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1 General

1.1 Introduction and Intended Use (Informative)

This Standard provides a map and descriptions for Digital Decoder Configuration Variables. Configuration Variables allow the decoder to be customized for each locomotive, or other mobile or stationary devices. Unless otherwise specified, configuration Variables shall be stored in non-volatile memory and must not change when power is removed from the decoder over long extended periods of time.

1.2 References

This standard should be interpreted in the context of the following NMRA Standards, Technical Notes, and Technical Information.

1.2.1 Normative

- S-9.2 DCC Communication Standard, which covers the format of the information sent via Digital Command Stations to Digital Decoders
- S-9.2.1 DCC Extended Packet Formats, which provides a minimal, basic packet format required for interoperability
- S-9.2.1.1 DCC Advanced Extender Packet Formats, which contains methods for reading and writing CV's.
- S-9.2.3 Service Mode Programming, which covers the programming mode to allow customization and test of Digital Decoders

1.2.2 Informative

- RCN-225 Configuration Variable Standards, with which this standard is intended to be in harmony

1.3 Requirements and Definitions

Tables 1 and 2 identify each of the Configuration Variables (CVs), along with additional information about each one. Following Table 1 is a written description of each of the CVs. In Tables 1 and 2 each Configuration Variable (CV) is identified by name and number, along with the following information:

- **Required:** Mandatory (M), Recommended (R) or Optional (O). CVs identified as Mandatory (M) must be implemented in order to conform to this Standard, while those marked as Recommended (R) are strongly encouraged but not mandatory, and those marked Optional (O) are at the manufacturer's discretion.

- **Default Value:** the required factory default value when the CV is provided in an implementation.
- **Read-Only:** indicates a CV whose value should be set by the manufacturer and which the user cannot modify.
- **Uniform Spec**: Many CVs are implementation specific, and no uniform specification is required. Others must be implemented in a uniform fashion in order to achieve compatibility. A "Y" in the Uniform Spec column indicates a CV which requires implementation by manufacturers according to a common specification. A blank in the Uniform Specification means that the CV must be used for its designated purpose, but the action taken by the decoder for a specific value can vary from manufacturer to manufacturer.
- ~~**Dynamic**: CVs in this range are dynamic and are used for Unsolicited Decoder Initiated Transmission. Manufacturers who utilize these CVs are requested to contact the NMRA DCC WG for current uniform specifications.~~

Table 1 - Multi-function Decoder Configuration Variables

CV Name	CV #	Required	Default Value	Read	Uniform Spec	~~Dynamic (Volatile)~~	Additional Comments
Multi-function Decoders:							
Primary Address	1	M	3		Y		
Vstart	2	M					
Acceleration Rate	3	M					
Deceleration Rate	4	M					
Vhigh	5	M					
Vmid	6	M					
Manufacturer Version No.	7	M		Y			Manufacturer defined version info
Manufactured ID	8	M		Y	Y		Values assigned by NMRA
Total PWM Period	9	O					
EMF Feedback Cutout	10	O					
Packet Time-Out Value	11	R					
Power Source Conversion	12	O			Y		Values assigned by NMRA
Alternate Mode Function Status F1-F8	13	O			Y		
Alternate Mode Function. Status F$_L$,F9-F12	14	O			Y		
Decoder Lock	15-16	O	0		Y		
Extended Address	17+18	M			Y		
Consist Address	19	R			Y		
Extended Consist Address	20	-					~~Reserved by NMRA for future use~~ Experimental use of extended address consists initially proposed by Zimo
Consist Addr Active for F1-F8	21	O			Y		
Consist Addr Active for FL-F9-F12	22	O			Y		
Acceleration Adjustment	23	O			Y		
Deceleration Adjustment	24	O			Y		
Speed Table/Mid-range Cab Speed Step	25	O			Y		
	26						Reserved by NMRA for future use
Decoder Automatic Stopping Configuration	27	O			Y		Under re-evaluation – see details
Bi-Directional Communication Configuration	28	O			Y		Under re-evaluation – see details
Configuration Data #1	29	M[1]			Y		
Error Information	30	O			Y		
Index High Byte	31	O			Y		Primary index for CV257-512 00000000 - 00001111 reserved by NMRA for future use.
Index Low Byte	32	O			Y		Secondary index for CV257-512
Output Loc. FL(f), FL(r), F1-F12	33-46	O			Y		

Manufacturer Unique	47-64	O					Reserved for manufacturer use
Kick Start	65	O					
Forward Trim	66	O					
Speed Table	67-94	O					
Reverse Trim	95	O					
	96 ~~104~~	-					Reserved by NMRA for future use
	97-104						Reserved for manufacturer use
User Identifier #1	105	O					Reserved for customer use
User Identifier #2	106	O					Reserved for customer use
	107-111	-					Reserved by NMRA for future use CV107,108: expanded Mfg. ID CV109-111: expanded CV7
Manufacturer Unique	112-256	O					Reserved for manufacturer use
Indexed area	257-512						Indexed area - see CV# 31,32 Index values of 0-4095 reserved by NMRA
	513-879	-					Reserved by NMRA for future use
	880-~~895~~					~~Y~~	Reserved by NMRA for future use
~~Decoder Load~~	~~892~~	~~O~~				~~Y~~	~~Y~~
~~Dynamic Flags~~	~~893~~	~~O~~				~~Y~~	~~Y~~
~~Fuel/Coal~~	~~894~~	~~O~~				~~Y~~	~~Y~~
~~Water~~	~~895~~	~~O~~				~~Y~~	~~Y~~
SUSI Sound and Function Modules	~~896~~ 897-1024	O			Y		See TN-9.2.3

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1   If any of these features are provided, then this CV is Mandatory

Note: While all *Digital Decoders* need not implement all variables, it is required that if a function is provided, that all the relevant CV information be adhered to.

Additional Comments: CVs identified as "Reserved by NMRA for future use" are allocated for future needs and must not be used by an implementer without prior written approval from the NMRA Technical Department. CVs identified as "Values assigned by NMRA" indicate that the allowable values are defined by the NMRA and any requests for additional values should be directed to the NMRA Technical Department. CVs identified as "Reserved for manufacturer use" are allocated for use by implementers, for which no prior NMRA authorization is needed, and for which no common usage across decoders from different implementers can be assured by the NMRA

1.3.1   General Definitions

Binary numerical quantities are stored such that the rightmost bit is the least significant, and the leftmost is the most significant:

Configuration Variable   MSB |d07|d06|d05|d04|d03|d02|d01|d00| LSB

1.3.2   Descriptions of Configuration Variables for Multi-Function Decoders

Configuration Variable 1:   Primary Address

Bits 0-6 contain an address with a value between 1 and 127. Bit seven must have a value of "0". If the value of ~~Configuration Variable #1~~ is ~~"00000000"~~ then DCC protocol is disabled. ~~the decoder will go out of NMRA digital mode and convert to the alternate power source as~~

~~defined by Configuration Variable #12.~~ This setting will not affect the Digital Decoder's ability to respond to service mode packets (see S 9.2.3). The default value for this Configuration Variable is 3, if the decoder is not installed in a locomotive or other unit when shipped from the manufacturer.

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Configuration Variable 2:   Vstart

Vstart is used to define the voltage drive level used as the start voltage on the motor. The voltage drive levels shall correspond linearly to the voltage applied to the motor at speed step one, as a fraction of available rectified supply voltage. When the voltage drive level is

80   equal to zero, there shall be zero voltage applied to the motor. When it is at maximum "11111111", the full available rectified voltage shall be applied.

Configuration Variable 3:   Acceleration Rate

Determines the decoder's acceleration rate. The formula for the acceleration rate shall be

85   equal to (the contents of CV#3*.896)/(number of speed steps in use). For example, if the contents of CV#3 =2, then the acceleration is 0.064 sec/step for a decoder currently using 28 speed steps. If the content of this parameter equals "0" then there is no programmed momentum during acceleration.

Configuration Variable 4:   Deceleration Rate

90   Determines a decoder's braking rate, in the same fashion as acceleration above (CV #3).

Configuration Variable 5:   Vhigh

Vhigh is used to specify the motor voltage drive levels at the maximum speed step. This value shall be specified as a fraction of available rectified supply voltage. When the contents

95   of CV#5 equal "11111111", the full available rectified voltage shall be applied. Values of "00000000" or "00000001" shall indicate that Vhigh is not used in the calculation of the speed table.

Configuration Variable 6:   Vmid

100   Vmid specifies the voltage drive level at the middle speed step. Vmid is used to generate a performance curve in the decoder that translate speed step values into motor voltage drive levels and is specified as a fraction of available rectified supply voltage. Values of 00000000 or 00000001 shall indicate that Vmid is not used in the calculation of the speed table.

105   Configuration Variable 7:   Manufacturer Version Number

This is reserved for the manufacturer to store information regarding the version of the decoder.

Configuration Variable 8:   Manufacturer ID
CV8 shall contain the NMRA assigned id number of the manufacturer of this decoder. The

110   currently assigned manufacturer ID codes are listed in Appendix A of this Standard. The use

of a value not assigned by the NMRA shall immediately cause the decoder to not be in conformance to this Standard. The CV shall be implemented as a read-only value, which cannot be modified.

Configuration Variable 9:   Total PWM Period

115   The value of CV#9 sets the nominal PWM period at the decoder output and therefore the frequency is proportional to the reciprocal of the value. ~~The recommend formula for PWM period should be: PWM period (uS) = (131 + MANTISSA x 4)x 2 EXP ,Where MANTISSA is in bits 0-4 bits of CV#9 (low order) and EXP is bits 5-7 for CV#9.~~ If the value programmed into CV-9 falls outside a decoder's capability, it is suggested (but not required)
120   that the decoder "adjust" the value to the appropriate highest or lowest setting supported by the decoder.

Configuration Variable 10:   EMF Feedback Cutout

    Contains a value between 1 and ~~128~~ 126 that indicates the speed step above which the back
125   EMF motor control cuts off. When 14 or 28 speed steps are used the LSB's of the value are truncated appropriately.

Configuration Variable 11:   Packet time-out Value

    Contains the maximum time period that the decoder will maintain its speed without
130   receiving a valid packet. See S 9.2.4 Section C for further information.

Configuration Variable 12:   Power Source Conversion[2]

    Contains the identity of the alternate power source to which the decoder will be converted should CV #1 contain all zeros. This is also the primary alternative power source selected
135   should the decoder perform power source conversion. The currently assigned Power Source Conversion codes are listed in Appendix B of this Standard. The decoder may only switch to analogue operation if this is enabled and none of the supported digital operating modes are recognized. It is irrelevant whether the digital operating mode is enabled. Bit 2 in CV 29 must also be set for analog operation. If none of the recognized digital operating modes are
140   enabled or if no digital operating mode is recognized and the corresponding analogue operating mode is blocked, the decoder has to switch off all outputs.

Configuration Variable 13:   Alternate Mode Function Status

    Indicates the status of each function (F1 through F8) when the unit is operating in alternate
145   power mode, which cannot control the functions. If a function can be controlled, then the corresponding bit is ignored. A value of "0" indicates the function is off, while a value of "1" indicates the function is on. Bit 0 corresponds to F1, while Bit 7 corresponds to F8.

Configuration Variable 14:   Alternate Mode Function 2 Status

150   Indicates the status of each function (F9 through F12, & FL) when the unit is operating in alternate power mode, which cannot control the functions. If a function can be controlled, then the corresponding bit is ignored. A value of "0" indicates the function is off, while a value of "1" indicates the function is on. FL in the forward direction is controlled by bit 0, FL in the reverse direction is controlled by bit 1. Bit 2 corresponds to F9, while Bit 5

155   corresponds to F12.

Configuration Variables 15, 16:   Decoder Lock

The Decoder Lock is used to change CVs in only one of several decoders with the same short address (CV1) or long address (CV17 and CV18) that are installed in the same

160   locomotive. Assign a number to CV16 in each decoder (i.e., 1 to motor decoder, 2 to sound decoder, 3 or higher to other decoders) before the decoders are installed in the locomotive. To change a value in another CV of one of the installed decoders, first write the number 1 (motor), 2 (sound), or 3 or higher (other) into CV15, then send the new value to the CV to be changed. The decoders will compare CV15 to CV16 and, if the values are equal, the CV

165   to be changed will be changed. If the values in CV15 and CV16 are different, the update will be ignored. A value of 0 in CV16 disables decoder lock.

Configuration Variables 17, 18:   Extended Address

The Extended Address is the locomotives address when the decoder is set up for extended

170   addressing (indicated by a value of "1" in bit location 5 of CV#29). CV#17 contains the most significant bits of the two-byte address and must have a value between 11000000 and 11100111, inclusive, in order for this two-byte address to be valid. CV 18 contains the least significant bits of the address and may contain any value.

175   Configuration Variable 19:   Consist Address

Contains a 7-bit address in bit positions 0-6. Bit 7 indicates the relative direction of this unit within a consist, with a value of "0" indicating normal direction, and a value of "1" indicating a direction opposite the unit's normal direction. If the seven-bit address in bits 0-6 is "0000000" the unit is not in a consist.

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Configuration Variable 21:   Consist Address Active for F1-F8

Defines for functions F1-F8 whether the function is controlled by the consist address. For each Bit a value of "1" indicates that the function will respond to instructions addressed to the consist address and instructions addressed to the locomotive address (CV1 or

185   CV17/CV18). A value of "0" indicates that the function will only respond to instructions addressed to the locomotive address. F1 is indicated by bit 0. F8 by bit 7.

Configuration Variable 22:   Consist Address Active for FL and F9-F12

Defines for function FL whether the function is controlled by the consist address. For each

190   Bit a value of "1" indicates that the function will respond to instructions addressed to the

consist address and instructions addressed to the locomotive address (CV1 or CV17/CV18). A value of "0" indicates that the function will only respond to instructions addressed to the locomotive address. FL in the forward direction is indicated by bit 0, FL in the reverse direction is controlled by bit 1. Bit 2 corresponds to F9, while Bit 5 corresponds to F12.

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Configuration Variable 23:   Acceleration Adjustment

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This Configuration Variable contains additional acceleration rate information that is to be added to or subtracted from the base value contained in Configuration Variable #3 using the formula (the contents of CV#23*.896)/(number of speed steps in use). This is a 7-bit value (bits 0-6) with bit 7 being reserved for a sign bit (0-add, 1-subtract). In case of overflow, the maximum acceleration rate shall be used. In case of underflow no acceleration shall be used. The expected use is for changing momentum to simulate differing train lengths/loads, most often when operating in a consist.

205   ### Configuration Variable 24:   Deceleration Adjustment

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This Configuration Variable contains additional braking rate information that is to be added to or subtracted from the base value contained in Configuration Variable #4 using the formula (the contents of CV#24*.896) / (number of speed steps in use). This is a 7-bit value (bits 0-6) with bit 7 being reserved for a sign bit (0-add,1-subtract). In case of overflow, the maximum deceleration rate shall be used. In case of underflow no deceleration shall be used. The expected use is for changing momentum to simulate differing train lengths/loads, most often when operating in a consist.

Configuration Variable 25:   Speed Table/Mid-Range Cab Speed Step

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A value between 2 and 127 shall be used to indicate 1 of 126 factory preset speed tables. A value of "00000010" indicates that the curve shall be linear. A value between 128 and 154 defines the 28-speed step position (1-~~26~~ 27) which will define where the mid-range decoder speed value will be applied (CV6). In 14-speed mode the decoder will utilize this value divided by two If the value in this variable is outside the range, the default mid cab speed of 14 (for 28 speed mode or 7 for 14 speed mode) shall be used as the mid speed value. Values of ~~"00000000" or "00000001"~~ 0, 1, or > 154 shall indicate that this CV is not used in the calculation of the speed table.

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Configuration Variable 27:   Decoder Automatic Stopping Configuration

Used to configure which actions will cause the decoder to automatically stop.

Table 2 – CV 27 Parameters

Bit #	Description	Setting
Bit 0	Enable/Disable Auto Stop in the presence of an asymmetrical DCC signal which is more positive on the right rail	"0" = Disabled "1" = Enabled
Bit 1	Enable/Disable Auto Stop in the presence of an asymmetrical DCC signal which is more positive on the left rail	"0" = Disabled "1" = Enabled
Bit 2	Enable/Disable Auto Stop in the presence of an Signal Controlled Influence cutout signal	"0" = Disabled "1" = Enabled
Bit 3	Reserved for Future Use	-
Bit 4	Enable/Disable Auto Stop in the presence of ~~reverse polarity opposite direction~~ DC	"0" = Disabled "1" = Enabled
Bit 5	Enable/Disable Auto Stop in the presence ~~forward polarity same direction~~ DC	"0" = Disabled "1" = Enabled
Bit 6	Reserved for Future Use	-
Bit 7	Reserved for Future Use	-

230   **Note:** If the decoder does not support a feature contained in this table, it shall not allow the corresponding bit to be set improperly (i.e., the bit should always contain it's default value)

Configuration Variable 28:   Bi-Directional Communication Configuration (RailCom)
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Used to configure decoder's Bi-Directional communication characteristics when CV29-Bit 3 is set.

Table 3 - CV 28 Parameters

Bit #	Description	Setting
Bit 0	~~Enable/Disable Unsolicited Decoder Initiated Transmission~~ Enable Channel 1 Address Broadcast	~~"0" = Disabled~~ ~~"1" = Enabled~~ "0" = Locked "1" = Released
Bit 1	~~Enable/Disable Initiated Broadcast Transmission using Asymmetrical DCC Signal~~ Enable Channel 2 Data and Acknowledge	~~"0" = Disabled~~ ~~"1" = Enabled~~ "0" = Locked "1" = Released
Bit 2	~~Enable/Disable Initiated Broadcast Transmission using Signal Controlled Influence Signal~~ Switch Off Channel 1 Enable Automatically	~~"0" = Disabled~~ ~~"1" = Enabled~~ "0" = Locked "1" = Released
Bit 3	Reserved for future use	-
Bit 4	~~Reserved for future use~~ Enable Programming Address 0003 (Long Address 3)	"0" = Locked "1" = Released
Bit 5	Reserved for future use	-
Bit 6	~~Flag Bits, Reserved for Future Use~~ Enable High-current RailCom	"0" = Locked "1" = Released
Bit 7	~~Flag Bits, Reserved for Future Use~~ Enable Automatic Registration (RCN-218 or RailComPlus®)	"0" = Locked "1" = Released

Note: If the decoder does not support a feature contained in this table, it shall not allow the
240   corresponding bit to be set improperly (i.e., the bit should always contain its default value).

Configuration Variable 29:　　　Configurations Supported

Table 4 – CV 29 Parameters

Bit #	Description	Setting
Bit 0	Locomotive Direction	"0" = normal, "1" = reversed. This bit controls the locomotive's forward and backward direction in digital mode only. Directional sensitive functions, such as headlights (FL and FR), will also be reversed so that they line up with the locomotive's new forward direction. See S-9.1.1 for more information.
Bit 1	FL location	0" = bit 4 in Speed and Direction instructions control FL, "1" = bit 4 in function group one instruction controls FL. See S-9.2.1 for more information.
Bit 2	Power Source Conversion	"0" = NMRA Digital Only, "1" = Power Source Conversion Enabled, See CV12 for more information.
Bit 3	Bi-Directional Communications	"0" = Bi-Directional Communications disabled, "1" = Bi-Directional Communications enabled. See S-9.3.2 for more information.
Bit 4	Speed Table	"0" = speed table set by configuration variables #2,#5, and #6, "1" = Speed Table set by configuration variables #66-#95
Bit 5	DCC Addressing	"0" = one byte or basic address from CV1, "1" = two byte addressing (also known as extended addressing from CV17 and CV18), See S 9.2.1 for more information.
Bit 6	Reserved for future use	-
Bit 7	Accessory Decoder	"0" = Multifunction Decoder, "1" = Accessory Decoder (see CV #541 for a description of assignments for bits 0-6)

Note: If the decoder does not support a feature contained in this table, it shall not allow the corresponding bit to be set improperly (i.e., the bit should always contain its default value).

Configuration Variable 30:　　ERROR Information

In the case where the decoder has an error condition this Configuration Variable shall contain the error condition as specified by the manufacturer. A value of "0" indicates that no error has occurred.

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Configuration Variable 31:   Index High Byte Configuration ~~Variable 32 Index Low Byte~~

255   The Indexed Address is the address of the indexed CV page when the decoder is set up for indexed CV operation. CV#31 contains the most significant bits of the two-byte address and may have any value between 00010000 and 11111111 inclusive. Values of 00000000 thru 00001111 are reserved by the NMRA for future use. (4096 indexed pages) CV#32 contains the least significant bits of the index address and may contain any value. This gives a total of 61,440 indexed pages, each with 256 bytes of CV data available to manufacturers.

260   **Note:** If the decoder does not support a feature contained in this table, it shall not allow the corresponding bit to be set improperly (i.e., the bit should always contain its default value).

Configuration Variable 32:   Index Low Byte

265   The Indexed Address is the address of the indexed CV page when the decoder is set up for indexed CV operation. CV#31 contains the most significant bits of the two-byte address and may have any value between 00010000 and 11111111 inclusive. Values of 00000000 thru 00001111 are reserved by the NMRA for future use. (4096 indexed pages) CV#32 contains the least significant bits of the index address and may contain any value. This gives a total of 61,440 indexed pages, each with 256 bytes of CV data available to manufacturers.

270   **Note:** If the decoder does not support a feature contained in this table, it shall not allow the corresponding bit to be set improperly (i.e., the bit should always contain its default value).

Configuration Variables 33-46:   Output Locations 1-14 for Functions FL(f), FL(r), and F1-F12

275   Contains a matrix indication of which function inputs control which Digital Decoder outputs. This allows the user to customize which outputs are controlled by which input commands. The outputs that Function FL(f) controls are indicated in CV #33, FL (r) in CV#34, F1 in CV #35, to F12 in CV#46. A value of "1" in each bit location indicates that the function controls that output. This allows a single function to control multiple outputs, or the same output to be controlled by multiple functions. CVs 33-37 control outputs 1-8. CVs

280   38-42 control outputs 4-11 CVs 43-46 control outputs 7-14. The defaults are FL (f) controls output 1, FL (r) controls output 2, F1 controls output 3 to F12 controls output 14. The lowest numbered output is in the LSB of the CV, as shown in the table below.

Table 5 - Output Position vs. CV (a 'd' indicates the default position)

CV	Description	MSB 14	13	12	11	10	9	Output 8	7	6	5	4	3	2	LSB 1
33	Forward Headlight FL(f)														d
34	Reverse Headlight FL(r)													d	
35	Function 1												d		
36	Function 2											d			
37	Function 3										d				
38	Function 4									d					
39	Function 5								d						
40	Function 6							d							
41	Function 7						d								
42	Function 8					d									
43	Function 9				d										
44	Function 10			d											
45	Function 11		d												
46	Function 12	d													

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Configuration Variable 47-64:   Manufacturer unique

Configuration Variable 65:   Kick Start

290   Specifies the amount of extra Kick that will supplied to the motor when transitioning between stop and the first speed step.

Configuration Variable 66:   Forward Trim

Specifies a scale factor by which a voltage drive level should be multiplied, when the controller is driving the unit in the forward direction. It is interpreted as n/128. If the
295   Forward Trim configuration variable contains a value of "0" then forward trim is not implemented.

Configuration Variables 67-94:   Speed Table

The speed table is defined to be 28 bytes wide, consisting of 28 values for forward speeds. A
300   digital controller that uses this table shall have at least 64 voltage drive levels and can have as many as 256 so that a smooth power curve can be constructed. Note that voltage drive levels are specified in integer values, in the same way as most other parameters. This means that a drive level of 1/4 maximum voltage corresponds to 0100000, not 0010000, as you would expect if the number specified a fraction with a fixed denominator, i.e., value 32 out
305   of a fixed 128 levels (see Definitions section).

Configuration Variable 95:   Reverse Trim

Specifies a scale factor by which a voltage drive level should be multiplied, when the controller is driving the unit in reverse. It is interpreted as n/128. If the Reverse Trim configuration variable contains a value of "0" then reverse trim is not implemented.

Configuration Variable 96 104:   NMRA Reserved

Configuration Variables 97-104:   Manufacturer unique

Configuration Variables 105, 106:   User Identification #1 and #2

These CVs are reserved for use by the owner of the decoder to store identification information, e.g., NMRA membership number. CV#105 is ID #1 and CV#106 is ID #2

Configuration Variable 107-111:   NMRA Reserved

CVs 107, 108: with CV8=0xEE, a 16-bit manufacturer ID is stored in these two CVs

CVs 109-111: with CV7=   , these three CVs expand the version number feature

Configuration Variables 107, 108:   Extended manufacturer ID / manufacturer specific CVs

If the value CV8=0xEE, a 12-bit manufacturer ID is stored in these two CVs. The 8 least significant bits go into CV108 with the 4 most significant bits going into CV107 bits 0-3; CV107 bits 4-7 must be 0000 and ignored by programming tools.

Configuration Variables 109 – 111:   Extended Manufacturer Version Number

These three CVs are intended for an extension of the manufacturer's version number in CV7. The values used in CV7 and CVs 109-111 are assigned at the manufacturer's discretion without restriction.

Configuration Variable 112-128:   Manufacturer unique

Configuration Variables 112-256:   Manufacturer unique

CVs in this range are already being used by many manufacturers. Opening up this area officially is an attempt to legitimize what is already being done.

Configuration Variable 257-512: Indexed access area. (see also CV#31, 32)

This is the indexed area. It contains a total of 65536 pages, each 256 bytes in length. The first 4096 pages are reserved for NMRA use. The remaining 61440 pages are available to manufacturers for their own purposes. For the manufacturer that needs only 256 additional bytes of CVs, he can simply specify a base address in CV#31-32 and not respond if that address is not enabled without actually paging data. The pages are addressed via CV 31 (high address bits) and CV 32 (lower address bits).

Configuration Variable 880-895:   Dynamic CVs

345 ~~CVs in this range are dynamic and are used for Unsolicited Decoder Initiated Transmission. Manufacturers who utilize these CVs are requested to contact the NMRA DCC WG for current uniform specifications.~~

Configuration Variables 880-896:   Reserved NMRA / RailCommunity

350 These CVs are reserved. CVs 892 to 896 were reserved for dynamic values to be read via RailCom but are not required at this point in time. Therefore, these CVs are also marked as reserved.

~~Configuration Variable 892:   Decoder Load~~

~~Specifies the current load of the decoder. The load is volatile and is not stored across power interruptions.~~

355 ~~Bits 0-6 indicate the value of the load with 0 indicating no load~~

~~Bit 7 indicates a positive or negative load.~~

~~Configuration Variable 893:   Flags~~

~~Up to 8 dynamic flags can be transmitted Bits 0-7 Reserved for future use.~~

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~~Configuration Variable 894:   Fuel/Coal~~

~~Specifies the amount of Fuel/Coal left before the decoder will stop the locomotive. A value of 0 indicates that the Fuel/Coal is totally consumed, a value of 254 indicates totally full and a value of 255 indicates that this CV is not currently supported, and its contents should not~~
365 ~~be transmitted~~

~~Configuration Variable 895:   Water~~

~~Specifies the amount of water left before the decoder will stop the locomotive. A value of 0 indicates that the water is totally consumed, a value of 254 indicates totally full and a value~~
370 ~~of 255 indicates that this CV is not currently supported, and its contents should not be transmitted.~~

Configuration Variables ~~896~~ 897-1024:   SUSI (Serial User Standard Interface)

Reserved ~~until March 2005~~ for use by SUSI to define CVs for Sound and Function auxiliary
375 modules. See Technical Note TI-9.2.3 for details.

1.3.3 Descriptions of Configuration Variables for Accessory Decoders

Previous version of this Standard established CVs 513-1024 to be used by accessory decoders. CVs 1-512 were reserved for NMRA use. However, many accessory decoders were sold that used CVs
380 1-512. This was done for various reasons, including in inability of some command stations to access CVs above 512. In recognition of many accessory decoders using the lower CVs and the desire to create more space for manufacturers, the CV definitions as previously defined have been moved

from 513-1024 down to 1-512. Using the CVs 513-1024, as defined in Table 2, are optional. The manufacturer may use these upper CVs in any manner they see appropriate. These changes will
385 allow existing accessory decoders to use CVs 513-1024 as previously defined.

1.3.3.1   Accessory Decoders – CV Support

Any accessory decoder using CVs for configuration must follow the NMRA CV standard as outlined in this document. Accessory decoders that do not support CVs for configuration must have detailed documentation that is readily available, i.e., instruction sheet(s) supplied with the decoder
390 or downloadable instructions from the manufacturer's website.

1.3.3.2   Accessory Decoders – Service Mode Programming

If an accessory decoder does not support programming mode it should be clearly noted in the decoder's documentation. Also, since identification is not possible by reading CVs, the decoder shall be clearly marked with the make and model number of the device.
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Table 6 - Accessory Decoder Configuration Variables

CV Name Accessory Decoders:	CV #	CV # (optional)	Required	Default Value	Read Only	Uniform Spec	Additional Comments
Decoder Address LSB	1	513	M	1		Y	6 LSB of accessory decoder address
Auxiliary Activation	2	514	O				Auxiliary activation of outputs
Time On F1	3	515	O				
Time On F2	4	516	O				
Time On F3	5	517	O				
Time On F4	6	518	O				
Manufacturer Version Info	7	519	M				Manufacturer defined version info
Manufacturer ID	8	520	M		Y	Y	Values assigned by NMRA
Decoder Address MSB	9	521	M	0		Y	3 MSB of accessory decoder address
	10-27		-				Reserved by NMRA for future use
Bi-Directional Communication Configuration	28	540	O			Y	
Accessory Decoder Configuration	29	541	M[1]			Y	similar to CV#29; for acc. decoders
	30		-				Reserved by NMRA for future use
Indexed Area Pointers	31, 32						Index High and Low Address
Manufacturer Unique	33-81		O				Reserved for manufacturer use
	82-111						Reserved by NMRA for future use
Manufacturer Unique	112-128		O				Reserved for manufacturer use
Manufacturer Unique	129-256						
Indexed Area	257-512						Indexed area - see CV# 31,32 Index address values of 0-4095 reserved by NMRA
Manufacturer Unique	513-895		O				Reserved for manufacturer use
	896-1024						Reserved by NMRA for future use

Configuration Variable 1 [513]:   Decoder Address (LSB)

Contains the low-order address bits for Accessory Decoders. The high-order address bits are stored in CV9 [521]. Two types of Accessory Decoder addressing are supported: Decoder-Address and Output-Address. An accessory decoder must support one type, and optionally the other type. The type of decoder is specified in CV29 [541], bit 6. Decoders using either type of addressing will respond to the same Accessory Decoder Control Packet when CV1 [513] = 1 and CV9 [521] = 0. The factory default value is 1. The type(s) of addressing supported must be clearly documented in the manual and on the packaging.

(1) Decoder-Address: Contains the six least significant bits of the accessory decoder's address in bits 0-5. These bits are transmitted as bits 0-5 in the first byte of the accessory decoder packet. See S-9.2.1 for more information.

(2) Output-Address: The user places the output address Contains the address value results from the following formula: Output Address modulus 256. (ex. Output Address mod 256, or Output Address % 256).

The values contained in CV1 [513] and CV9 [521] correspond to the bits in the Accessory Decoder packets as follows:

Accessory-Output = (CV1 [513] + (CV9 [521] *256)) - 1

Bits 0 & 1 of the Accessory-Output are transmitted as bits 1 & 2 of byte 2 of both Accessory Decoder Control Packets. Bits 2-7 of the Accessory-Output are transmitted as bits 0-5 of byte 1 of both Accessory Decoder Control Packets. The three least-significant bits of CV9 [521] contain the ones-complement of bits 4-6 of both Accessory Decoder Control Packets (See S-9.2.1 for more information on the Accessory Decoder Control Packets).

If an accessory decoder supports more than one sequential output the value in CV1 [513] will be the first output in the series

Configuration Variable 2 [514]:   Auxiliary Activation

Bits 1-8 = Auxiliary activation: = "0" output is not activated by an auxiliary input, "1" output can be activated by an auxiliary input.

Configuration Variables 3-6 [515-518]:   Time On for Functions F1-F4

Functions F1-F4 can have the time the outputs are active set by Configuration Variables 3 [515] – 6 [518]. Configuration Variable 3 [515] controls Function F1 and Configuration Variable 6 [518] Controls Function F4. Contains a time that the output is on each time the state of the function is activated. A value of all "0"s indicates continuous on.

Configuration Variable 7 [519]:   Manufacturer Version Number
          (See CV #7 for the description).

Configuration Variable 8 [520]:   Manufacturer ID
          (See Appendix A for a list of Manufacturer IDs; See CV #8 for the description).

Configuration Variable 9 [521]:   Decoder Address (MSB)

Contains the high-order address bits for Accessory Decoders. The low-order address bits are stored in CV1 [513]. Two types of Accessory Decoder addressing are supported: Decoder-Address and Output-Address. An accessory decoder must support one type, and optionally the other type. The type of decoder is specified in CV29 [541], bit 6. Decoders using either type of addressing will respond to the same Accessory Decoder Control Packet when CV1 [513] = 1 and CV9 [521] = 0. The type(s) of addressing supported must be clearly documented in the manual and on the packaging. The bits transmitted are the ones complement of the value in this CV. See S-9.2.1 for more information on the Accessory Decoder Control Packets.

(1) Decoder-Address: Contains the three most significant bits of the accessory decoder's address in bits 0-2. These bits are transmitted as bits 4-6 in the second byte of the accessory decoder packet.

(2) Output-Address: Contains the address value results from the quotient of the following formula: Output Address divided by 256 (Output Address div 256, Output Address / 256).

See CV513 [1] for an explanation of how to determine the contents of CV1 [513] and CV9 [521].

Configuration Variable 28 [540]:   Bi-Directional Communication Configuration

Used to configure decoder's Bi-Directional communication characteristics. when CV29 [541]-Bit 3 is set

Table 7 – CV 28 [540] Parameters

Bit #	Description	Setting
Bit 0	Enable/Disable Unsolicited Decoder Initiated Transmission	"0" = Disabled "1" = Enabled
Bit 1	Not Used	-
Bit 2	Reserved for future use.	-
Bit 3	Reserved for future use.	-
Bit 4	Reserved for future use.	-
Bit 5	Reserved for future use.	-
Bit 6	Flag Bits, Reserved for future use	-
Bit 7	Flag Bits, Reserved for future use	-

Note: If the decoder does not support a feature contained in this table, it shall not allow the corresponding bit to be set improperly (i.e., the bit should always contain its default value).

Configuration Variable 29 [541]:   Accessory Decoder Configurations Supported

Bit #	Description	Setting
Bit 0	Reserved for future use.	
Bit 1	Reserved for future use.	
Bit 2	Reserved for future use.	
Bit 3	Bi-Directional Communications	"0" = Bi-Directional Communications disabled "1" = Bi-Directional Communications enabled. See S-9.3.2 for more information.
Bit 4	Reserved for future use.	
Bit 5	Decoder Type	"0" = Basic Accessory Decoder "1" = Extended Accessory Decoder
Bit 6	Addressing Method	"0" = Decoder Address method "1" = Output Address method
Bit 7	Accessory Decoder	"0" = Multifunction Decoder (See CV-29 for description of bit Assignments for bits 0-6) "1" = Accessory Decoder If bit 7 = 1, then the decoder may ignore the two most-significant bits of the CV number in Service Mode only. Using this feature CV513 becomes CV1, etc.

465   Decoders which perform the translation must clearly document the feature in their manual.

Note: If the decoder does not support a feature contained in this table, it must not allow the corresponding bit to be set improperly (i.e., the bit should always contain its default value).

Configuration Variable 31:   Index Address High Byte

470 Configuration Variable 32:   Index Address Low Byte

The Indexed Address is the address of the indexed CV page when the decoder is set up for indexed CV operation. CV#31 contains the most significant bits of the two-byte address and may have any value between 00010000 and 11111111 inclusive. Values of 00000000 through 00001111 are reserved by the NMRA for future use. (4096 indexed pages) CV#32 475 contains the least significant bits of the index address and may contain any value. This gives a total of 61,440 indexed pages, each with 256 bytes of CV data available to manufacturers. Refer to previous section *1.3.2, Descriptions of Configuration Variables for Multi-Function Decoders* for CV31 and CV32 definitions.

2 Appendix A: Manufacturer ID codes as assigned by the NMRA
480

[This appendix is published separately since it is under constant revision]

3 Appendix B: Power Source Conversion codes as assigned by the NMRA

485

The following Power Source Conversion codes (via values placed in CV12) have been assigned by the NMRA Technical Department in harmony with RailCommunity. Manufacturers wishing to use conversions not on this list shall apply to the NMRA Technical Department for the assignment for a conversion ID.

490
          00000001 = ~~Analog Power Conversion~~ DC (Analog Mode Direct Current)
          00000010 = Radio Control
          00000100 = ~~Zero-1~~ DCC (digital operation)
          00001000 = ~~TRIX~~ Selectrix
          00010000 = ~~CTC 16 / Railcommand~~ AC (Analog Mode Alternating Current)
495
          00100000 = ~~FMZ (Fleischmann)~~ Motorola (digital operation)
          01000000 = mfx (digital operation)
          10000000 = Reserved for Future Protocols or Modes of Operation

4 Appendix C: Process for changing Manufacturer Specific CVs to Optional or Uniform.

500

[An official process whereby CVs incorporated initially as Manufacturer Specific options may be incorporated into the Standard for optional and/or uniform usage by all manufacturers needs to be defined and inserted here.]

505

5 Document History

Date	Description
July 1995	First Release
March 1997	Revisions approved by NMRA BOD
July 2003	Revisions approved by NMRA BOD
July 2006	Revisions approved by NMRA BOD
July 2007	Revisions approved by NMRA BOD
July 2012	Revisions approved by NMRA BOD
11-Nov-2022	Moved to new template format. Table 1 - Multi-function Decoder Configuration Variables – Requirement for CV2 thru CV5, CV17, and CV18 changed from Optional to Mandatory
20-Jan-2023	Added Sections 1.3.3.1, Accessory Decoders – CV Support; 1.3.3.2, Accessory Decoders – Programming Track Mode
8-Jun-2023	Added information to sections 1.2.1 Normative and 1.2.2 Informative. Changed CV 19 from Optional to Recommended. Removed references to Dynamic CVs. Reverted CVs 880-895 to reserved. Changes and corrections to Table 1 and to definitions for CVs 9, 10, 12, 16, 21, 22, 25, 27, 28 (including Table 2 and Table 3) to harmonize with RCN-225. CVs 97-104 changed to Manufacturer unique. CVs 107-111 changed to harmonize with RCN-225. Typos and miscellaneous corrections made. Definitions for Accessory Decoder CV31 and CV32 changed to refer to Mobile Decoder definitions for CVs 31-32. Appendix B changed to harmonize with RCN-225.

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