Acceptable values range from 0-255

Add a value of 8 to CV 61 to enable Button Control of Braking (defaults to function button 6, see the Function Remapping guide in this book for information on remapping the brake button). To enable braking tail lights add a value of 128 to the value found in CV 61.

Button Control of Braking:

Button Control of Braking is used most commonly with trolley cars where they are starting and stopping frequently. By pressing the button (default 6) to brake the locomotive the brake lights (if that effect is being used) will turn on, and the decoder will slow the locomotive to stopping at the rate defined below under Braking Deceleration.

See Quick Preset on page 24 for an easy way to setup Trolley Features

Braking Deceleration

Braking Deceleration Rate	CV 126 (0)
---------------------------	------------

Acceptable values range from 0-255

Like standard momentum, the values range from 0 which will be a nearly instantaneous stop to 255 which will cause the locomotive to very gradually decelerate to a complete stop.

Braking Deceleration:

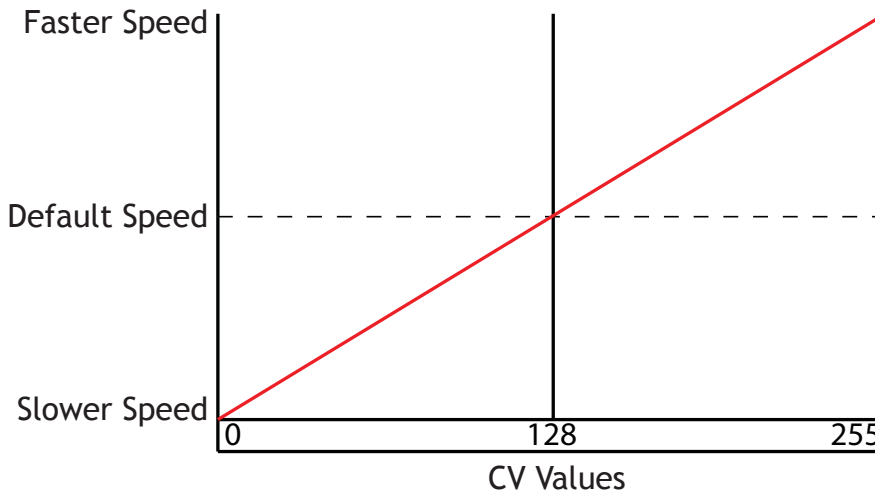
Braking deceleration defines the rate at which the decoder will slow the locomotive to a complete stop during a braking cycle. When braking deceleration is active, and the brake button has been applied the base deceleration will not effect the actual deceleration and only the braking deceleration will be considered.

NOTE: This version of Button Controlled Braking and Brake Deceleration does not work on TCS WOWSound decoders. WOWSound decoders have their own version of 2 Button Controlled Braking, <u>However the Brake Lights work correctly on a decoder using the 2 Button Brake.</u>

Motor Trim

An overview of its purpose and how to implement it

CV 66 (128)	Forward Motor Trim
CV 95 (128)	Reverse Motor Trim



Motor Trim Explained:

Motor trim allows the entire speed range of a decoder to be shifted up (faster) or down (slower) using CV 66 and CV 95. This makes speed matching locomotives for consist as well as adjusting for those notoriously fast and slow locomotives a breeze. If your locomotive performs slightly differently in forward than reverse you can adjust the trim in both directions independently to even out the speed curve regardless of direction. Motor trim can be used on top of User Loadable Speed tables and 3 point Speed Curves to adjust the entire range up or down. This way if you have the perfect speed curve but your locomotive is still slower or faster than you would like you can shift your custom curve up or down without adjusting each individual value.

Motor Trim Values:

As outlined in the diagram above, a value above 128 will increase the overall speed (the higher the number the faster the locomotive will go) and values below 128 will slow the locomotive (the lower the value the slower the locomotive will travel). The resolution (precision of the adjustment) of the values for motor trim is 4. This means that for every 4 you add or subtract from the trim value the speed will be adjusted by one degree of difference.

Motor Trim to Speed Match Locomotives:

Adjusting the Motor Trim CV's is a quick way to speed match dissimilar locomotives for consist especially on locomotives that have different speed characteristics when running in reverse. It is best to make your adjustments on the faster of the two locomotives since you can always slow it down, but not be able to speed it up enough to match the other locomotive.

Momentum (Acceleration/Deceleration)

An overview of its purpose and how to implement it

Momentum Explained:

While most locomotives are accurately scaled down such that the details, sizing, color etc. etc. are accurate representations of the actual locomotive, but due to size and weight constraints most models have a far greater power-to-weight ratio than their life size counterparts. This means that they can accelerate at a rate that even the most powerful full size locomotives could not achieve.

While for some slowly ramping the speed one speed step at a time provides smooth and slow enough acceleration (and deceleration) for those who want slower acceleration rates, or wish to set a speed and have their locomotive slowly ramp itself up to that speed Momentum allows the user to adjust how long it takes for the decoder to change speed. This creates the illusion of a heavy locomotive slowly accelerating to overcome it's weight, or the slow deceleration of locomotive that has to slow the heavy load behind it.

CV 3 (0)	The rate of Acceleration
CV 4 (0)	The rate of Deceleration

Momentum Usage:

Momentum is controlled by adjusting the values of CV 3 and CV 4. Values between 1-255 are accepted and the larger the value used the longer it will take for the decoder to ramp up (Acceleration) or ramp down (deceleration) its speed from one speed step to the next.

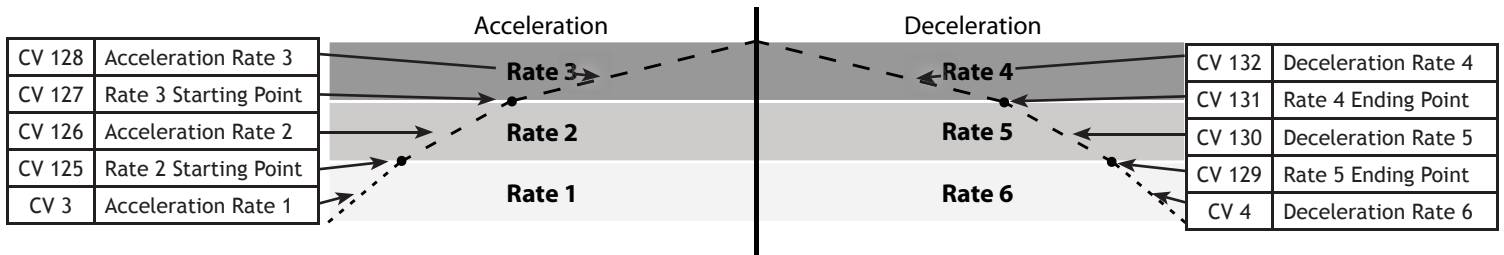
Typical values for both acceleration and deceleration fall between 5-50 and with minimal tweaking should allow the user to replicate nearly any size load on any train.

Variable Momentum

An overview of its purpose and how to implement it

Variable Momentum Explained:

For the most advanced users sometimes simple Acceleration and Deceleration controls (momentum) can't quite produce the precisely prototypical operation they are looking for. In such cases variable momentum can be used to design precise and independently adjustable Acceleration and Deceleration (variable momentum). For most users this level of refined control will be far more precise than needed, but for modelers trying to squeeze every bit of real world detail into their trains we provide variable momentum.



Variable Momentum Usage and Adjustment:

Variable uses five CV's for Acceleration and five CV's for deceleration (as pictured in the above diagram). Both Accel. and Decel. have three different rates of speed change as well as two points used to identify when to move from one rate to the next. As you can see above Acceleration has Rates 1, 2, and 3, and transition points between 1 and 2, and 2 and 3. Deceleration has Rates 4, 5, and 6 and transition points between 4 and 5, and 5 and 6.

Implementing Variable Momentum is as simple as programming values between 0-255 into all of the CV's outlined above. To achieve the ideal curve a bit of trial and error and adjustment will be required. Typically the rate starting and ending points are values between 80-150 and the rate values tend to fall somewhere between 10-90 though again the range of values are much larger than that and will require a certain amount of tweaking.

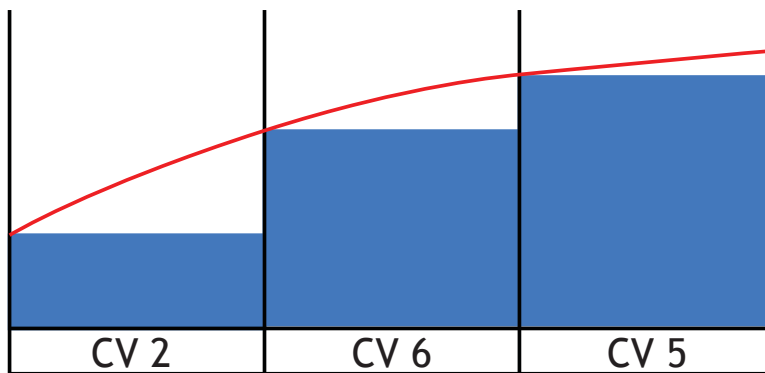
3 Point Speed Curves

An overview of its purpose and how to implement it

3 Point Speed Curves Explained:

In most applications of acceleration and deceleration the rate at which a locomotive increases its speed forms a curve where the early speed steps do not increase the speed as rapidly as later speed steps. Whereas User Loadable Speed Tables have 28 individual speed steps to adjust and allows for speed plateaus, dips, and non-continuous speed curves, for most applications a simple Speed Curve will be more than adequate to create the prototypical movement of most locomotives.

To this end Speed Curves employs 3 CV's, each defining the rate of speed of a given range of speed steps. Using the Start Volts, Mid Volts, and Top Volts the speed steps from 1-128 are divided into three equal sections. Adjusting the values in the corresponding CV's shifts the standard speed curve up or down (within the specific range) thereby creating an entirely new rate of speed from each speed step to the next.



3 Point Speed Curves Usage and Adjustment:

To enable 3 Point Speed Curves simply program values into CV 2 (Start Volts), CV 6 (Mid Volts), and CV 5 (Top Volts).

The Speed Curve is defined in CV's 2, 6 and 5 with each CV corresponding to approximately 1/3 of the speed range. Values may range from 1-255 and every value of 18 (approximately) added to one of the Speed Curve CV's adds about 1 volt to the motor speed at the CV being adjusted.

NOTE: 3 Point Speed Curves do not allow for parabolic speed curves. That is to say each consecutive CV must have a value higher than, or equal to, the CV before it.

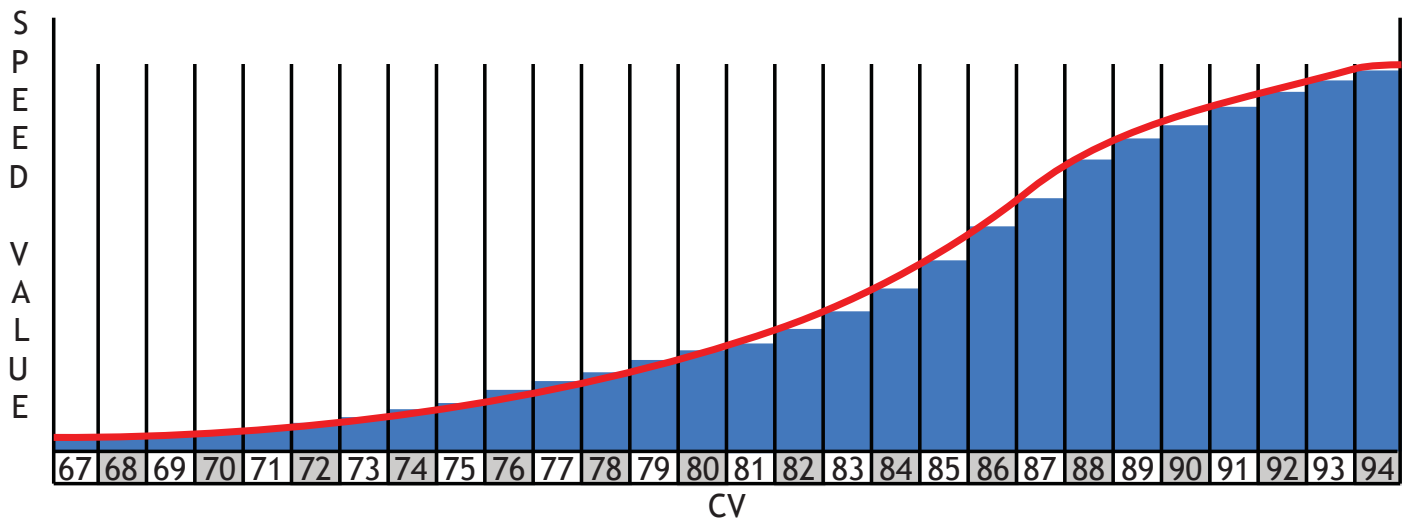
User Loadable Speed Tables

An overview of its purpose and how to implement it

User Loadable Speed Tables Explained:

For those looking for the ultimate of fine tuned speed adjustment User Loadable Speed Tables allows 28 speed steps to be individually defined. When running in 128 speed steps the gaps between the user defined speeds are averaged out and divided amongst the extra speed steps creating a smooth and even speed curve matching the points set by the user.

While for some this level of control and the time required to fine tune a unique speed table may be excessive for some users, others may find in this exactly the level of precise control needed to create a their ideal motor operation. If simple adjustment is all that is required, or speed matching two locomotives is the goal using Motor Trim and Speed Curves is typically a much easier and very effective option. User Loadable Speed Tables should be used only in those situations where ultra-fine control is needed and the other motor control options have been exhausted.



User Loadable Speed Tables Usage and Adjustment:

To enable User Loadable Speed Tables (ULST) add a value of 16 to whatever value you find in CV 29.

ULST values are defined in 28 CV's from CV 67 to 94. Each CV defines 1/28th of the speed range (as shown in blue above) and the decoder uses each value as a point to generate the speed curve used by the locomotive (shown in red above). Every value of 9 (approximately) added to one of the ULST CV's adds about 1 speed step (or approximately .5v) to the motor speed at the CV being adjusted.

If you are using 14 speed step mode only the CV's highlighted in gray above will affect the speed curve of the locomotive. The remaining CV's are only applicable in 28/128 speed step mode.

NOTE: ULST do not allow for parabolic speed curves. That is to say each consecutive CV must have a value higher than, or equal to, the CV before it.

CV 67 = 8	CV 74 = 64	CV 81 = 124	CV 88 = 194
CV 68 = 16	CV 75 = 72	CV 82 = 134	CV 89 = 204
CV 69 = 24	CV 76 = 80	CV 83 = 144	CV 90 = 214
CV 70 = 32	CV 77 = 88	CV 84 = 154	CV 91 = 224
CV 71 = 40	CV 78 = 96	CV 85 = 164	CV 92 = 234
CV 72 = 48	CV 79 = 104	CV 86 = 174	CV 93 = 244
CV 73 = 56	CV 80 = 114	CV 87 = 184	CV 94 = 255

Quick Presets

A quick way to set up certain features using CV 8

Ditch Light Preset:

CV 8 = 10	Program a value of 10 into CV 8 to make the Violet and Green wires into Ditch Lights. Button 1 will turn them on and Button 2 will make them alternate on and off for the holdover time period in CV 63.
-----------	--

Using this preset changes the following:

CV 35 = 4	Green wire mapped to button 1.
CV 36 = 4	Violet wire mapped to button 1.
CV 51 = 42	Green wire set to Ditch Light Left in both forward and reverse.
CV 52 = 43	Violet wire set to Ditch Light Right in both forward and reverse.
CV 124 = 8	Maps Ditch Light Blink to button 2.

Standard Trolley Preset:

CV 8 = 11	Program a value of 11 into CV 8 to set up the standard Trolley Features. Button controlled Brake on Button 6 and working Brake Lights when Button 3 is on with Running Lights.
-----------	--

Using this preset changes the following:

CV 61 = 9	Enables BEMF and Button Controlled Brake on Button 6
CV 3 = 5	Acceleration Setting
CV 4 = 5	Deceleration Setting
CV 34 = 16	Remaps yellow wire to button 3 (Turns on Brake light feature when Button 3 is on)
CV 49 = 32	Makes Headlight Non-Directional
CV 50 = 46	Makes the yellow wire into working Brake Lights
CV 64 = 5	Dim value for running lights
CV 126 = 5	Brake Deceleration Rate

IMPORTANT NOTE: For the running lights (tail lights) to be dim until the brake is applied you must program CV 61 to a value of 137 AFTER you have set CV 8 to 11.

Deluxe Trolley Preset:

CV 8 = 12	Program a value of 12 into CV 8 to set up the Deluxe Trolley Features. Button controlled Brake on Button 6 and working Brake Lights when Button 3 is on with Running Lights, On/off Function on Green wire with Button 1 and Violet wire with Button 4, and Rotary Beacon on brown wire with Button 5
-----------	---

Using this preset changes the following:

CV 61 = 9	Enables Button Controlled Brake on Button 6
CV 3 = 5	Acceleration Setting
CV 4 = 5	Deceleration Setting
CV 34 = 16	Remaps the yellow wire into working Brake Lights
CV 49 = 32	Makes Headlight Non-Directional
CV 50 = 46	Makes the yellow wire into working Brake Lights
CV 64 = 5	Dim value for running lights
CV 126 = 5	Brake Deceleration Rate
CV 36 = 32	Maps Violet wire to button 4 On/Off
CV 39 = 64	Maps Brown wire to button 5
CV 53 = 38	Makes Brown wire a Rotary Beacon

IMPORTANT NOTE: For the running lights (tail lights) to be dim until the brake is applied you must program CV 61 to a value of 137 AFTER you have set CV 8 to 12.