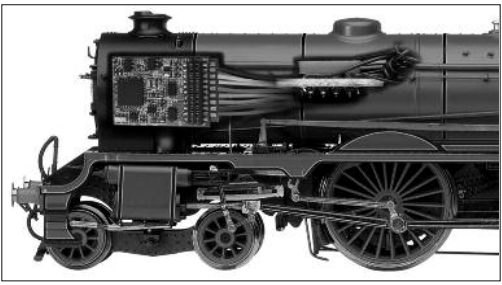
R8245 Locomotive Decoder



The Sapphire or professional decoder is NMRA compliant and tested. It also supports RailCom® and asymmetric DCC.

The Sapphire is fully compatable with both the Select and Elite systems.

The points below outline the Sapphires main benefits:

- Built to conform to all relevant NMRA Standards.
- High frequency back-emf motor control – high frequency to reduce audible noise.
- Supports RailCom®.
- Asymmetrical DCC support.
- Size: Length 23.0 mm x Width 17.0 mm x Height 5.0 mm.
- Low speed gear for shunting operations.
- 14, 28 and 128 speed steps.

- Optional operation on conventional DC layouts.
- Provides 1A continuous motor current, 1.5A stall.
- Four function outputs rated at 200mA each. Total current sum of function outputs = 500mA.
- Directional or independent lighting with dimming and extensive special effects.
- Supports advanced consist control and extended addressing.
- Support for programming on the mainline (operations mode programming).
- Support for all form of programming asx described in NMRA RP-9.2.3.
- 21-pin connector.

Important Note:

The locomotive must be removed from the track before installing or removing a locomotive decoder.

To prevent the risk of electro-static damage occurring to the decoder, NEVER directly touch the component parts of a decoder PCB.

1 Detailed specification

1.1 General specification

ID	Function	Description
GS001	NMRA standards	Designed and built to NMRA standards: S 9.1, S 9.2, RP 9.1.1, RP 9.2.1, RP 9.2.2, RP 9.2.3, RP 9.2.4, RP 9.3.1, RP 9.3.2.
GS002	NMRA Plug	21-pin system.
GS003	Current capacity	Total max continuous current carrying capacity: 1.5A. Motor output: 1A continuous, 1.5A stall. Functional output 1, 2, 3, 4: 200mA each. Total current-carrying capacity of function outputs: 500mA.
GS004	Protection	Motor overload protection. Functional output overload protection.
GS005	Motor drive	HEX FET H-Bridge drive for brushed DC motors. High-frequency control to reduce the audible noise. It is recognised that different motors require different feedback control algorithms and hence it is possible to select the algorithm. It is possible to fine tune performance via the various CV values. The algorithms will not support brushless or AC motors. The minimum, maximum and mid speed can be set and the decoder adapts the characteristic speed line dynamically to ensure a steady, even curve. It is also possible to program an individual characteristic speed curve.
GS006	Speed steps	14, 28, 128.
GS007	Size	Length 23.0mm x Width 17.0 mm x Height 5.0mm.
GS008	Addressing	Standard (basic) and advanced consist control and extended addressing.
GS009	Programming	Support for programming on the mainline (operations mode programming). Support for all form of programming as described in NMRA RP-9.2.3.
GS010	Starting & braking delay	Starting and breaking delays can be set independently of each other.
GS011	Shunting speed	A shunting speed mode can be entered which halves the speed of the locomotive and hence prevents accidents from happening.
GS012	Simulation	Amounts of water and fuel can be stored in the decoder which will enable simulation driving. Burn rate is proportional to the current speed the locomotive is traveling as normalized to a 128 speed step value.

ID	Function	Description
GS013	Asymmetrical DCC	The decoder is compatible with asymmetrical DCC and hence can automatically respond to certain sections of the layout and provide autonomous operation.
GS014	"Auto" control	Locomotive can start/stop based upon timer junctions, without input from the controller.
GS015	Clock	Built-in clock – this will be re-set when the power is cycled.
GS016	RailCom®	The decoder has complete bi-directional communication features.
GS017	Function outputs	The decoder has four function outputs can be mapped to the functions of the digital system according to NMRA specifications.
GS018	Lighting effects	Different lighting effects can be set at the four function outputs: • steady state, • strobe, • flickering/random fast flash, • flashing.

1.2 Supported CV values

CV Name	CV	Range	Default	Description
Primary Address	1	1-127	3	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 the decoder will go out of NMRA digital mode and convert to the alternate power source as defined by Configuration Variable #12.
Vstart	2	0-255	0	Vstart is used to define the voltage drive level used as the start voltage on the motor.
Acceleration Rate	3	0-255	5	Starting.
Deceleration Rate	4	0-255	5	Braking Delay.
Vhigh	5	0-255	255	Vhigh is used to specify the motor voltage drive levels at the maximum speed step.
Vmid	6	0-255	48	Vmid specifies the voltage drive level at the middle speed step.
Manufacturer Version No.	7	10	10	Manufacturer defined version info.

CV Name	CV	Range	Default	Description
Manufactured ID	8	48	48	Values assigned by NMRA.
EMF Feedback Cutout	10	1-128	128	Contains a value between 1 and 128 that indicates the speed step above which the back EMF motor control cuts off.
Extended Address High-Order Byte	17	192-231	192	The Extended Address is the locomotives address when the decoder is set up for extended 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.
Extended Address Low-Order Byte	18	0-255	100	
Consist Address	19	0-255	0	Contains a seven bit address in bit positions 0-6. Bit 7 indicates the relative direction of this unit within a consist.
Bi-Directional Communication Configuration — RailCom®	28	0-7	7	Used to Configure decoder's Bi-Directional communication characteristics when CV29-Bit 3 is set. Bit RailCom® configuration 7(dec). Bit 0: channel 1 release for address broadcast 1. Bit 1: channel 2 release for data 1. Bit 2: channel 1 release for command acknowledge 1.
Configuration Data #1	29	0-48	6	Configuration byte. 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. *Bit 1 = FL location: "0" = bit 4 in Speed and Direction instructions control FL, "1" = bit 4 in function group one instruction controls FL* *Bit 2 = Power Source Conversion: "0" = NMRA Digital Only, "1" = Power Source Conversion Enabled.* Bit 3 = Bi-Directional Communications: "0" = Bi-Directional Communications disabled, "1" = Bi-Directional Communications enabled. *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 = "0" = one byte addressing, "1" = two byte addressing (also known as extended addressing). 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).

CV Name	CV	Range	Default	Description
ERROR Information	30	0-7	0	B7 B6 B5 B4 B3 B2 B1 B0 X X X X X E3 E2 E1 Bit 0 Motor short-circuit. Bit 1 Light (OUTPUT0-1) short-circuit. Bit 2 Light (OUTPUT2-3) short-circuit. Bit 3-7 Always 0.
Function Mapping	33-36			Contains a matrix of which function inputs control which outputs.

			Default Value								
				Binary							
CV Name	CV	Range	Decimal	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3 (Light 3)	Bit 2 (Light 2)	Bit 1 (Light 1)	Bit 0 (Light 0)
Light activated upon F0 Forward	33	0-15	1	X	X	X	X	0	0	0	1
Light activated upon F0 Reverse	34	0-15	2	X	X	X	X	0	0	1	0
Light activated upon F1	35	0-15	4	X	X	X	X	0	1	0	0
Light activated upon F2	36	0-15	8	X	X	X	X	1	0	0	0

X : unimplemented , always 0.
Value in bit 3-0 of CV33-36 : 1 – activate the corresponding light.
0 – deactivate the corresponding light.

Read/Set clock — Hours	50	0-23	0	Real Time Clock: hours, Only Readable/writeable in Operational Mode.
Read/Set clock — Mins	51	0-59	0	Real Time Clock : mins, Only Readable/writeable in Operational Mode.
Asymmetric DCC configuration	52	0-7	0	bit 0 = 1 ABC activated. bit 1 = 1 ABC direction-dependency deactivated. bit 2 = 1 Activate push-pull operation with intermediate stop.
Intermediate stopping time	53	0-255	3	Intermediate stopping time in ADCC (in Sec).

CV Name	CV	Range	Default	Description
Speed Table	67-94	0-255		Speed table.
	67	0-255	1	
	68	0-255	2	
	69	0-255	3	
	70	0-255	5	
	71	0-255	8	
	72	0-255	11	
	73	0-255	16	
	74	0-255	20	
	75	0-255	26	
	76	0-255	31	
	77	0-255	39	
	78	0-255	45	
	79	0-255	54	
	80	0-255	62	
	81	0-255	72	
	82	0-255	81	
	83	0-255	92	
	84	0-255	102	
	85	0-255	115	
	86	0-255	126	
	87	0-255	141	
	88	0-255	153	
	89	0-255	169	
	90	0-255	182	
	91	0-255	199	

CV Name	CV	Range	Default	Description
	92	0-255	217	
	93	0-255	232	
	94	0-255	255	
User Identifier number #1	105	0-255	255	For customer use.
User Identifier number #2	106	0-255	255	For customer use.
Signal Time Out	111	0-59	20	Signal Time Out(second). While in digital operations mode each Multi Function Digital Decoder shall have a Packet Update time out value. While in digital operations mode, if the packet time-out value is exceeded, the Multi Function Digital Decoder will bring to a stop all controlled devices. The purpose of this time-out is to insure that each Multi Function Digital Decoder receives a periodic update from the Digital Command Station and thereby help prevent runaway conditions. The user should be able to define the value for this time-out within these restrictions: – a value of 0 disables the time-out (i.e., the user has chosen not to have a time-out). – a value range of 1 through TIMEOUT_MAX sets the time-out to the chosen value. The minimum value of TIMEOUT_MAX will be 20 seconds. It may be longer at the manufacturer's discretion.
Shunting mode	112	0-1	0	0- Shunting Mode Off. 1- Shunting Mode On.
Light effect of function output 0	113	0-3	0	0 – steady state. 1 – strobe. 2 – flickering / random fast flash. 3 – steady flashing.
Light effect of function. output 1	114	0-3	0	

CV Name	CV	Range	Default	Description
Light effect of function output 2	115	0-3	0	0 – steady state. 1 – strobe. 2 – flickering / random fast flash. 3 – steady flashing.
Light effect of function output 3	116	0-3	0	
Dimming Value for Output 0	117	0-15	15	Sets brightness for Output 0 for Light effect – steady state.
Dimming Value for Output 1	118	0-15	15	Sets brightness for Output 1 for Light effect – steady state.
Dimming Value for Output 2	119	0-15	15	Sets brightness for Output 2 for Light effect – steady state.
Dimming Value for Output 3	120	0-15	15	Sets brightness for Output 3 for Light effect – steady state.
Delay time – hour, before Events start	121	0-23	0	Set delay time : hour.
Delay time – min, before Events start	122	0-59	0	Set delay time : min.
Delay time – sec, before Events start	123	0-59	0	Set delay time : sec.
Event 1 – action	124	0-255	0	Set the speed and direction of locomotive in event 1.
				CV 124,128,132,136 action specification bit 0 to bit 6 (S0-S6) determine the normalized Speed (0 – 126) bit 7(Dir) determines Direction, normalized. By CV29 – default dir bit.

B7	B6	B5	B4	B3	B2	B1	B0
Dir	S6	S5	S4	S3	S2	S1	S0

Event 1 acting time – hour	125	0-23	0	Set event 1 running time : hour.
Event 1 acting time – min	126	0-59	0	Set event 1 running time : min.

CV Name	CV	Range	Default	Description
Event 1 acting time – sec	127	0-59	0	Set event 1running time : sec.
Event 2 – action	128	0-255	0	Set the speed and direction of locomotive in event 2.
Event 2 acting time – hour	129	0-23	0	Set event 2 running time : hour.
Event 2 acting time – min	130	0-59	0	Set event 2 running time : min.
Event 2 acting time – sec	131	0-59	0	Set event 2running time : sec.
Event 3 – action	132	0-255	0	Set the speed and direction of locomotive in event 3.
Event 3 acting time – hour	133	0-23	0	Set event 3 running time: hour.
Event 3 acting time – min	134	0-59	0	Set event 3 running time : min.
Event 3 acting time – sec	135	0-59	0	Set event 3 running time : sec.
Event 4 action	136	0-255	0	Set the speed and direction of locomotive in – event 4.
Event 4 acting time – hour	137	0-23	0	Set event 4 running time : hour.
Event 4 acting time – min	138	0-59	0	Set event 4 running time : min.
Event 4 acting time – sec	139	0-59	0	Set event 4 running time : sec.

CV Name	CV	Range	Default	Description
Event Control	140	–	0	Decimal Value: 0 No Event 1 Event 1. 2 Event 1+Event 2. 3 Event 1+Event 2+Event 3. 4 Event 1+Event 2+Event 3+Event4. 10 Repeating Event 1+Event 2. 11 Repeating Event 1+Event 2+Event 3. 12 Repeating Event 1+Event 2. +Event 3+Event 4.
Current Fuel/Coal	142	0-255	–	Equivalent to CV894, Only Readable/writeable in Operational Level Mode.
Current Water	143	0-255	–	Equivalent to CV895, Only Readable/writeable in Operational Level Mode.
Initial Coal	144	0-254	254	The initial value of CV142/CV894 upon power up cycle.
Initial Water	145	0-254	254	The initial value of CV143CV895 upon power up cycle.
Simulation Control Flag	146	0-3	0	B7 B6 B5 B4 B3 B2 B1 B0 X X X X X X • • B0: Simulation On/Off B1: Light Pattern 1 1- Simulation On. 0- Simulation Off. 1- Light Pattern 1 activated upon running out of water/coal. 0- No lighting effect upon running out of water/coal.
Motor Control algorithm	150	0-1	0	Decimal Number: 0: PID algorithm 0 (used in Intrain V1.3). 1: PID algorithm 1 (include the control for Lima Locomotive).

CV Name	CV	Range	Default	Description
Fuel/Coal	894	0-255	–	Amount of virtual fuel/coal stored in the locomotive for driving simulation Only Readable/writeable in Operational Mode.
Water	895	0-255	–	Amount of virtual water stored in the locomotive for driving simulation Only Readable/writeable in Operational Mode.

1.3 Hardware

Function	Description
Main MPU	Provides the main functionality – decodes track based signal, supplies PWM output to motor and provides functional output. The unit will support back EMF feedback control.
Amp	Amplify PWM signal to drive the motor. Capable of driving 1.0A continuous, 1.5A peak and stall.
Receive electronics	Receives the communications signal from the track and converts it to be compatible with the MPU. Also enables the module to operate under standard DC and pick-up asymmetric DCC.
Transmit electronics	Transmits the RailCom© signal to the track.

2 Regulations

The systems is built to the following safety and EMC standards:

EN71 Part 1 Mechanical and Physical properties.

EN71 Part 2 Flammability.

EN71 Part 3 Specification for the migration of certain elements.

EN71 Part 5 Chemical Toys (sets) other than experimental sets.

EN71 Part 6 Graphic Symbol for age warning abeling.

EN50088 Safety of Electrical Toys (both battery and mains).

EN61558-2-7 Specification for Low Voltage Power Supply Units – toys. (Previously EN60742).

EN55014 EMC The Electro Magnetic Compatibility Directive.

R&TTE (The Radio Equipment and Telecommunications Terminal Equipment Directive).

Australia/New Zealand 3108:1994. Approval and Test Specification-particular requirements for isolating transformers and safety isolating transformers.

ASTM (USA) F963A Mechanical and Electrical Toy Safety (ASTM-American Society of Testing and Materials).

CPSC (USA) (Consumer Product Safety Commission).

FCC (USA version of the EN55014 EMC).

UL Regulations: including UL696 and UL697 for the PSU – UL817 SPT-2 for cable assembly.

CUL Regulations: CAN/CSA-C22, No 173-M1983.

For dudiligence reasons, the system is designed to pass EN55022 – general EMC.