Network Notes

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Chapter 1

The Network Protocol

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1.1 Overview

Loconet is a peer-to-peer distributed network system on which all devices can monitor the network data flow. The network is event driven by different devices in time, and is not polled by a centralised controller in normal operation. The normal network state is quiet, with no data traffic unless a device has information to send.

The network data is sent in asynchronous format using 1 start bit, 8 data bits and 1 stop bit. The 8 bit data is transmitted least significant bit first. The bit times are 60.0 μS or 16,660 baud +/- 1.5%. A computer can connect to a Digitrax USB interface at higher baud rates and the device will make the necessary conversion. Bytes may be transmitted back-to-back, with a start bit immediately following the stop bit of the previous character.

All the network communications are via multi-byte messages. The command station is the device that maintains the refresh stack for DCC packet generation and generates the DCC track data. Refresh of information is typically only performed for a mobile decoder. A stationary decoder is not refreshed and individual immediate commands are sent out to the track as requested.

The command station is only privileged in respect to performing the task of maintaining the locomotive refresh stack and generating DCC packets. In this way other network transactions may occur that the command station does not need to be involved with or understand, as long as they follow the message protocol and timing requirements. i.e. other devices may have a dialog on the network without disturbing or involving the command

station. Devices on the network monitor the messages, check for format and data integrity and parse good messages to decode if action is required in the context. Devices such as throttles, input sensors, computer interfaces and control panels may generate the network messages without needing prompting or polling by a central controller.

Devices frequently will be added and removed from an operating the network. The devices and protocol are tolerant of electrical and data transients. The format chosen gives a good degree of data integrity, guaranteed quick network-state synchronisation, high data throughput, good distribution of access to many competing devices and low event latency.

1.2 Message Format

The data bytes on the network are defined as 8 bit data with the most significant bit as an opcode flag bit. If the most significant bit is 1, then the 7 least significant bits are interpreted as a network opcode. The opcode byte may only occur once in a valid message and is the first byte of a message. The opcode does not necessarily uniquely identify a message type. Sometimes the opcode must be used in combination with other bits or bytes in the message to determine the message type signature. All the remaining bytes in the message must have a most significant bit of 0, including the last checksum byte. The checksum is the 1's complement of the byte wise exclusive or of all the bytes in the message, except the checksum itself. To validate data accuracy, all the bytes in a correctly formatted message are exclusive or'ed. If this resulting byte value is 0xFF, then the message data is accepted as good. Any message that has format or framing errors, data errors or is a fragment caused by noise glitches and does not completely follow the message format will be ignored by all receivers, and a new opcode will be scanned for re-synchronisation.

The opcodes may be examined to determine message length and if subsequent response message is required. Data bits d6 and d5 encode the message length. The message length includes the opcode and the checksum bytes. When bit d3 equals 1 a follow-on message or reply is expected. For variable byte messages the byte following the opcode in the message is a 7 bit byte count.

d7	d6	d5	d4	d3	d2	d1	d0	
1	0	0	E	D	C	B	A	2 byte message
1	0	1	E	D	C	B	A	4 byte message
1	1	0	E	D	C	B	A	6 byte message
1	1	1	E	D	C	B	A	Variable length message.

The A,B,C,D,E are bits available to encode 32 opcodes per message length.

1.3 Slots

The command station contains an array of read/write slots. There are two classes of slots (locomotive slot and system slot) and two protocols for manipulating the slots. Protocol 1 allows up to 120 locomotive slots and each slot contains 10 bytes of data relating to the locomotive. Protocol 2 allows up to 960 locomotive slots and each slot contains 15 bytes of data relating to the locomotive. Not all command stations implement both protocols. A command station may also not implement the maximum number of locomotive slots for the protocols it supports. Where a command station implements both protocols messages from both protocols can be freely mixed. The user should check the Global System Track Status bits in a **LocoSlotDataP1** or **LocoSlotDataP2** response to determine which protocols are supported. In this document message mnemonics that are suffixed "P1" belong to protocol 1 and those suffixed "P2" belong to protocol 2. Protocol 1 uses a single 7 bit number to identify a slot. Protocol 2 uses a 3 bit number to identify the page or bank of slots and a 7 bit number to identify the slot within the page or bank. In both protocols slots numbered 0 to 119 (0x00 to 0x77) are locomotive slots and those numbered 120 to 127 (0x78 to 0x7F) are system slots. The slot number is similar to a file handle. System slots are encoded differently from the locomotive slots.

System Slot#	Description
123 (0x7B)	Fast Clock
124 (0x7C	Programming Interface
127 (0x7F)	Option Switch Settings

Initially all locomotive slots are empty and are said to be Free. A Free slot does not have a locomotive address loaded and no DCC commands are generated by the command station for it. To control a locomotive a throttle must request a slot from the command station and take ownership of it.

1.3.1 Slot State

A locomotive slot's slot state is determined by bits d5 and d4 of the Slot Status 1 byte of the applicable **LocoSlotData1** or **LocoSlotDataP2** response and whether the locomotive's address has been loaded. The slot state determines whether DCC commands are generated for it and if throttles can take control of it.

Slot State	d5	d4	Address Loaded	Decoder Refreshed	Any Throttle
Free	0	0	No	No	Yes
New	0	0	Yes	No	Yes
Common	0	1	Yes	Yes	Yes
Idle	1	0	Yes	No	Yes
In-Use	1	1	Yes	Yes	No

1.3.2 Throttle ID

The Throttle ID for a physical throttle is derived from the throttle's serial number. Digitrax serial numbers are 16-bit numbers. The Throttle ID is split into two parts consisting of the least significant bits of the low and high bytes of the serial number respectively. For example a physical throttle with the serial number of 0xFFFE would have a Throttle ID of 0x7E 0x7F with 0x7E being the low byte. The low byte of the Throttle ID is required by some of the protocol 2 commands to ensure that only the throttle that has ownership of the locomotive slot is the one that updates the slot. A software throttle should choose a Throttle ID that does not clash with that of a physical throttle.

1.3.3 Protocol 1

1. The throttle requests a slot for the locomotive address by sending either a **GetLocoSlotDataSAdrP1** or **GetLocoSlotDataLAdrP1** request to the command station. Which one depends on what type of address the locomotive's decoder is programmed to use.
2. If a slot has been previously loaded with the locomotive's address, then the command station will return a **LocoSlotDataP1** response.
3. If the locomotive's address is not currently in a slot, then the command station will load the new locomotive address into a Free slot, with speed equal to zero, direction forwards, functions off and 128 step mode, and return a **LocoSlotDataP1** response.
4. If there are no Free slots to load the new locomotive address into, the command station with return a **NoFreeSlotsP1** response and this procedure is terminated.
5. The throttle must then examine the slot data bytes to work out how to process the command station response.
6. If the slot state is New, Common or Idle then the throttle requests a "null move" operation by sending the command station a **MoveSlotsP1** request. The command station returns a **LocoSlotDataP1** response.

7. If the slot state is In-Use and the slot's Throttle ID does not match that of the throttle then the throttle should ask the user if they wish to "steal" the slot. If the answer is no then this procedure is terminated.

8. The throttle now takes ownership of the slot by updating the slot's Throttle ID to that of the throttle and writing the updated slot data to the command station by sending a **SetLocoSlotDataP1** request. If the request is successful then the command station will return a **setSlotDataOKP1** response.

9. The throttle will then be able to update speed, direction and function information. Whenever slot information is changed in an active slot, the slot is flagged to be updated as the next DCC packet sent to the track.

1.3.4 Protocol 2

1. The throttle requests a slot for the locomotive address by sending either a **GetLocoSlotDataSAdrP2** or **GetLocoSlotDataLAdrP2** request to the command station. Which one depends on what type of address the locomotive's decoder is programmed to use.

2. If a slot has been previously loaded with the locomotive's address, then the command station will return a **LocoSlotDataP2** response.

3. If the locomotive's address is not currently in a slot, then the command station will load the new locomotive address into a Free slot, with speed equal to zero, direction forwards, functions off and 128 step mode, and return a **LocoSlotDataP2** response.

4. If there are no Free slots to load the new locomotive address into, the command station with return a **NoFreeSlotsP2** response and this procedure is terminated.

5. The throttle must then examine the slot data bytes to work out how to process the command station response.

6. If the slot state is New, Common or Idle then the throttle requests a "null move" operation by sending the command station a **MoveSlotsP2** request. The command station returns a **LocoSlotDataP2** response.

7. If the slot state is In-Use and the slot's Throttle ID does not match that of the throttle then the throttle should ask the user if they wish to "steal" the slot. If the answer is no then this procedure is terminated.

8. The throttle now takes ownership of the slot by updating the slot's Throttle ID to that of the throttle and writing the updated slot data to the command station

by sending a **SetLocoSlotDataP2** request. If the request is successful then the command station will return a **setSlotDataOKP2** response.

9. The throttle will then be able to update speed, direction and function information. Whenever slot information is changed in an active slot, the slot is flagged to be updated as the next DCC packet sent to the track.

Example:

```
getLocoSlotDataSAdrP2
     0xbe 0x00 0x17 0x56

locoSlotDataP2
     0xe6 0x15 0x01 0x05 0x03 0x17 0x00 0x47 0x00 0x00
     0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x5b

moveSlotsP2
     0xd4 0x39 0x05 0x01 0x05 0x13

locoSlotDataP2
     0xe6 0x15 0x01 0x05 0x33 0x17 0x00 0x47 0x00 0x00
     0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x6b

setLocoSlotDataP2
     0xee 0x15 0x01 0x05 0x33 0x17 0x00 0x47 0x00 0x00
     0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x6d 0x52 0x5c

setSlotDataOKP2
     0xb4 0x6e 0x7f 0x5a
```

1.3.5 Purging

If a device disconnects from the network and so does not access or reference a slot within the system purge time, the command station will force the un-accessed slot to Common status so other system devices can use the slot. The typical purge time of a command station is about 200 seconds. A good "ping" or slot update activity is about every 100 seconds, i.e. if a user makes no change to a throttle/slot within 100 seconds, the throttle/device should automatically send another speed update at the current speed to reset the purge timeout for that slot.

1.4 Messages

The following information is provided for each of the messages:

Description:

Description of the message's function.

Protocol:

Which protocol the message belongs to. Only messages that relate to refresh slots belong to a protocol.

Group:

Which message size group the message belongs to.

Opcode:

The opcode mnemonic. This is the Digitrax assigned mnemonic when known.

Type:

The message type - broadcast, command, response, or message.

Encoding:

How the message is encoded byte by byte.

Response:

The response expected from a command message, if applicable.

Signature:

The bits and bytes that must be tested to determine the message's unique type.

Notes:

Any notes.

1.4.1 Ack

Description:

This message provides a response code from a command.

Group:

4-Byte Message

Opcode:

OPC_LONG_ACK

Type:

Response

Encoding:

Byte 0:

1	0	1	1	0	1	0	0	0xB4	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<LOPC>	Opcode of the command that this message is a response to with the most significant bit set to 0.

Byte 2:

0	n	n	n	n	n	n	n	<ACK1>	Response code.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	1	0	1	0	0	0xB4

Notes:

None.

1.4.2 Busy

Description:

The **Busy** broadcast message allows the command station to keep the network active whilst it is performing a task that requires a response, and entails a significant processing delay, i.e. it can ensure no new requests are started until it has responded to the last message. The **Busy** message should be simply stripped and ignored.

Group:

2-Byte Message

Opcode:

OPC_BUSY

Type:

Broadcast

Encoding:

Byte 0:

1	0	0	0	0	0	0	1	0x81	Opcode.

Byte 1:

0	1	1	1	1	1	1	0	0x7E	Checksum.

Response:

None

Signature:

Byte 0:

1	0	0	0	0	0	0	1	0x81

Notes:

None.

1.4.3 CfgSlotDataP1

Description:

This response provides the current command station configuration slot data. It is sent by the command station in response to the **GetCfgSlotDataP1** command.

Protocol:

1

Group:

Variable-Byte Message

Opcode:

OPC_SL_RD_DATA

Type:

Response

Encoding:

Byte 0:

1	1	1	0	0	1	1	1	0xE7	Opcode.

Byte 1:

0	0	0	0	1	1	1	0	0x0E	Message length (14 bytes).

OST1 to OST6 encode the command station's option switch table. The narrative is based upon information in the the DCS210 and DCS240 user manuals. A bit value of 1 means that the switch is closed and a value of 0 means that a switch is thrown. OpSw 8, OpSw 16, OpSw 24, OpSw 32 and OpSw 40 cannot be read due to bit 7 being cleared in the message format. The manual shows these switches as defaulting to thrown, i.e. 0, and are flagged in all cases except OpSw 40 as "do not change".

Byte 2:

0	1	1	1	1	1	1	1	0x7F	Configuration slot number.

Byte 3:

0	d6	d5	d4	d3	d2	d1	d0	<OST1>	Option switch table byte 1.

Bit	Switch #	Default	Effect on system operation
d6	OpSw 07	t	do not change
d5	OpSw 06	t	t = check for decoder before programming
			c = program without checking for device
d4	OpSw 05	t	do not change
d3	OpSw 04	t	do not change
d2	OpSw 03	t	t = command station's booster normal
			c = command station's booster is auto reversing
d1	OpSw 02	t	t = command station mode
			c = booster only mode.
d0	OpSw 01	t	do not change.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0

<OST2> Option switch table byte 2.

Bit	Switch #	Default	Effect on system operation
d6	OpSw 15	t	t = purging will not change loco speed
			c = purging will force a loco to 0 speed
d5	OpSw 14	t	t = loco address purging enabled
			c = loco address purging disabled
d4	OpSw 13	t	t = loco address purge time 200 seconds
			c = loco address purge time 600 seconds
d3	OpSw 12	t	do not change
d2	OpSw 11	t	do not change
d1	OpSw 10	c	do not change
d0	OpSw 09	c	do not change

Byte 5:

0	d6	d5	d4	d3	d2	d1	d0

<OST3> Option switch table byte 3.

Bit	Switch #	Default	Effect on system operation
d6	OpSw 23	t	SW23
d5	OpSw 22	c	SW22
d4	OpSw 21	c	SW21
d3	OpSw 20	t	t = enable address 0x00 or analog stretching for conventional locos . c = disable address 0x00 or analog stretching for conventional locos
d2	OpSw 19	t	do not change
d1	OpSw 18	t	t = normal command station booster short circuit shutdown time c = extended command station booster short circuit shutdown time
d0	OpSw 17	t	t = automatic advanced decode (FX) consists are enabled c = automatic advanced decode (FX) consists are disabled

SW21	SW22	SW23	Global system default type for new locos
t	t	t	28 step mode
t	t	c	reserved
t	c	t	14 step mode
t	c	c	reserved
c	t	t	reserved
c	t	c	reserved
c	c	t	128 step mode
c	c	c	128 step FX mode

Byte 6:

0	d6	d5	d4	d3	d2	d1	d0	<OST4>	Option switch table byte 4.

Bit	Switch #	Default	Effect on system operation
d6	OpSw 31	t	t = normal route/switch output rate when not trinary c = fast route/switch output rate when not trinary
d5	OpSw 30	t	do not change
d4	OpSw 29	t	do not change
d3	OpSw 28	t	t = enable interrogate commands at power on c = disable interrogate commands at power on
d2	OpSw 27	t	t = enable normal switch commands, a.k.a. the "Bushby bit" c = disable normal switch commands, a.k.a. the "Bushby bit" (allows attached computer to handle switch control logic)
d1	OpSw 26	c	t = disable routes c = enable routes
d0	OpSw 25	t	t = enable route echo over the Network c = disbale route echo over the Network

Byte 7:

0	d6	0	0	d3	d2	d1	d0	<TRK>	Global system track status.

d6	1 means this command station implements version 2 slot commands. This can be turned off on the DCS240 by setting the OpSw 44 to be closed.
d3	1 means the programming track is busy.
d2	1 means this master implements the Network version 1.1 capability, 0 means the master is a DT200.
d1	0 means the track is paused, broadcast an emergency stop.
d0	1 means the DCC packets are on in the master, global power up.

Byte 8:

0	d6	d5	d4	d3	d2	d1	d0

<OST5> Option switch table byte 5.

Bit	Switch #	Default	Effect on system operation
d6	OpSw 39	t	c = clear all internal memory states, including OpSw 36 and 37
d5	OpSw 38	t	t = loco reset button activates OpSw 39 c = loco reset activates slot zero
d4	OpSw 37	t	c = clears all routes
d3	OpSw 36	t	c = clears all mobile decoder info and consists
d2	OpSw 35	t	t = enables loco reset buttone c = disable loco reset button
d1	OpSw 34	t	t = disallow track to power up to run state, if set to run prior to power up c = allow track to power up to run state, if set to run prior to power up
d0	OpSw 33	c	t = track power off at power on c = allow track power to restore to prior state at power on

Byte 9:

0	d6	d5	d4	d3	d2	d1	d0

<OST6> Option switch table byte 6.

Bit	Switch #	Default	Effect on system operation
d6	OpSw 47	t	t = normal program track setting c = program track is brake generator when not programming. Braking is DCC set to speed 0 (not emergency stop) for address 0, light on, broadcast to all addresses.
d5	OpSw 46	t	do not change
d4	OpSw 45	t	t = enable reply for switch state request c = disable reply for switch state request
d3	OpSw 44	t	do not change (DCS210)
	OpSw 44	t	maximum slots to 400 (DCS240) and enable protocol 2 support
	OpSw 44	c	maximum slots to 120 (DCS240) and disable protocol 2 support
d2	OpSw 43	t	t = enable the Network update of command station's track status c = disable the Network update of command station's track status
d1	OpSw 42	t	t = enable 2 short beeps when loco address purged c = disable 2 short beeps when loco address purged
d0	OpSw 41	t	t = diagnostic click disabled c = diagnostic click when valid the Network commands incoming and routes being output

Byte 10:

0	d6	d5	d4	d3	d2	d1	d0

Unknown.

d6
d5
d4
d3
d2
d1
d0

Byte 11:

0	n	n	n	n	n	n	n	<CSM>	Product code.

Product Code	Model
0x1B	DCS210
0x1C	DCS240

Byte 12:

0	d6	d5	d4	d3	d2	d1	d0	Unknown.

d6
d5
d4
d3
d2
d1
d0

Byte 13:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	1	0	0	1	1	1	0xE7

Byte 1:

0	0	0	0	1	1	1	0	0x0E

Byte 2:

0	1	1	1	1	1	1	1	0x7F

Byte 7:

0	×	0	0	×	×	×	×

Notes:

None.

1.4.4 ConsistDirF0F4

Description:

This command sets the consist element's direction and function F0 to F4 states.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_CONSIST_FUNC

Type:

Command

Encoding:

Byte 0:

1	0	1	1	0	1	1	0	0xB6	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	0	d5	d4	d3	d2	d1	d0	<DIRF>	Consist element's direction and function F0 to F4 states.

d5	Direction: 1 means forward and 0 means backwards.
d4	F0 state: 1 means on and 0 means off.
d3	F4 state: 1 means on and 0 means off.
d2	F3 state: 1 means on and 0 means off.
d1	F2 state: 1 means on and 0 means off.
d0	F1 state: 1 means on and 0 means off.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	1	0	1	1	0	0xB6

Byte 1:

0	n	n	n	n	n	n	n	less than 0x78

Byte 2:

0	0	×	×	×	×	×	×

Notes:

None.

1.4.5 GetBrdOpSw

Description:

Get board option switch setting.

Group:

6-Byte Message

Opcode:

OPC_BRD_OPSW (unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	0	0	0	0xD0	Opcode.

Byte 1:

0	1	1	0	0	0	1	d0	The bit d0 is the most significant bit of the board id.

Byte 2:

0	n	n	n	n	n	n	n	<BIDL>	Least significant 7 bits of the board id.

Byte 3:

0	n	n	n	n	n	n	n	<BTYPE>	Board type code.

Board	Type Code
PM4	0x70.
BDL16	0x71.
SE8C	0x72.
DS64	0x73.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Byte and bit number.

The high nibble encodes the byte number, and the low nibble the bit number. The byte number is calculated as (OpSw# - 1) >> 3 and the bit number is (OpSw# - 1) - byte number × 8.

Byte 5:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

Ack ¡- *** SHOULD NOT BE A RESPONSE ***

Signature:

Byte 0:

1	1	0	1	0	0	0	0	0xD0

Byte 1:

0	1	1	0	0	0	1	×

Notes:

*** THIS HAS NOT BEEN TESTED ***

1.4.6 GetCfgSlotDataP1

Description:

This command requests the configuration slot data. The command station responds with a **CfgSlotDataP1** message.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_RQ_SL_DATA

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	0	1	1	0xBB	Opcode.

Byte 1:

0	1	1	1	1	1	1	1	0x7F

Byte 2:

0	0	0	0	0	0	0	0	0x00

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

CfgSlotDataP1

Signature:

Byte 0:

1	0	1	1	1	0	1	1	0xBB

Byte 1:

0	1	1	1	1	1	1	1

0x7F

Byte 2:

0	0	0	0	0	0	0	0

0x00

Notes:

None.

1.4.7 GetInterfaceData

Description:

This command is sent by a computer to request an **InterfaceData** response from the attached network interface device.

Group:

2-Byte Message

Opcode:

OPC_BUSY

Type:

Command

Applicable Hardware:

Digitrax PR4 and DCS240.

Encoding:

Byte 0:

1	0	0	0	0	0	0	1	0x81	Opcode.

Byte 1:

0	1	1	1	1	1	1	0	0x7E	Checksum.

Response:

Interface device returns an **InterfaceData** response.

Signature:

None - the command is intercepted by the interface and is not passed on to the network.

Notes:

None.

1.4.8 GetLocoSlotDataLAdrP1

Description:

This command requests the slot number for the selected locomotive address. If the locomotive is found in the slot table then the command station returns an **LocoSlotDataP1** response with the slot information. If it is not found then the command station will put the locomotive into a free slot and then return an **LocoSlotDataP1** response with the slot information. If there are no free slots then the command station returns an **Ack** containing a response code of 0x00.

The command station will generate NMRA 14 bit or long address packets for the locomotive. The address must be in the range 128 to 9983.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_LOCO_ADR

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	1	1	1	0xBF	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<ADR2>	Address high 7 bits.

Byte 2:

0	n	n	n	n	n	n	n	<ADR>	Address low 7 bits.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP1 if success, otherwise

Ack

<LOPC>	<ACK1>	Meaning
0x3F	0x00	No free slot, command failed.

Signature:

Byte 0:

1	0	1	1	1	1	1	1	0xBF

Byte 1:

0	n	n	n	n	n	n	n	not equal to 0

Notes:

This command is not supported by the Digitrax DT200 command station.

1.4.9 GetLocoSlotDataLAdrP2

Description:

This command requests the slot number for the selected locomotive address. If the locomotive is found in the slot table then the command station returns an **LocoSlotDataP2** response with the slot information. If it is not found then the command station will put the locomotive into a free slot and then return an **LocoSlotDataV2** response with the slot information. If there are no free slots then the command station returns an **Ack** containing a response code of 0x00.

The command station will generate NMRA 14 bit or long address packets for the locomotive. The address must be in the range 128 to 9983.

Protocol:

2

Group:

4-Byte Message

Opcode:

OPC_LOCO_ADR_P2 (unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	1	1	0	0xBE	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<ADR2>	Address high 7 bits.

Byte 2:

0	n	n	n	n	n	n	n	<ADR>	Address low 7 bits.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP2 if success, otherwise

Ack.

<LOPC>	<ACK1>	Meaning
0x3E	0x00	No free slot, command failed.

Signature:

Byte 0:

1	0	1	1	1	1	1	0	0xBE

Byte 1:

0	n	n	n	n	n	n	n	not equal to 0

Notes:

None.

1.4.10 GetLocoSlotDataP1

Description:

This command requests the locomotive slot data for the specified slot number. The command station responds with a **LocoSlotDataP1** response.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_RQ_SL_DATA

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	0	1	1	0xBB	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	0	0	0	0	0	0	d0	0x00

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP1

Signature:

Byte 0:

1	0	1	1	1	0	1	1	0xBB

Byte 1:

0	n	n	n	n	n	n	n	less than 0x78

Byte 2:

0	0	0	0	0	0	0	d0	0x00

Notes:

None.

1.4.11 GetLocoSlotDataP2

Description:

This command requests the locomotive slot data for the specified slot number. The command station responds with a **LocoSlotDataP2** response.

Protocol:

2

Group:

4-Byte Message

Direction: → Switch

Opcode:

OPC_RQ_SL_DATA

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	0	1	1	0xBB	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	1	0	0	d3	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7. The bit d3 does something but its function is not yet known.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP2

Signature:

Byte 0:

1	0	1	1	1	0	1	1	0xBB

Byte 1:

0	n	n	n	n	n	n	n	less than 0x78

Byte 2:

0	1	0	0	×	×	×	×

Notes:

None.

1.4.12 GetLocoSlotDataSAdrP1

Description:

This command requests the slot number for the selected locomotive address. If the locomotive is found in the slot table then the command station returns an **LocoSlotDataP1** response with the slot information. If it is not found then the command station will put the locomotive into a free slot and then return an **LocoSlotDataP1** response with the slot information. If there are no free slots then the command station returns an **Ack** containing a response code of 0x00.

The command station will generate NMRA 7 bit or short address packets for the locomotive. The address has the range 0 to 127. The analog locomotive is selected with address 0.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_LOCO_ADR

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	1	1	1	0xBF	Opcode.

Byte 1:

0	0	0	0	0	0	0	0	0x00	

Byte 2:

0	n	n	n	n	n	n	n	<ADR>	Short address in the range 0 to 127.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP1 if success, otherwise

Ack

<LOPC>	<ACK1>	Meaning
0x3F	0x00	No free slot, command failed.

Signature:

Byte 0:

1	0	1	1	1	1	1	1	0xBF

Byte 1:

0	0	0	0	0	0	0	0	0x00

Notes:

None.

1.4.13 GetLocoSlotDataSAdrP2

Description:

This command requests the slot number for the selected locomotive address. If the locomotive is found in the slot table then the command station returns an **LocoSlotDataP2** response with the slot information. If it is not found then the command station will put the locomotive into a free slot and then return an **LocoSlotDataP2** response with the slot information. If there are no free slots then the command station returns an **Ack** containing a response code of 0x00.

The command station will generate NMRA 7 bit or short address packets for the locomotive. The address has the range 0 to 127. The analog locomotive is selected with address 0.

Protocol:

2

Group:

4-Byte Message

Opcode:

OPC_LOCO_ADR_P2 (unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	1	1	0	0xBE	Opcode.

Byte 1:

0	0	0	0	0	0	0	0	0x00

Byte 2:

0	n	n	n	n	n	n	n	<ADR>	Short address in the range 0 to 127.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP2 if success, otherwise

Ack

<LOPC>	<ACK1>	Meaning
0x3E	0x00	No free slot, command failed.

Signature:

Byte 0:

1	0	1	1	1	1	1	0	0xBE

Byte 1:

0	0	0	0	0	0	0	0	0x00

Notes:

None.

1.4.14 IMMPacket

Description:

Send n-byte DCC immediate packet.

Group:

Variable-Byte Message

Opcode:

OPC_IMM_PACKET

Type:

Command

Encoding:

Byte 0:

1	1	1	0	1	1	0	1	0xED	Opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x0B	Message length (11 bytes).

Byte 2:

0	1	1	1	1	1	1	1	0x7F

Byte 3:

0	d6	d5	d4	0	d2	d1	d0	<REPS>	Number of immediate bytes and repeat count.

d6 N2. Number of immediate bytes.
d5 N1. Number of immediate bytes.
d4 N0. Number of immediate bytes.
d2 R2. Repeat count.
d1 R1. Repeat count.
d0 R0. Repeat count.

Byte 4:

0	0	1	d4	d3	d2	d1	d0	<DHII>	High bits of IM1 to IM5.

d4 IM5.7. High bit.
d3 IM4.7. High bit.
d2 IM3.7. High bit.
d1 IM2.7. High bit.
d0 IM1.7. High bit.

Byte 5:

0	d6	d5	d4	d3	d2	d1	d0	<IM1>	Data item 1 low 7 bits.

Byte 6:

0	d6	d5	d4	d3	d2	d1	d0	<IM2>	Data item 2 low 7 bits.

Byte 7:

0	d6	d5	d4	d3	d2	d1	d0	<IM3>	Data item 3 low 7 bits.

Byte 8:

0	d6	d5	d4	d3	d2	d1	d0	<IM4>	Data item 4 low 7 bits.

Byte 9:

0	d6	d5	d4	d3	d2	d1	d0	<IM5>	Data item 5 low 7 bits.

Byte 10:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

Ack.

<LOPC>	<ACK1>	Meaning
0x7D	0x7F	Command OK, if command station.
0x7E	<lim address>	Command OK, if limited master.
0x7D	0x00	Internal buffer busy or full.

Signature:

Byte 0:

1	1	1	0	1	1	0	1	0xED

Byte 1:

0	0	0	1	0	0	0	0	0x0B

Byte 2:

0	1	1	1	1	1	1	1

0x7F

Byte 3:

0	×	×	×	0	×	×	×

Byte 4:

0	0	1	×	×	×	×	×

Notes:

None.

1.4.15 InterfaceData

Description:

This is sent by an interface device in response to a **getInterfaceData** command.

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Response

Applicable Hardware:

Digitrax PR4 and DCS240.

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x10	Message length (16 bytes).

Byte 2:

0	0	1	0	0	0	1	0	0x22

Byte 3:

0	0	1	0	0	0	1	0	0x22

Byte 4:

0	0	0	0	0	0	0	1	0x01

Byte 5:

0	0	0	0	0	0	0	0	0x00

Byte 6:

0	n	n	n	n	n	n	n	<D1>	Serial Number low byte low 7 bits.

Byte 7:

0	n	n	n	n	n	n	n	<D2>	Serial Number high byte low 7 bits.

Byte 8:

0	n	n	n	n	n	n	n	<D3>	It contains a value but the meaning is unknown.

Byte 9:

0	n	n	n	n	n	n	n	<D4>	Unknown - set to zero for PR4 and DCS240.

Byte 10:

0	n	n	n	n	n	n	n	<PXCT2>	Unknown - set to zero for PR4 and DCS240.

Byte 11:

0	n	n	n	n	n	n	n	<D5>	Maybe hardware version.

Byte 12:

0	n	n	n	n	n	n	n	<D6>	Software version.

Byte 13:

0	n	n	n	n	n	n	n	<D7>	Maybe hardware version.

Byte 14:

0	n	n	n	n	n	n	n	<D8>	Product code.

Byte 15:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None

Signature:

Byte 0:

1	1	1	0	0	1	0	1	0xE5

Byte 1:

0	0	0	1	0	0	0	0	0x10

Byte 2:

0	0	1	0	0	0	1	0	0x22

Byte 3:

0	0	1	0	0	0	1	0	0x22

Byte 4:

0	0	0	0	0	0	0	1	0x01

Byte 5:

0	0	0	0	0	0	0	0	0x00

Byte 10:

0	0	0	0	0	0	0	0	0x00

Notes:

```
PR4 #1

<D0> 0xe5 OPCODE
<D1> 0x10 LENGTH
<D2> 0x22 SRC
<D3> 0x22 DSTL
<D4> 0x01 DSTH
<D5> 0x00 PXCT1 <- I would have expected b4 = 1
<D6> 0x08 Serial Number Low Byte
<D7> 0x07 Serial Number High Byte - Actual serial number 0x0788
<D8> 0x16
<D9> 0x00
<D10> 0x00 PXCT2
<D11> 0x00
<D12> 0x00
<D13> 0x00
<D14> 0x24 Product Code for PR4
<D15> 0x36  CHSUM

PR4 #2

<D0> 0xe5 OPCODE OPC_PEER_XFER
<D1> 0x10 LENGTH
<D2> 0x22 SRC
```

```
<D3> 0x22 DSTL
<D4> 0x01 DSTH
<D5> 0x00 PXCT1
<D6> 0x57 Serial Number Low Byte
<D7> 0x13 Serial Number High Byte - Actual serial number 0x1357
<D8> 0x16
<D9> 0x00
<D10> 0x00 PXCT2
<D11> 0x00
<D12> 0x00
<D13> 0x00
<D14> 0x24 Product Code for PR4
<D15> 0x7d CHKSUM

DCS240

<D0> 0xe5 OPCODE
<D1> 0x10 Length
<D2> 0x22 SRC
<D3> 0x22 DSTL
<D4> 0x01 DSTH
<D5> 0x00 PXCT1 <- I would have expected b4 to be 1
<D6> 0x2b Serial Number Low Byte
<D7> 0x0a  Serial Number High Byte - Actual serial number 0x0aab
<D8> 0x14
<D9> 0x00
<D10> 0x00 PXCT2
<D11> 0x01 Hardware Version?
<D12> 0x03 Software Version
<D13> 0x01 Hardware Version?
<D14> 0x1c Product Code for DCS240
<D15> 0x21
```

1.4.16 IPLDataLoad

Description:

This command loads firmware data into a device that supports IPL. D1 is the lowest addressed byte and D8 is the highest addressed byte.

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Command

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x10	Message length (16 bytes).

Byte 2:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 3:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 4:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 5:

0	1	0	0	d3	d2	d1	d0	<PXCT1>	Download code 0x40 and high bits of D1 to D4.

d3 D4.7. High bit
d2 D3.7. High bit
d1 D2.7. High bit
d0 D1.7. High bit

Byte 6:

0	n	n	n	n	n	n	n	<D1>	Data Byte 1. Low 7 bits.

Byte 7:

0	n	n	n	n	n	n	n	<D2>	Data Byte 2. Low 7 bits.

Byte 8:

0	n	n	n	n	n	n	n	<D3>	Data Byte 3. Low 7 bits.

Byte 9:

0	n	n	n	n	n	n	n	<D4>	Data Byte 4. Low 7 bits.

Byte 10:

0	0	1	0	n	n	n	n	<PXCT2>	Data type code 0x20 and high bits for D5 to D8.

d3	D8.7. High bit
d2	D7.7. High bit
d1	D6.7. High bit
d0	D5.7. High bit

Byte 11:

0	n	n	n	n	n	n	n	<D5>	Data Byte 5. Low 7 bits.

Byte 12:

0	n	n	n	n	n	n	n	<D6>	Data Byte 6. Low 7 bits.

Byte 13:

0	n	n	n	n	n	n	n	<D7>	Data Byte 7. Low 7 bits.

Byte 14:

0	n	n	n	n	n	n	n	<D8>	Data Byte 8. Low 7 bits.

Byte 15:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None

Signature:

Byte 0:

1	1	1	0	0	1	0	1	0xE5

Byte 1:

0	0	0	1	0	0	0	0	0x10

Byte 2:

0	1	1	1	1	1	1	1	0x7F

Byte 3:

0	1	1	1	1	1	1	1	0x7F

Byte 4:

0	1	1	1	1	1	1	1	0x7F

Byte 5:

0	1	0	0	×	×	×	×

Byte 10:

0	0	1	0	×	×	×	×

Notes:

None.

1.4.17 IPLDevData

Description:

An IPL capable device sends this response in response to an **IPLDiscover** broadcast message.

*** THIS NEEDS CHECKING ***

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Response

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	1	0	0	0x14	Message length (20 bytes).

Byte 2:

0	0	0	0	1	1	1	1	0x0F

Byte 3:

0	0	0	1	0	0	0	0	0x10

Byte 4:

0	0	0	0	d3	d2	d1	d0	<PXCT1>

d3 D4.7. High bit
d2 D3.7. High bit
d1 D2.7. High bit
d0 D1.7. High bit

Byte 5:

0	n	n	n	n	n	n	n	<D1>	Product code low 7 bits.

Product Code	Device
0x01	LNRP
0x04	UT4
0x0C	WTL12
0x14	DB210 Opto
0x15	DB210
0x16	DB220
0x1A	DCS210+
0x1B	DCS210
0x1C	DCS240
0x23	PR3
0x24	PR4
0x2A	DT402
0x32	DT500
0x33	DCS51
0x34	DCS52
0x3E	DT602
0x51	BXPA1
0x58	BXP88
0x5C	UR92
0x63	LNWI

Byte 6:

0	n	n	n	n	n	n	n	<D2>	Hardware version 2 low 7 bits.

D2	Meaning
0x00	Slave all
0x18	Slave RF24

Byte 7:

0	n	n	n	n	n	n	n	<D3>	Data item 3. Low 7 bits.

Byte 8:

0	d6	d5	d4	d3	d2	d1	d0	<D4>	Software Version Number low 7 bits.

d6 version number bit 3
d5 version number bit 2.
d4 version number bit 1
d3 version number bit 0
d2 subversion number bit 2
d1 subversion number bit 1
d0 subversion number bit 0

e.g. 0x09 decodes as version 1.1.

Byte 9:

0	0	0	0	d3	d2	d1	d0	<PXCT2>	High bits of D5 to D8.

d3 D8.7. High bit
d2 D7.7. High bit
d1 D6.7. High bit
d0 D5.7. High bit

Byte 10:

0	n	n	n	n	n	n	n	<D5>	Data item 5. Low 7 bits.

Byte 11:

0	n	n	n	n	n	n	n	<D6>	Serial number low byte low 7 bits.

Byte 12:

0	n	n	n	n	n	n	n	<D7>	Serial number high byte low 7 bits.

Byte 13:

0	n	n	n	n	n	n	n	<D8>	Data item 8. Low 7 bits.

Byte 14:

0	0	0	0	n	n	n	n	<PXCT3>	High bits for D9 to D12.

d3 D12.7. High bit
d2 D11.7. High bit
d1 D10.7. High bit
d0 D9.7. High bit

Byte 15:

0	n	n	n	n	n	n	n	<D9>	Data item 9. Low 7 bits.

Byte 16:

0	n	n	n	n	n	n	n	<D10>	Data item 10. Low 7 bits.

Byte 17:

0	n	n	n	n	n	n	n	<D11>	Data item 11. Low 7 bits.

Byte 18:

0	n	n	n	n	n	n	n	<D12>	Data item 8. Low 12 bits.

Byte 19:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Notes:

These came from DigiPLII:

e5 14 0f 08 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00 08

e5 14 0f 10 00 24 00 00 00 02 00 08 07 00 00 00 00 00 00 38

e5 14 0f 10 00 24 00 00 00 00 00 57 13 00 00 00 00 00 00 71

e5 14 0f 10 00 1b 00 00 03 02 00 54 10 00 00 00 00 00 00 4f

PR4 with serial number 0x0788 ver 0

PR4 with serial 0x1357 ver 0

DCS210 with SN 0x10D4 ver 0.3

DCS240 with SN 0x0AAB ver 0.3

1.4.18 IPLDiscover

Description:

This broadcast message requests IPL capable devices to report their IPL information. The devices each respond with a **IPLDevData** response.

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Broadcast

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	1	0	0	0x14	Message length (20 bytes).

Byte 2:

0	0	0	0	1	1	1	1	0x0F

Byte 3:

0	0	0	0	1	0	0	0	0x08

Byte 4:

0	0	0	0	0	0	0	0	0x00

Byte 5:

0	0	0	0	0	0	0	0	0x00

Byte 6:

0	0	0	0	0	0	0	0	0x00

Byte 7:

0	0	0	0	0	0	0	0	0x00

Byte 8:

0	0	0	0	0	0	0	0	0x00

Byte 9:

0	0	0	0	0	0	0	0	0x00

Byte 10:

0	0	0	0	0	0	0	0	0x00

Byte 11:

0	0	0	0	0	0	0	1	0x01

Byte 12:

0	0	0	0	0	0	0	0	0x00

Byte 13:

0	0	0	0	0	0	0	0	0x00

Byte 14:

0	0	0	0	0	0	0	0	0x00

Byte 15:

0	0	0	0	0	0	0	0	0x00

Byte 16:

0	0	0	0	0	0	0	0	0x00

Byte 17:

0	0	0	0	0	0	0	0	0x00

Byte 18:

0	0	0	0	0	0	0	0	0x00

Byte 19:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

IPLDevData

Signature:

Byte 0:

1	1	1	0	0	1	0	1	0xE5

Byte 1:

0	0	0	1	0	1	0	0	0x14

Byte 2:

0	0	0	0	1	1	1	1	0x0F

Byte 3:

0	0	0	0	1	0	0	0	0x08

Byte 4:

0	0	0	0	0	0	0	0	0x00

Byte 5:

0	0	0	0	0	0	0	0	0x00

Byte 6:

0	0	0	0	0	0	0	0	0x00

Byte 7:

0	0	0	0	0	0	0	0	0x00

Byte 8:

0	0	0	0	0	0	0	0	0x00

Byte 9:

0	0	0	0	0	0	0	0	0x00

Byte 10:

0	0	0	0	0	0	0	0	0x00

Byte 11:

0	0	0	0	0	0	0	1	0x01

Byte 12:

0	0	0	0	0	0	0	0	0x00

Byte 13:

0	0	0	0	0	0	0	0	0x00

Byte 14:

0	0	0	0	0	0	0	0	0x00

Byte 15:

0	0	0	0	0	0	0	0	0x00

Byte 16:

0	0	0	0	0	0	0	0	0x00

Byte 17:

0	0	0	0	0	0	0	0	0x00

Byte 18:

0	0	0	0	0	0	0	0	0x00

Notes:

None.

1.4.19 IPLEndLoad

Description:

This command ends a device firmware update.

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Command

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x10	Message length (16 bytes).

Byte 2:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 3:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 4:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 5:

0	1	0	0	0	0	0	0	0x40	Download code.

Byte 6:

0	0	0	0	0	0	0	0	0x00	

Byte 7:

0	0	0	0	0	0	0	0	0x00	

Byte 8:

0	0	0	0	0	0	0	0	0x00	

Byte 9:

0	0	0	0	0	0	0	0	0x00	

Byte 10:

0	1	0	0	n	n	n	n	0x40	End load type code.

Byte 11:

0	0	0	0	0	0	0	0	0x00	

Byte 12:

0	0	0	0	0	0	0	0	0x00	

Byte 13:

0	0	0	0	0	0	0	0	0x00	

Byte 14:

0	0	0	0	0	0	0	0	0x00	

Byte 15:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None

Signature:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	

Byte 1:

0	0	0	1	0	0	0	0	0x10	

Byte 2:

0	1	1	1	1	1	1	1	0x7F	

Byte 3:

0	1	1	1	1	1	1	1	0x7F	

Byte 4:

0	1	1	1	1	1	1	1	0x7F

Byte 5:

0	1	0	0	0	0	0	0	0x40

Byte 6:

0	0	0	0	0	0	0	0	0x00

Byte 7:

0	0	0	0	0	0	0	0	0x00

Byte 8:

0	0	0	0	0	0	0	0	0x00

Byte 9:

0	0	0	0	0	0	0	0	0x00

Byte 10:

0	1	0	0	n	n	n	n	0x40

Byte 11:

0	0	0	0	0	0	0	0	0x00

Byte 12:

0	0	0	0	0	0	0	0	0x00

Byte 13:

0	0	0	0	0	0	0	0	0x00

Byte 14:

0	0	0	0	0	0	0	0	0x00

Notes:

None.

1.4.20 IPLSetAddr

Description:

This command sets the address of where to load the next block of firmware data.

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Command

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	OPC_PEER_XFER opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x10	Message length (16 bytes).

Byte 2:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 3:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 4:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 5:

0	1	0	0	d3	d2	d1	d0	<PXCT1>	Download code 0x40 and high bits of D1 to D4.

d3 D4.7. High bit
d2 D3.7. High bit
d1 D2.7. High bit
d0 D1.7. High bit

Byte 6:

0	n	n	n	n	n	n	n	<D1>	Address High Byte. Low 7 bits.

Byte 7:

0	n	n	n	n	n	n	n	<D2>	Address Mid Byte. Low 7 bits.

Byte 8:

0	n	n	n	n	n	n	n	<D3>	Address Low Byte. Low 7 bits.

Byte 9:

0	0	0	0	0	0	0	0	<D4>	Reserved always 0x00. Low 7 bits.

Byte 10:

0	0	0	1	n	n	n	n	<PXCT2>	Address type code 0x10 and high bits for D5 to D8.

d3 D8.7. High bit
d2 D7.7. High bit
d1 D6.7. High bit
d0 D5.7. High bit

Byte 11:

0	0	0	0	0	0	0	0	<D5>	Reserved always 0x00. Low 7 bits.

Byte 12:

0	0	0	0	0	0	0	0	<D6>	Reserved always 0x00. Low 7 bits.

Byte 13:

0	0	0	0	0	0	0	0	<D7>	Reserved always 0x00. Low 7 bits.

Byte 14:

0	0	0	0	0	0	0	0	<D8>	Reserved always 0x00. Low 7 bits.

Byte 15:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None

Signature:

Byte 0:

1	1	1	0	0	1	0	1	0xE5

Byte 1:

0	0	0	1	0	0	0	0	0x10

Byte 2:

0	1	1	1	1	1	1	1	0x7F

Byte 3:

0	1	1	1	1	1	1	1	0x7F

Byte 4:

0	1	1	1	1	1	1	1	0x7F

Byte 5:

0	1	0	0	×	×	×	×

Byte 9:

0	0	0	0	0	0	0	0	0x00

Byte 10:

0	0	0	1	×	×	×	×

Byte 11:

0	0	0	0	0	0	0	0	0x00

Byte 12:

0	0	0	0	0	0	0	0	0x00

Byte 13:

0	0	0	0	0	0	0	0	0x00

Byte 14:

0	0	0	0	0	0	0	0	0x00

Notes:

None.

1.4.21 IPLSetupBL2

Description:

This command initiates a firmware update for a device that supports IPL Bootloader 2 protocol.

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Command

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x10	Message length (16 bytes).

Byte 2:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 3:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 4:

0	1	1	1	1	1	1	1	0x7F	Broadcast id.

Byte 5:

0	1	0	0	d3	d2	d1	d0	<PXCT1>	Download code 0x40 and high bits of D1 to D4.

d3 D4.7. High bit
d2 D3.7. High bit
d1 D2.7. High bit
d0 D1.7. High bit

Byte 6:

0	n	n	n	n	n	n	n	<D1>	Manufacturer code. Low 7 bits.

Code	Manufacturer
0x00	Digitrax

Byte 7:

0	n	n	n	n	n	n	n	<D2>	Product code. Low 7 bits.

Byte 8:

0	n	n	n	n	n	n	n	<D3>	Hardware version. Low 7 bits.

Byte 9:

0	n	n	n	n	n	n	n	<D4>	Software version. Low 7 bits.

Byte 10:

0	0	0	0	n	n	n	n	<PXCT2>	Setup download type code 0x00 and high bits for D5 to D8.

d3	D8.7. High bit
d2	D7.7. High bit
d1	D6.7. High bit
d0	D5.7. High bit

Byte 11:

0	n	n	n	n	n	n	n	<D5>	Options. Low 7 bits.

Byte 12:

0	0	0	0	0	0	0	0	<D6>	Reserved always 0x00. Low 7 bits.

Byte 13:

0	n	n	n	n	n	n	n	<D7>	Number of blocks to erase 7. Low 7 bits.

This is calculated as INT(0.5 + (Last Address - First Address) / Erase Blk Size).

Byte 14:

0	0	0	0	0	0	0	0	<D8>	Reserved always 0x00. Low 7 bits.

Byte 15:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None

Signature:

Byte 0:

1	1	1	0	0	1	0	1	0xE5

Byte 1:

0	0	0	1	0	0	0	0	0x10

Byte 2:

0	1	1	1	1	1	1	1	0x7F

Byte 3:

0	1	1	1	1	1	1	1	0x7F

Byte 4:

0	1	1	1	1	1	1	1	0x7F

Byte 5:

0	1	0	0	d3	×	×	×

Byte 10:

0	0	0	0	×	×	×	×

Byte 12:

0	0	0	0	0	0	0	0	0x00

Byte 14:

0	0	0	0	0	0	0	0	0x00

Notes:

None.

1.4.22 LinkSlotsP1

Description:

This command links slot SL1 to slot SL2. The command station sets SL_CONUP/DN flags appropriately. If the command was successful then a **LocoSlotDataP1** response will be returned. An invalid link will return a **Ack** with a response code of 0x00.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_LINK_SLOTS

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	0	0	1	0xB9	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SL1>	Slot number in the range 0x01 to 0x77.

Byte 2:

0	n	n	n	n	n	n	n	<SL2>	Slot number in the range 0x01 to 0x77.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP1

or

Ack

<LOPC>	<ACK1>	Meaning
0x39	0x00	Invalid link, link failed.

Signature:

Byte 0:

1	0	1	1	1	0	0	1	0xB9

Byte 1:

0	n	n	n	n	n	n	n	in the range 0x01 to 0x77.

Byte 2:

0	n	n	n	n	n	n	n	in the range 0x01 to 0x77.

Notes:

None.

1.4.23 LinkSlotsP2

Description:

This command links slot SL1 to slot SL2. The command station sets SL_CONUP/DN flags appropriately. If the command was successful then a **LocoSlotDataP2** response will be returned. An invalid link will return a **Ack** with a response code of 0x00.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial Mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	1	1	d2	d1	d0	<SL1P>	Bits d2 to d0 contain the SL1 slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SL1#>	Slot number SL1 in the range 0x00 to 0x77.

Byte 3:

0	1	0	0	0	d2	d1	d0	<SL2P>	Bits d2 to d0 contain the SL2 slot page number in the range 0x0 to 0x7.

Byte 4:

0	n	n	n	n	n	n	n	<SL2#>	Slot number SL2 in the range 0x00 to 0x77.

Byte 5:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

LocoSlotDataP2 or **Ack**.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	1	1	×	×	×

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	0	0	0	×	×	×

Byte 4:

0	n	n	n	n	n	n	n	less than 0x78

Notes:

None.

1.4.24 LocoBinStateP2

Description:

This command sets the locomotive's binary states with addresses in the range 1 to 32767. The address of 0 is a broadcast command and will set or reset all binary states.

Protocol:

2?

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	0	d4	d3	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7. The bit d4 contains the function state where 1 means on and 0 means off. The bit d3 contains the high bit of the binary state address (bit 14).

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number.

Byte 3:

0	n	n	n	n	n	n	n	<BSA0>	Binary state address bits 0 to 6.

Byte 4:

0	n	n	n	n	n	n	n	<BSA1>	Binary state address bits 7 to 13.

Byte 5:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	0	×	×	×	×	×

Notes:

*** THIS HAS NOT BEEN TESTED ***

1.4.25 LocoDirF0F4P1

Description:

This function sets the locomotive's direction and function F0 to F4 states.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_LOCO_DIRF

Type:

Command

Encoding:

Byte 0:

1	0	1	0	0	0	0	1	0xA1	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	0	d5	d4	d3	d2	d1	d0	<DIRF>	Locomotive's direction and state of functions F0 to F4.

d5 Direction: 1 means forward and 0 means backwards.
d4 F0 state: 1 means on and 0 means off.
d3 F4 state: 1 means on and 0 means off.
d2 F3 state: 1 means on and 0 means off.
d1 F2 state: 1 means on and 0 means off.
d0 F1 state: 1 means on and 0 means off.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	0	0	0	0	1	0xA1

Byte 1:

0	n	n	n	n	n	n	n	less than 0x78

Byte 2:

0	0	×	×	×	×	×	×

Notes:

None.

1.4.26 LocoDirF0F4P2

Description:

This command sets the locomotive's direction and function F0 to F4 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number.

Byte 3:

0	0	0	0	0	1	1	0	0x06	Subcode.

Byte 4:

0	0	d5	d4	d3	d2	d1	d0	Direction and function states.

d5 Direction: 1 means forward and 0 means backwards.
d4 F0 state: 1 means on and 0 means off.
d3 F4 state: 1 means on and 0 means off.
d2 F3 state: 1 means on and 0 means off.
d1 F2 state: 1 means on and 0 means off.
d0 F1 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	0	0	×	×	×

Byte 3:

0	0	0	0	0	1	1	0	0x06

Byte 4:

0	0	×	×	×	×	×	×

Notes:

None.

1.4.27 LocoF0F6P2

Description:

This command sets the locomotive's function F0 to F6 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D5_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	1	0xD5	Opcode.

Byte 1:

0	0	0	1	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	1	1	0	1	1	0	1	0x6D	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Function states.

d6	F6 state: 1 means on and 0 means off.
d5	F5 state: 1 means on and 0 means off.
d4	F0 state: 1 means on and 0 means off.
d3	F4 state: 1 means on and 0 means off.
d2	F3 state: 1 means on and 0 means off.
d1	F2 state: 1 means on and 0 means off.
d0	F1 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	1	0xD5

Byte 1:

0	0	0	1	0	×	×	×

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	1	0	1	1	0	1	0x6D

Notes:

None.

1.4.28 LocoF5F8P1

Description:

This command sets the locomotive's function F5 to F8 states.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_LOCO_SND

Type:

Command

Encoding:

Byte 0:

1	0	1	0	0	0	1	0	0xA2	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	0	0	0	d3	d2	d1	d0	<SND>	Locomotive's function F5 to F8 states.

d3 F8 state: 1 means on and 0 means off.
d2 F7 state: 1 means on and 0 means off.
d1 F6 state: 1 means on and 0 means off.
d0 F5 state: 1 means on and 0 means off.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	0	0	0	1	0	0xA2

Byte 1:

0	n	n	n	n	n	n	n	less than 0x78

Byte 2:

0	0	0	0	×	×	×	×

Notes:

None.

1.4.29 LocoF7F13P2

Description:

This command sets the locomotive's function F7 to F13 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D5_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	1	0xD5	Opcode.

Byte 1:

0	0	0	1	1	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	1	1	0	1	1	0	1	0x6D	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Function states.

d6 F13 state: 1 means on and 0 means off.
d5 F12 state: 1 means on and 0 means off.
d4 F11 state: 1 means on and 0 means off.
d3 F10 state: 1 means on and 0 means off.
d2 F9 state: 1 means on and 0 means off.
d1 F8 state: 1 means on and 0 means off.
d0 F7 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	1	0xD5

Byte 1:

0	0	0	1	1	×	×	×	

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	1	0	1	1	0	1	0x6D

Notes:

None.

1.4.30 LocoF5F11P2

Description:

This command sets the locomotive's function F5 to F11 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number.

Byte 3:

0	0	0	0	0	1	1	1	0x07	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Function states.

d6	F11 state: 1 means on and 0 means off.
d5	F10 state: 1 means on and 0 means off.
d4	F9 state: 1 means on and 0 means off.
d3	F8 state: 1 means on and 0 means off.
d2	F7 state: 1 means on and 0 means off.
d1	F6 state: 1 means on and 0 means off.
d0	F5 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	0	0	×	×	×

Byte 3:

0	0	0	0	0	1	1	1	0x07

Notes:

None.

1.4.31 LocoF12F20F28P2

Description:

This command sets the locomotive's function F12, F20, and F28 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number.

Byte 3:

0	0	0	0	0	1	0	1	0x05	Subcode.

Byte 4:

0	0	0	0	0	d2	d1	d0	Function states.

d2 F28 state: 1 means on and 0 means off.
d1 F20 state: 1 means on and 0 means off.
d0 F12 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	0	0	×	×	×

Byte 3:

0	0	0	0	0	1	0	1	0x05

Byte 4:

0	0	0	0	0	×	×	×

Notes:

None.

1.4.32 LocoF13F19P2

Description:

This command sets the locomotive's function F13 to F19 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number.

Byte 3:

0	0	0	0	1	0	0	0	0x08	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Function states.

d6 F19 state: 1 means on and 0 means off.
d5 F18 state: 1 means on and 0 means off.
d4 F17 state: 1 means on and 0 means off.
d3 F16 state: 1 means on and 0 means off.
d2 F15 state: 1 means on and 0 means off.
d1 F14 state: 1 means on and 0 means off.
d0 F13 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	0	0	×	×	×

Byte 3:

0	0	0	0	1	0	0	0	0x08

Notes:

None.

1.4.33 LocoF14F20P2

Description:

This command sets the locomotive's function F14 to F20 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D5_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	1	0xD5	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	1	1	0	1	1	0	1	0x6D	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Function states.

d6 F20 state: 1 means on and 0 means off.
d5 F19 state: 1 means on and 0 means off.
d4 F18 state: 1 means on and 0 means off.
d3 F17 state: 1 means on and 0 means off.
d2 F16 state: 1 means on and 0 means off.
d1 F15 state: 1 means on and 0 means off.
d0 F14 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	1	0xD5

Byte 1:

0	0	1	0	0	×	×	×	

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	1	0	1	1	0	1	0x6D

Notes:

None.

1.4.34 LocoF21F27P2

Description:

This command sets the locomotive's function F21 to F27 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number.

Byte 3:

0	0	0	0	0	1	0	1	0x09	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Function states.

d6	F27 state: 1 means on and 0 means off.
d5	F26 state: 1 means on and 0 means off.
d4	F25 state: 1 means on and 0 means off.
d3	F24 state: 1 means on and 0 means off.
d2	F23 state: 1 means on and 0 means off.
d1	F22 state: 1 means on and 0 means off.
d0	F21 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	0	0	×	×	×

Byte 3:

0	0	0	0	1	0	0	1	0x09

Notes:

None.

1.4.35 LocoF21F28P2

Description:

This command sets the locomotive's function F21 to F28 states.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D5_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	1	0xD5	Opcode.

Byte 1:

0	0	1	d4	d3	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7. d4 and d3 encode the F28 state where 0b10 means on and 0b01 means off.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	1	1	0	1	1	0	1	0x6D	Subcode.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0		Function states.

d6 F27 state: 1 means on and 0 means off.
d5 F26 state: 1 means on and 0 means off.
d4 F25 state: 1 means on and 0 means off.
d3 F24 state: 1 means on and 0 means off.
d2 F23 state: 1 means on and 0 means off.
d1 F22 state: 1 means on and 0 means off.
d0 F21 state: 1 means on and 0 means off.

Byte 5:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	1	0xD5

Byte 1:

0	0	1	d4	d3	×	×	×	d4 and d3 can be 0b10 or 0b01

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	1	0	1	1	0	1	0x6D

Notes:

None.

1.4.36 LocoSlotDataP1

Description:

This response provides the data for a specific locomotive slot.

Protocol:

1

Group:

Variable-Byte Message

Opcode:

OPC_SL_RD_DATA

Type:

Response

Encoding:

Byte 0:

1	1	1	0	0	1	1	1	0xE7	Opcode.

Byte 1:

0	0	0	0	1	1	1	0	0x0E	Message length (14 bytes).

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77. Slot 0x00 is the dispatch special slot.

Byte 3:

d7	d6	d5	d4	d3	d2	d1	d0	<STAT1>	Slot status 1.

d7	d6	
0	0	Free, no consist linking.
0	1	Consist sub-member.
1	0	Consist top-member.
1	1	Consist Mid-Consist member.

Note: d7 is set to 0 in the message by the command station and so may not correctly reflect the actual setting in the slot table.

d5	d4	
0	0	Free slot, no valid data. Not refreshed.
0	1	Common. Locomotive address in this slot. Refreshed.
1	0	Idle. Locomotive address in this slot. Not refreshed.
1	1	In Use. Locomotive address in this slot. Refreshed.

d3	
0	No slot consist linked into this slot.
1	Slot consist linked into this slot.

d2	d1	d0	
0	0	0	28 step decoder. 3-byte packet regular mode
0	0	1	28 step decoder. Generate trinary packets for this mobile address
0	1	0	14 step decoder.
0	1	1	128 step decoder.
1	0	0	28 step decoder. Allow advanced consisting
1	0	1	reserved
1	1	0	reserved
1	1	1	128 step decoder. Allow advanced consisting

Byte 4:

0	n	n	n	n	n	n	n	<ADR>	If <ADR2> is 0 then this contains the NMRA short address. If <ADR2> is greater than 0 then this contains the low 7 bits of the NMRA long address.

Byte 5:

0	n	n	n	n	n	n	n	<SPD>	Speed in the range 0x00 to 0x7F. 0x00 means inertial stop and 0x01 means emergency stop. Other values mean increasing speed.

Byte 6:

0	0	d5	d4	d3	d2	d1	d0	<DIRF>	Locomotive direction and state of functions F0 to F4.

d5 Direction: 1 means forward and 0 means backwards.
d4 F0 state: 1 means on and 0 means off.
d3 F4 state: 1 means on and 0 means off.
d2 F3 state: 1 means on and 0 means off.
d1 F2 state: 1 means on and 0 means off.
d0 F1 state: 1 means on and 0 means off.

Byte 7:

0	d6	0	0	d3	d2	d1	d0	<TRK>	Global system track status.

d6 1 means this command station implements protocol 2 messages. This can be turned off on the DCS240 by setting the OpSw 44 to be closed.
d3 1 means the programming track is busy.
d2 1 means this command station implements protocol 1 messages and 0 means the command station is a DT200.
d1 0 means the track is paused, broadcast an emergency stop.
d0 1 means the DCC packets are on in the command station and the track power is on.

Byte 8:

0	0	0	0	d3	d2	0	d0	<SS2>	Slot status 2.

d3 1 means expansion in ID1/2, 0 means encoded alias.
d2 1 means expansion ID1/2 is not ID usage.
d0 1 means this slot has suppressed advanced consist.

Byte 9:

0	n	n	n	n	n	n	n	<ADR2>	If <ADR2> is greater than 0 then this contains the high 7 bits of the NMRA long address.

Byte 10:

0	0	0	0	d3	d2	d1	d0	<SND>	Function F5 to F8 states.

d3 F8 state: 1 means on and 0 means off.
d2 F7 state: 1 means on and 0 means off.
d1 F6 state: 1 means on and 0 means off.
d0 F5 state: 1 means on and 0 means off.

Byte 11:

0	n	n	n	n	n	n	n	<ID1>	7-bit ls ID code written by throttle when STAT2.4 = 1.

Byte 12:

0	n	n	n	n	n	n	n	<ID2>	7-bit ms ID code written by throttle when STAT2.4 = 1.

Byte 13:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	1	0	0	1	1	1	0xE7

Byte 1:

0	0	0	0	1	1	1	0	0x0E

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78.

Byte 6:

0	0	×	×	×	×	×	×

Byte 7:

0	×	0	0	×	×	×	×

Byte 8:

0	0	0	0	×	×	0	×

Byte 10:

0	0	0	0	×	×	×	×

Notes:

None.

1.4.37 LocoSlotDataP2

Description:

This response provides data for a specific locomotive slot.

Protocol:

2

Group:

Variable-Byte Message

Opcode:

OPC_SL_RD_DATA_P2 (Unofficial mnemonic)

Type:

Response

Encoding:

Byte 0:

1	1	1	0	0	1	1	0	0xE6	Opcode.

Byte 1:

0	0	0	1	0	1	0	1	0x15	Message length (21 bytes).

Byte 2:

0	0	0	0	0	d2	d1	d0	<SLOTP#>	Slot page number in the range 0x0 to 0x7.

Byte 3:

0	n	n	n	n	n	n	n	<SLOTL#>	Slot number in the range 0x00 to 0x77.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	<STAT1>	Slot status 1.

d7	d6	
0	0	Free, no consist linking.
0	1	Consist sub-member.
1	0	Consist top-member.
1	1	Consist Mid-Consist member.

Note: d7 is set to 0 in the message by the command station and so may not correctly reflect the actual setting in the slot table.

d5	d4	
0	0	Free slot, no valid data. Not refreshed.
0	1	Common. Locomotive address in this slot. Refreshed.
1	0	Idle. Locomotive address in this slot. Not refreshed.
1	1	In Use. Locomotive address in this slot. Refreshed.

d3	
0	No slot consist linked into this slot.
1	Slot consist linked into this slot.

d2	d1	d0	
0	0	0	28 step decoder. 3-byte packet regular mode
0	0	1	28 step decoder. Generate trinary packets for this mobile address
0	1	0	14 step decoder.
0	1	1	128 step decoder.
1	0	0	28 step decoder. Allow advanced consisting
1	0	1	reserved
1	1	0	reserved
1	1	1	128 step decoder. Allow advanced consisting

Byte 5:

0	n	n	n	n	n	n	n	<ADR>	Low address.

Byte 6:

0	n	n	n	n	n	n	n	<ADR2>	High address.

Byte 7:

0	d6	d5	d4	d3	d2	d1	d0	<TRK>	Global system track status.

d6 1 means this command station implements protocol 2 messages. This can be turned off on the DCS240 by setting the OpSw 44 to be closed.
d5 Reserved. Set to 0.
d4 Reserved. Set to 0.
d3 1 means the programming track is busy.
d2 1 means this command station implements protocol 1 messages. 0 means the command station is a DT200.
d1 0 means the track is paused, broadcast an emergency stop.
d0 1 means the DCC packets are on in the command station and track power is on.

Byte 8:

0	d6	d5	d4	d3	d2	d1	d0

<SPD> Speed in the range 0x00 to 0x7F. 0x00 means inertial stop and 0x01 means emergency stop. Other values mean increasing speed.

Byte 9:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F8 state: 1 means on and 0 means off
d5 F0 state: 1 means on and 0 means off
d4 F12 state: 1 means on and 0 means off
d3
d2
d1 F20 state: 1 means on and 0 means off
d0

Byte 10:

0	d6	d5	d4	d3	d2	d1	d0

Direction.

d6
d5 Direction: 1 means forwards and 0 means backwards
d4
d3
d2
d1
d0

Byte 11:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F11 state: 1 means on and 0 means off
d5 F10 state: 1 means on and 0 means off
d4 F9 state: 1 means on and 0 means off
d3
d2
d1
d0

Byte 12:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F19 state: 1 means on and 0 means off
d5 F18 state: 1 means on and 0 means off
d4 F17 state: 1 means on and 0 means off
d3 F16 state: 1 means on and 0 means off
d2 F15 state: 1 means on and 0 means off
d1 F14 state: 1 means on and 0 means off
d0 F13 state: 1 means on and 0 means off

Byte 13:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F7 state: 1 means on and 0 means off
d5 F6 state: 1 means on and 0 means off
d4 F5 state: 1 means on and 0 means off
d3 F4 state: 1 means on and 0 means off
d2 F3 state: 1 means on and 0 means off
d1 F2 state: 1 means on and 0 means off
d0 F1 state: 1 means on and 0 means off

Byte 14:

0	d6	d5	d4	d3	d2	d1	d0

Unknown.

d6
d5
d4
d3
d2
d1
d0

Byte 15:

0	d6	d5	d4	d3	d2	d1	d0	Unknown.

d6
d5
d4
d3
d2
d1
d0

Byte 16:

0	d6	d5	d4	d3	d2	d1	d0	Consist slot page number.

d6
d5
d4
d3
d2 Consist slot page b2
d1 Consist slot page b1
d0 Consist slot page b0

Byte 17:

0	n	n	n	n	n	n	n	Consist slot number in the range 0x00 to 0x77.

Byte 18:

0	d6	d5	d4	d3	d2	d1	d0	Throttle id low bits.

Byte 19:

0	d6	d5	d4	d3	d2	d1	d0	Throttle id high bits.

Byte 20:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	1	0	0	1	1	0

0xE6

Byte 1:

0	0	0	1	0	1	0	1

0x15

Byte 2:

0	0	0	0	0	×	×	×

Byte 7:

0	×	0	0	×	×	×	×

Notes:

None.

1.4.38 LocoSpdP1

Description:

This command sets the locomotive's speed in the range 0 to 127. 0 means inertial stop and 1 means emergency stop. Other values mean increasing speed.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_LOCO_SPD

Type:

Command

Encoding:

Byte 0:

1	0	1	0	0	0	0	0	0xA0	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	n	n	n	n	n	n	n	<SPD>	Locomotive speed in the range 0 to 127.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	0	0	0	0	0	0xA0

Byte 1:

0	n	n	n	n	n	n	n

less than 0x78

Notes:

None.

1.4.39 LocoSpdP2

*** THIS WAS SENT BY iTrain NEEDS TESTING ***

Description:

This function sets the locomotive's speed in the range 0 to 127. 0 means inertial stop and 1 means emergency stop. Other values mean increasing speed.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	0	0	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	0	0	0	0	1	0	0	0x04	Subcode.

Byte 4:

0	n	n	n	n	n	n	n	<SPD>	Locomotive speed in the range 0x00 to 0x7F.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	0	0	×	×	×

Byte 3:

0	0	0	0	0	1	0	0	0x04

Notes:

None.

1.4.40 LocoSpdDirP2

Description:

This function sets the locomotive's speed in the range 0 to 127 and direction. 0 means inertial stop and 1 means emergency stop. Other values mean increasing speed.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D5_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	1	0xD5	Opcode.

Byte 1:

0	0	0	0	d3	d2	d1	d0	<SLOTP>	Bits d2 to d0 contain the slot page number in the range 0x0 to 0x7. Bit d3 contains the direction where 1 means forwards and 0 means backwards.

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	1	1	0	1	1	0	1	0x6D	Subcode.

Byte 4:

0	n	n	n	n	n	n	n	<SPD>	Locomotive speed in the range 0x00 to 0x7F.

Byte 5:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	1	0	1	0xD5

Byte 1:

0	0	0	0	×	×	×	×

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	1	0	1	1	0	1	0x6D

Notes:

None.

1.4.41 MoveSlotsP1

Description:

Move slots.

SRC	DEST	Action
0	×	Dispatch get. Return **LocoSlotDataP1** of dispatch slot.
SRC	0	Dispatch put. Mark slot as dispatch.
SRC	SRC	Null move. SRC is set to in use.
SRC	DEST	Move slot data from SRC to DEST if not in use. Clear SRC.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_MOVE_SLOTS

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	0	1	0	0xBA	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SRC>	Source slot number in the range 0x00 to 0x77.

Byte 2:

0	n	n	n	n	n	n	n	<DEST>	Destination slot number in the range 0x00 to 0x77.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP1

or

Ack.

<LOPC>	<ACK1>	Meaning
0x3A	0x00	Illegal move.

Signature:

Byte 0:

1	0	1	1	1	0	1	0	0xBA

Byte 1:

0	n	n	n	n	n	n	n	less than 0x78

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Notes:

None.

1.4.42 MoveSlotsP2

Description:

Move slots.

SRC	DEST	Action
0	×	Dispatch get. Return **LocoSlotDataP2** of dispatch slot.
SRC	0	Dispatch put. Mark slot as dispatch.
SRC	SRC	Null move. SRC is set to in use.
SRC	DEST	Move slot data from SRC to DEST if not in use. Clear SRC.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial Mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	1	1	d2	d1	d0	<SRCP>	Bits d2 to d0 contain the source slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SRC>	Source slot number.

Byte 3:

0	0	0	0	0	d2	d1	d0	<DESTP>	Bits d2 to d0 contain the destination slot page number in the range 0x0 to 0x7.

Byte 4:

0	n	n	n	n	n	n	n	<DEST>	Destination slot number.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP2 or **Ack**.

*** NEED TO CONFIRM ERROR CODE ***

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	1	1	×	×	×

Byte 3:

0	0	0	0	0	×	×	×

Notes:

None.

1.4.43 PeerXfer16

Description:

This command sends the 8 bytes of data from one device to another peer to peer. This message takes many forms and so what is presented here is a generic description. The specific forms are included elsewhere as detailed messages in their own right.

SRC	DSTL	DSTH	Comments
0x00			Source is command station.
Don't Care	0x00	0x00	Broadcast Message.
0x70 to 0x7E			Reserved.
0x7F	0x00	0x00	Broadcast throttle message transfer.
0x7F	ID1	ID2	Throttle message transfer. ID1 and ID2 encode ID.

Protocol:

1

Group:

Variable-Byte Message

Opcode:

OPC_PEER_XFER

Type:

Message

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	0	0	0	0x10	Message length (16 bytes).

Byte 2:

0	n	n	n	n	n	n	n	<SRC>	Source id in the range 0x00 to 0x7F.

Byte 3:

0	n	n	n	n	n	n	n	<DSTL>	Destination id low in the range 0x00 to 0x7F.

Byte 4:

0	n	n	n	n	n	n	n	<DSTH>	Destination id high in the range 0x00 to 0x7F.

Byte 5:

0	d6	d5	d4	d3	d2	d1	d0	<PXCT1>	Address type code and high bits of D1 to D4.

d6 XC2. Address type code.
d5 XC1. Address type code.
d4 XC0. Address type code.
d3 D4.7. High bit
d2 D3.7. High bit
d1 D2.7. High bit
d0 D1.7. High bit

XC2	XC1	XC0	Meaning
0	0	0	7 bit peer to peer addresses.
0	0	1	reserved.
0	1	0	reserved.
0	1	1	reserved.
1	0	0	IPL download.
1	0	1	reserved.
1	1	0	reserved.
1	1	1	reserved.

Byte 6:

0	n	n	n	n	n	n	n	<D1>	Data item 1. Low 7 bits.

Byte 7:

0	n	n	n	n	n	n	n	<D2>	Data item 2. Low 7 bits.

Byte 8:

0	n	n	n	n	n	n	n	<D3>	Data item 3. Low 7 bits.

Byte 9:

0	n	n	n	n	n	n	n	<D4>	Data item 4. Low 7 bits.

Byte 10:

0	n	n	n	n	n	n	n	<PXCT2>	Data type code and high bits for D5 to D8.

d6 XC5. Data type code.
d5 XC4. Data type code.
d4 XC3. Data type code.
d3 D8.7. High bit
d2 D7.7. High bit
d1 D6.7. High bit
d0 D5.7. High bit

XC5	XC4	XC3	Meaning
0	0	0	ANSI text string. IPL download setup subcode.
0	0	1	IPL download address subcode.
0	1	0	IPL download send data subcode.
0	1	1	IPL download verify data subcode.
1	0	0	IPL download end of operation subcode.
1	0	1	reserved.
1	1	0	reserved.
1	1	1	reserved.

Options flags

```
private static final int DO_NOT_CHECK_SOFTWARE_VERSION = 0x00;
    private static final int CHECK_SOFTWARE_VERSION_LESS = 0x04;

    private static final int DO_NOT_CHECK_HARDWARE_VERSION = 0x00;
    private static final int REQUIRE_HARDWARE_VERSION_EXACT_MATCH = 0x01;
    private static final int ACCEPT_LATER_HARDWARE_VERSIONS = 0x03;
```

Byte 11:

0	n	n	n	n	n	n	n	<D5>	Data item 5. Low 7 bits.

Byte 12:

0	n	n	n	n	n	n	n	<D6>	Data item 6. Low 7 bits.

Byte 13:

0	n	n	n	n	n	n	n	<D7>	Data item 7. Low 7 bits.

Byte 14:

0	n	n	n	n	n	n	n	<D8>	Data item 8. Low 7 bits.

Byte 15:

0	n	n	n	n	n	n	n

<CHK> Checksum.

Response:

None

Signature:

Byte 0:

1	1	1	0	0	1	0	1

0xE5

Byte 1:

0	0	0	1	0	0	0	0

0x10

Notes:

None.

1.4.44 ProgCV

Description:

The **ProgCV** command is used to read and write a locomotive's mobile decoder configuration variables.

Group:

Variable-Byte Message

Opcode:

OPC_WR_SL_DATA

Type:

Command

Encoding:

Byte 0:

1	1	1	0	1	1	1	1	0xEF	Opcode.

Byte 1:

0	0	0	0	1	1	1	0	0x0E	Message length.

Byte 2:

0	1	1	1	1	1	0	0	0x7C	Programming slot number.

Byte 3:

0	d6	d5	d4	d3	d2	d1	d0	<PCMD>	Programming command.

d6 0 means read and 1 means write
d5 1 means byte mode and 0 means bit mode
d4 TY1
d3 TY0
d2 0 means service mode on programming track, 1 means operations mode on mainline.
d1 1 - unknown
d0 1 - unknown

d5	d4	d3	d2	d1	d0	Programming Mode
1	0	0	0	×	×	Paged mode byte read/write on service track
1	0	1	0	×	×	Direct mode byte read/write on service track
0	0	1	0	×	×	Direct mode bit read/write on service track
×	1	0	0	×	×	Physical register byte read/write on service track
×	1	1	0	×	×	Service track reserved function
1	0	0	1	×	×	Ops mode byte program on mainline no feedback
1	0	1	1	×	×	Ops mode byte program on mainline with feedback
0	0	0	1	×	×	Ops mode bit program on mainline no feedback
0	0	1	1	×	×	Ops mode bit program on mainline with feedback

Byte 4:

0	0	0	0	0	0	0	0	0x00

Byte 5:

0	n	n	n	n	n	n	n	<HOPSA>	In operations mode programming this contains the 7 high address bits of the locomotive to program. 0x00 if service mode.

Byte 6:

0	n	n	n	n	n	n	n	<LOPSA>	In operations mode programming this contains the 7 low address bits of the locomotive to program. 0x00 if service mode.

Byte 7:

0	0	0	0	0	0	0	0	0x00

Byte 8:

0	0	d5	d4	0	0	d1	d0	<CVH>	Configuration Variable number high 3 bits and most significant bit of data byte.

d5 CV9
d4 CV8
d1 DATA7
d0 CV7

Byte 9:

0	n	n	n	n	n	n	n	<CVH>	Configuration Variable number low 7 bits. CV1 is 0x0000, CV2 is 0x0001 etc.

Byte 10:

0	n	n	n	n	n	n	n	<DATA>	Data value low 7 bits.

Byte 11:

0	n	n	n	n	n	n	n	<SNH>	Throttle ID low 7 bits of low byte.

Byte 12:

0	n	n	n	n	n	n	n	<SNL>	Throttle ID low 7 bits of high byte.

Byte 13:

0	1	1	1	1	1	1	0	0x7E	Checksum.

Response:

Ack and if command is accepted a **ProgSlotData** message

Signature:

Byte 0:

1	1	1	0	1	1	1	1	0xEF

Byte 1:

0	0	0	0	1	1	1	0	0x0E

Byte 2:

0	1	1	1	1	1	0	0	0x7C

Byte 4:

0	0	0	0	0	0	0	0	0x00

Byte 7:

0	0	0	0	0	0	0	0	0x00

Byte 8:

0	0	×	×	0	0	×	×

Notes:

None.

1.4.45 ProgSlotDataP1

Description:

This response provides data for the programming slot.

Group:

Variable-Byte Message

Opcode:

OPC_SL_RD_DATA

Type:

Response

Encoding:

Byte 0:

1	1	1	0	0	1	1	1	0xE7	Opcode.

Byte 1:

0	0	0	0	1	1	1	0	0x0E	Message length.

Byte 2:

0	1	1	1	1	1	0	0	0x7C	Programming slot number.

Byte 3:

0	d6	d5	d4	d3	d2	d1	d0	<PCMD>	Last programming command.

d6 0 means read and 1 means write
d5 1 means byte mode and 0 means bit mode
d4 TY1
d3 TY0
d2 0 means service mode on programming track, 1 means operations mode on mainline.
d1 1 - unknown
d0 1 - unknown

d5	d4	d3	d2	d1	d0	Programming Mode
1	0	0	0	×	×	Paged mode byte read/write on service track
1	0	0	1	×	×	Direct mode byte read/write on service track
0	0	0	1	×	×	Direct mode bit read/write on service track
×	0	1	0	×	×	Physical register byte read/write on service track
×	0	1	1	×	×	Service track reserved function
1	0	0	1	×	×	Ops mode byte program no feedback
1	0	1	1	×	×	Ops mode byte program with feedback
0	0	0	1	×	×	Ops mode bit program no feedback
0	0	1	1	×	×	Ops mode bit program with feedback

Byte 4:

0	0	0	0	d3	d2	d1	d0

<PSTAT>

d3 1 means user aborted the previous command
d2 1 means failed to detect read compare acknowledge from decoder
d1 1 means no write acknowledge response from decoder
d0 1 means service mode programming track is empty - no decoder detected

Byte 5:

0	n	n	n	n	n	n	n

<HOPSA> In operations mode programming this contains the 7 high address bits of the locomotive to program. 0x00 if service mode.

Byte 6:

0	n	n	n	n	n	n	n

<LOPSA> In operations mode programming this contains the 7 low address bits of the locomotive to program. 0x00 if service mode.

Byte 7:

0	d6	0	0	d3	d2	d1	d0

<TRK> Global system track status.

d6 1 means this command station implements version 2 slot commands. This can be turned off on the DCS240 by setting the OpSw 44 to be closed.
d3 1 means the programming track is busy.
d2 1 means this master implements the Network version 1.1 capability, 0 means the master is a DT200.
d1 0 means the track is paused, broadcast an emergency stop.
d0 1 means the DCC packets are on in the master, global power up.

Byte 8:

0	0	d5	d4	0	0	d1	d0	<CVH>	Configuration Variable number high 3 bits and most significant bit of data byte.

d5 CV9
d4 CV8
d1 DATA7
d0 CV7

Byte 9:

0	n	n	n	n	n	n	n	<CVH>	Configuration Variable number low 7 bits. CV1 is 0x0000, CV2 is 0x0001 etc.

Byte 10:

0	n	n	n	n	n	n	n	<DATA>	Data value low 7 bits.

Byte 11:

0	n	n	n	n	n	n	n	<SNH>	Throttle ID low 7 bits of low byte.

Byte 12:

0	n	n	n	n	n	n	n	<SNL>	Throttle ID low 7 bits of high byte.

Byte 13:

0	1	1	1	1	1	1	0	0x7E	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	1	0	0	1	1	1	0xE7

Byte 1:

0	0	0	0	1	1	1	0	0x0E

Byte 2:

0	1	1	1	1	1	0	0	0x7C

Byte 4:

0	0	0	0	×	×	×	×

Byte 7:

0	×	0	0	×	×	×	×

Byte 8:

0	0	×	×	0	0	×	×

Notes:

None.

1.4.46 PwrOff

Description:

This command turns the track power off.

Group:

2-Byte Message

Opcode:

OPC_GPOFF

Type:

Command

Encoding:

Byte 0:

1	0	0	0	0	0	1	0	0x82	Opcode.

Byte 1:

0	1	1	1	1	1	0	1	0x7D	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	0	0	0	0	1	0	0x82

Notes:

None.

1.4.47 PwrOn

Description:

This command turns the track power on.

Group:

2-Byte Message

Opcode:

OPC_GPON

Type:

Command

Encoding:

Byte 0:

1	0	0	0	0	0	1	1	0x83	Opcode.

Byte 1:

0	1	1	1	1	1	0	0	0x7C	Checksum.

Response:

After power on the command station sends an **getCfgSlotDataP1** message. It also sends a sequence of OPC_SW_REQ messages with the following values of SW1 and SW2:

SW1	SW2	Purpose
0x78	0x27	
0x79	0x27	
0x7A	0x27	
0x7B	0x27	
0x78	0x07	Interrogate all PM4 inputs?
0x79	0x07	Interrogate all BDL16 input reports?
0x7A	0x07	Interrogate all SE8 input reports?
0x7B	0x07	Interrogate all DS64 input reports.

Signature:

Byte 0:

1	0	0	0	0	0	1	1	0x83

Notes:

None.

1.4.48 Reset

Description:

This broadcast message is sent by a command station when its "Loco Reset" button has been pressed. Software should reload any locally cached slot data from the command station.

Group:

2-Byte Message

Opcode:

OPC_LOCO_RESET

Type:

Broadcast

Encoding:

Byte 0:

1	0	0	0	1	0	1	0	0x8A	Opcode.

Byte 1:

0	1	1	1	0	1	0	1	0x75	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	0	0	1	0	1	0	0x8A

Notes:

None.

1.4.49 SensRepGenIn

Description:

General sensor input report.

Group:

4-Byte Message

Opcode:

OPC_INPUT_REP

Type:

Message

Encoding:

Byte 0:

1	0	1	1	0	0	1	0	0xB2	Opcode.

Byte 1:

0	d6	d5	d4	d3	d2	d1	d0	<IN1>	Sensor address A7 to A1.

d6 A7.
d5 A6.
d4 A5.
d3 A4.
d2 A3.
d1 A2.
d0 A1.

Byte 2:

0	1	d5	d4	d3	d2	d1	d0	<IN2>	Sensor address A11 to A8, A0 and sensor input state.

d5 A0.
d4 Input state: 1 means sensor input >= 6V, and 0 means sensor input = 0V.
d3 A11.
d2 A10.
d1 A9.
d0 A8.

Byte 3:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	1	0	0	1	0	0xB2

Byte 2:

0	1	×	×	×	×	×	×

Notes:

None.

1.4.50 SensRepTurnIn

Description:

Turnout sensor input report.

Group:

4-Byte Message

Opcode:

OPC_SW_REP

Type:

Message

Encoding:

Byte 0:

1	0	1	1	0	0	0	1	0xB1	Opcode.

Byte 1:

0	d6	d5	d4	d3	d2	d1	d0	<SN1>	Sensor address A7 to A1.

d6 A7.
d5 A6.
d4 A5.
d3 A4.
d2 A3.
d1 A2.
d0 A1.

Byte 2:

0	1	d5	d4	d3	d2	d1	d0	<SN2>	Sensor address A11 to A8, A0 and sensor state.

d5 A0.
d4 Input sensor state, 1 means sensor >= 6V, 0 means sensor = 0V.
d3 A11.
d2 A10.
d1 A9.
d0 A8.

Byte 3:

0	n	n	n	n	n	n	n

<CHK> Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	1	0	0	0	1

0xB1

Byte 2:

0	1	×	×	×	×	×	×

Notes:

None.

1.4.51 SensRepTurnOut

Description:

Turnout sensor output report.

Group:

4-Byte Message

Opcode:

OPC_SW_REP

Type:

Message

Encoding:

Byte 0:

1	0	1	1	0	0	0	1	0xB1	Opcode.

Byte 1:

0	d6	d5	d4	d3	d2	d1	d0	<SN1>	Sensor address A6 to A0.

d6 A6.
d5 A5.
d4 A4.
d3 A3.
d2 A2.
d1 A1.
d0 A0.

Byte 2:

0	0	d5	d4	d3	d2	d1	d0	<SN2>	Sensor address A10 to A7 and sensor state.

d5 0 means closed output line is off and 1 means the closed output line is on.
d4 0 means thrown output line is off and 1 means the thrown output line is on.
d3 A10.
d2 A9.
d1 A8.
d0 A7.

Byte 3:

0	n	n	n	n	n	n	n

<CHK> Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	1	0	0	0	1

0xB1

Byte 2:

0	0	×	×	×	×	×	×

Notes:

None.

1.4.52 SetBrdOpSw

Description:

Set board OpSw.

Group:

6-Byte Message

Opcode:

OPC_BRD_OPSW (Unofficial mnemonic)

Type:

Broadcast

Encoding:

Byte 0:

1	1	0	1	0	0	0	0	0xD0	Opcode.

Byte 1:

0	1	1	1	0	0	1	d0	The bit d0 is the most significant bit of the board id.

Byte 2:

0	n	n	n	n	n	n	n	<BIDL>	Least significant 7 bits of the board id.

Byte 3:

0	n	n	n	n	n	n	n	<BTYPE>	Board type code.

Board	Type Code
PM4	0x70.
BDL16	0x71.
SE8C	0x72.
DS64	0x73.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	Byte and bit number.

The high nibble encodes the byte number, and the low nibble the bit number. The byte number is calculated as (OpSw# - 1) >> 3 and the bit number is (OpSw# - 1) - byte number × 8.

Byte 5:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

Ack

Signature:

Byte 0:

1	1	0	1	0	0	0	0	0xD0

Byte 1:

0	1	1	1	0	0	1	×

Notes:

None.

1.4.53 SetIdleState

Description:

This command sets the network to “idle” state. The command station broadcasts an emergency stop.

Group:

2-Byte Message

Opcode:

OPC_IDLE

Type:

Command

Encoding:

Byte 0:

1	0	0	0	0	1	0	1	0x85	Opcode.

Byte 1:

0	1	1	1	1	0	1	0	0x7A	Checksum.

Response:

None

Signature:

Byte 0:

1	0	0	0	0	1	0	1	0x85

Notes:

None.

1.4.54 SetLocoSlotDataP1

Description:

This command sets the locomotive slot data for the specified slot.

Protocol:

1

Group:

Variable-Byte Message

Opcode:

OPC_WR_SL_DATA

Type:

Command

Encoding:

Byte 0:

1	1	1	0	1	1	1	1	0xEF	Opcode.

Byte 1:

0	0	0	0	1	1	1	0	0x0E	Message length (14 bytes).

Byte 2:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77. Slot 0x00 is the dispatch special slot.

Byte 3:

d7	d6	d5	d4	d3	d2	d1	d0	<STAT1>	Slot status 1.

d7	d6	
0	0	Free, no consist linking.
0	1	Consist sub-member.
1	0	Consist top-member.
1	1	Consist Mid-Consist member.

Note: d7 is set to 0 in the message by the command station and so may not correctly reflect the actual setting in the slot table.

d5	d4	
0	0	Free slot, no valid data. Not refreshed.
0	1	Common. Locomotive address in this slot. Refreshed.
1	0	Idle. Locomotive address in this slot. Not refreshed.
1	1	In Use. Locomotive address in this slot. Refreshed.

d3	
0	No slot consist linked into this slot.
1	Slot consist linked into this slot.

d2	d1	d0	
0	0	0	28 step decoder. 3-byte packet regular mode
0	0	1	28 step decoder. Generate trinary packets for this mobile address
0	1	0	14 step decoder.
0	1	1	128 step decoder.
1	0	0	28 step decoder. Allow advanced consisting
1	0	1	reserved
1	1	0	reserved
1	1	1	128 step decoder. Allow advanced consisting

Byte 4:

0	n	n	n	n	n	n	n	<ADR>	If <ADR2> is 0 then this contains the NMRA short address. If <ADR2> is greater than 0 then this contains the low 7 bits of the NMRA long address.

Byte 5:

0	n	n	n	n	n	n	n	<SPD>	Speed in the range 0x00 to 0x7F. 0x00 means inertial stop and 0x01 means emergency stop. Other values mean increasing speed.

Byte 6:

0	0	d5	d4	d3	d2	d1	d0	<DIRF>	Locomotive direction and state of functions F0 to F4.

d5 Direction: 1 means forward and 0 means backwards.
d4 F0 state: 1 means on and 0 means off.
d3 F4 state: 1 means on and 0 means off.
d2 F3 state: 1 means on and 0 means off.
d1 F2 state: 1 means on and 0 means off.
d0 F1 state: 1 means on and 0 means off.

Byte 7:

0	d6	0	0	d3	d2	d1	d0	<TRK>	Global system track status.

d6 1 means this command station implements protocol 2 messages. This can be turned off on the DCS240 by setting the OpSw 44 to be closed.
d3 1 means the programming track is busy.
d2 1 means this command station implements protocol 1 messages and 0 means the command station is a DT200.
d1 0 means the track is paused, broadcast an emergency stop.
d0 1 means the DCC packets are on in the command station and the track power is on.

Byte 8:

0	0	0	0	d3	d2	0	d0	<SS2>	Slot status 2.

d3 1 means expansion in ID1/2, 0 means encoded alias.
d2 1 means expansion ID1/2 is not ID usage.
d0 1 means this slot has suppressed advanced consist.

Byte 9:

0	n	n	n	n	n	n	n	<ADR2>	If <ADR2> is greater than 0 then this contains the high 7 bits of the NMRA long address.

Byte 10:

0	0	0	0	d3	d2	d1	d0	<SND>	Function F5 to F8 states.

d3 F8 state: 1 means on and 0 means off.
d2 F7 state: 1 means on and 0 means off.
d1 F6 state: 1 means on and 0 means off.
d0 F5 state: 1 means on and 0 means off.

Byte 11:

0	n	n	n	n	n	n	n	<ID1>	7-bit ls ID code written by throttle when STAT2.4 = 1.

Byte 12:

0	n	n	n	n	n	n	n	<ID2>	7-bit ms ID code written by throttle when STAT2.4 = 1.

Byte 13:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

Ack

Signature:

Byte 0:

1	1	1	0	1	1	1	1	0xEF

Byte 1:

0	0	0	0	1	1	1	0	0x0E

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 6:

0	0	×	×	×	×	×	×

Byte 7:

0	×	0	0	×	×	×	×

Byte 8:

0	0	0	0	×	×	0	×

Byte 10:

0	0	0	0	×	×	×	×

Notes:

None.

1.4.55 SetLocoSlotDataP2

Description:

This command sets the locomotive slot data for the specified slot number.

Protocol:

2

Group:

Variable-Byte Message

Opcode:

OPC_WR_SL_DATA_P2 (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	1	0	1	1	1	0	0xEE	Opcode.

Byte 1:

0	0	0	1	0	1	0	1	0x15	Message length (21 bytes).

Byte 2:

0	0	0	0	0	d2	d1	d0	<SLOTP#>	Slot page number in the range 0x0 to 0x7.

Byte 3:

0	n	n	n	n	n	n	n	<SLOTL#>	Slot number in the range 0x00 to 0x77.

Byte 4:

0	d6	d5	d4	d3	d2	d1	d0	<STAT1>	Slot status 1.

d7	d6	
0	0	Free, no consist linking.
0	1	Consist sub-member.
1	0	Consist top-member.
1	1	Consist Mid-Consist member.

Note: d7 is set to 0 in the message by the command station and so may not correctly reflect the actual setting in the slot table.

d5	d4	
0	0	Free slot, no valid data. Not refreshed.
0	1	Common. Locomotive address in this slot. Refreshed.
1	0	Idle. Locomotive address in this slot. Not refreshed.
1	1	In Use. Locomotive address in this slot. Refreshed.

d3	
0	No slot consist linked into this slot.
1	Slot consist linked into this slot.

d2	d1	d0	
0	0	0	28 step decoder. 3-byte packet regular mode
0	0	1	28 step decoder. Generate trinary packets for this mobile address
0	1	0	14 step decoder.
0	1	1	128 step decoder.
1	0	0	28 step decoder. Allow advanced consisting
1	0	1	reserved
1	1	0	reserved
1	1	1	128 step decoder. Allow advanced consisting

Byte 5:

0	n	n	n	n	n	n	n	<ADR>	Low address.

Byte 6:

0	n	n	n	n	n	n	n	<ADR2>	High address.

Byte 7:

0	d6	d5	d4	d3	d2	d1	d0	<TRK>	Global system track status.

d6 1 means this command station implements protocol 2 messages. This can be turned off on the DCS240 by setting the OpSw 44 to be closed.
d5 Reserved. Set to 0.
d4 Reserved. Set to 0.
d3 1 means the programming track is busy.
d2 1 means this command station implements protocol 1 messages. 0 means the command station is a DT200.
d1 0 means the track is paused, broadcast an emergency stop.
d0 1 means the DCC packets are on in the command station and track power is on.

Byte 8:

0	d6	d5	d4	d3	d2	d1	d0

<SPD> Speed in the range 0x00 to 0x7F. 0x00 means inertial stop and 0x01 means emergency stop. Other values mean increasing speed.

Byte 9:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F8 state: 1 means on and 0 means off
d5 F0 state: 1 means on and 0 means off
d4 F12 state: 1 means on and 0 means off
d3
d2
d1 F20 state: 1 means on and 0 means off
d0

Byte 10:

0	d6	d5	d4	d3	d2	d1	d0

Direction.

d6
d5 Direction: 1 means forwards and 0 means backwards
d4
d3
d2
d1
d0

Byte 11:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6
d5
d4
d3
d2
d1
d0

F11 state: 1 means on and 0 means off
F10 state: 1 means on and 0 means off
F9 state: 1 means on and 0 means off

Byte 12:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F19 state: 1 means on and 0 means off
d5 F18 state: 1 means on and 0 means off
d4 F17 state: 1 means on and 0 means off
d3 F16 state: 1 means on and 0 means off
d2 F15 state: 1 means on and 0 means off
d1 F14 state: 1 means on and 0 means off
d0 F13 state: 1 means on and 0 means off

Byte 13:

0	d6	d5	d4	d3	d2	d1	d0

Functions.

d6 F7 state: 1 means on and 0 means off
d5 F6 state: 1 means on and 0 means off
d4 F5 state: 1 means on and 0 means off
d3 F4 state: 1 means on and 0 means off
d2 F3 state: 1 means on and 0 means off
d1 F2 state: 1 means on and 0 means off
d0 F1 state: 1 means on and 0 means off

Byte 14:

0	d6	d5	d4	d3	d2	d1	d0

Unknown.

d6
d5
d4
d3
d2
d1
d0

Byte 15:

0	d6	d5	d4	d3	d2	d1	d0

Unknown.

d6
d5
d4
d3
d2
d1
d0

Byte 16:

0	d6	d5	d4	d3	d2	d1	d0

Consist slot page number.

d6
d5
d4
d3
d2 Consist slot page b2
d1 Consist slot page b1
d0 Consist slot page b0

Byte 17:

0	n	n	n	n	n	n	n

Consist slot number in the range 0x00 to 0x77.

Byte 18:

0	d6	d5	d4	d3	d2	d1	d0

Throttle id low bits.

Byte 19:

0	d6	d5	d4	d3	d2	d1	d0

Throttle id high bits.

Byte 20:

0	n	n	n	n	n	n	n

<CHK> Checksum.

Response:

Ack

<LOPC>	<ACK1>	Meaning
0x6E	0x7F	Command OK.

Signature:

Byte 0:

1	1	1	0	1	1	1	0	0xEE

Byte 1:

0	0	0	1	0	1	0	1	0x15

*** THERE SHOULD BE MORE ONCE ALL THE BYTES ARE DETERMINED ***

Notes:

None.

1.4.56 SetLocoSlotStat1

Description:

This command sets the locomotive slot status 1 values for the specified slot number.

Protocol:

1

Group:

4-Byte Message

Opcode:

OPC_SLOT_STAT1

Type:

Command

Encoding:

Byte 0:

1	0	1	1	0	1	0	1	0xB5	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SLOT#>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	d6	d5	d4	d3	d2	d1	d0	<STAT1>	Slot status 1.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	0	1	1	0	1	0	1	0xB5

Byte 1:

0	n	n	n	n	n	n	n

less than 0x78

Notes:

None.

1.4.57 SetSwWithAck

Description:

This command sets a specified switch to a specified state. The switch responds with an **Ack**.

Group:

4-Byte Message

Opcode:

OPC_SW_ACK

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	1	0	1	0xBD	Opcode.

Byte 1:

0	d6	d5	d4	d3	d2	d1	d0	<SW1>	Switch address A6 to A0.

d6 A6.
d5 A5.
d4 A4.
d3 A3.
d2 A2.
d1 A1.
d0 A0.

Byte 2:

0	0	d5	d4	d3	d2	d1	d0	<SW2>	Switch address A10 to A7 and switch control bits.

d5 Direction. 1 means closed/green, and 0 means thrown/red.
d4 Output. 1 means on, and 0 means off.
d3 A10.
d2 A9.
d1 A8.
d0 A7.

Byte 3:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

Ack

<LOPC>	<ACK1>	Meaning
0x3D	0x00	FIFO is full, command rejected.
0x3D	0x7F	Command accepted.

Signature:

Byte 0:

1	0	1	1	1	1	0	1	0xBD

Byte 2:

0	0	×	×	×	×	×	×

Notes:

None.

1.4.58 OPC_SV_PROG

Operation: Program system variables.

Group: Variable-Byte Message

Direction: device → device

Encoding:

Byte 0:

1	1	1	0	0	1	0	1	0xE5	Opcode.

Byte 1:

0	0	0	1	0	1	0	0	0x14	Message length (20 bytes).

Byte 2:

0	n	n	n	n	n	n	n	<SRC>	Source id in the range 0x00 to 0x7F.

Byte 3:

0	n	n	n	n	n	n	n	<SV_CMD>	Specifies the SV access type.

Byte 4:

0	n	n	n	n	n	n	n	<DSTH>	Destination id high in the range 0x00 to 0x7F.

Byte 5:

0	n	n	n	n	n	n	n	<HOST>	Device host identifier.

This should be 0x00 for discover devices broadcast.

Host Id	Device
0x01	LNRP
0x04	UT4
0x0C	WTL12
0x14	DB210 Opto
0x15	DB210
0x16	DB220
0x1A	DCS210+
0x1B	DCS210
0x1C	DCS240
0x23	PR3
0x24	PR4
0x2A	DT402
0x32	DT500
0x33	DCS51
0x34	DCS52
0x3E	DT602
0x51	BXPA1
0x58	BXP88
0x5C	UR92
0x63	LNWI

Byte 6:

0	n	n	n	n	n	n	n

Hardware version.

Host Id	Device
0x00	Slave all
0x18	Slave RF24

Byte 7:

0	n	n	n	n	n	n	n

Reserved.

Byte 8:

0	d6	d5	d4	d3	d2	d1	d0

Software Version Number.

d6	version number bit 3
d5	version number bit 2.
d4	version number bit 1
d3	version number bit 0
d2	subversion number bit 2
d1	subversion number bit 1
d0	subversion number bit 0

e.g. 0x09 decodes as version 1.1.

This is set to 0x00 for discover devices broadcast message.

Byte 9:

0	d6	d5	d4	d3	d2	d1	d0	<PXCT1>	Address type code and high bits of D1 to D4.

d6 XC2. Address type code.
d5 XC1. Address type code.
d4 XC0. Address type code.
d3 D4.7. High bit
d2 D3.7. High bit
d1 D2.7. High bit
d0 D1.7. High bit

XC2	XC1	XC0	Meaning
0	0	0	7 bit peer to peer addresses.
0	0	1	reserved.
0	1	0	reserved.
0	1	1	reserved.
1	0	0	reserved.
1	0	1	reserved.
1	1	0	reserved.
1	1	1	reserved.

Byte 10:

0	n	n	n	n	n	n	n	<D1>	Data item 1. Low 7 bits.

Byte 11:

0	n	n	n	n	n	n	n	<D2>	Data item 2. Low 7 bits.

This should be 0x01 for a discover devices broadcast message.

Byte 12:

0	n	n	n	n	n	n	n	<D3>	Data item 3. Low 7 bits.

Byte 13:

0	n	n	n	n	n	n	n	<D4>	Data item 4. Low 7 bits.

Byte 14:

0	n	n	n	n	n	n	n	<PXCT2>	Data type code and high bits for D5 to D8.

d6 XC5. Data type code.
d5 XC4. Data type code.
d4 XC3. Data type code.
d3 D8.7. High bit
d2 D7.7. High bit
d1 D6.7. High bit
d0 D5.7. High bit

XC5	XC4	XC3	Meaning
0	0	0	ANSI text string.
0	0	1	reserved.
0	1	0	reserved.
0	1	1	reserved.
1	0	0	reserved.
1	0	1	reserved.
1	1	0	reserved.
1	1	1	reserved.

Byte 15:

0	n	n	n	n	n	n	n	<D5>	Data item 5. Low 7 bits.

Byte 16:

0	n	n	n	n	n	n	n	<D6>	Data item 6. Low 7 bits.

Byte 17:

0	n	n	n	n	n	n	n	<D7>	Data item 7. Low 7 bits.

Byte 18:

0	n	n	n	n	n	n	n	<D8>	Data item 8. Low 7 bits.

Byte 19:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Description:

This command sends the data from one device to another peer to peer.

SRC	DSTL	DSTH	Comments
0x0F	0x08	0x00	Discover devices broadcast message.
0x0F	0x10	0x00	Discover device response.

Response:

OPC_PEER_XFER_20 for discover devices.

Notes:

The discover response decoded peer transfer message encodes as follows:

D1	IPL Version Number
D2	Serial Number - low byte
D3	Serial Number - high byte
D4	
D5	Serial Number 2 - low byte
D6	Serial Number 2 - high byte
D7	
D8	

The IPL version number is encoded as follows:

d6	version number bit 3
d5	version number bit 2.
d4	version number bit 1
d3	version number bit 0
d2	subversion number bit 2
d1	subversion number bit 1
d0	subversion number bit 0

e.g. 0x09 decodes as version 1.1.

These came from DigiPLII:

message Length = 20 e5 14 0f 10 00 24 00 00 00 02 00 08 07 00 00 00 00 00 00 38

message Length = 20 e5 14 0f 08 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00 08

message Length = 20 e5 14 0f 10 00 24 00 00 00 00 00 57 13 00 00 00 00 00 00 71

message Length = 20 e5 14 0f 10 00 1b 00 00 03 02 00 54 10 00 00 00 00 00 00 4f

It reports PR4 with serial number 0x0788 ver 0 PR4 with serial 0x1357 ver 0 DCS240 with SN 0x0AAB ver 0.3 DCS210 with SN 0x10D4 ver 0.3

1.4.59 SwReq

Description:

Command a turnout controller to a specified state. *** CHECK THIS ***

Group:

4-Byte Message

Opcode:

OPC_SW_REQ

Type:

Command

Encoding:

Byte 0:

1	0	1	1	0	0	0	0	0xB0	Opcode.

Byte 1:

0	d6	d5	d4	d3	d2	d1	d0	<SW1>	Switch address A6 to A0.

d6 A6.
d5 A5.
d4 A4.
d3 A3.
d2 A2.
d1 A1.
d0 A0.

Byte 2:

0	0	d5	d4	d3	d2	d1	d0	<SW2>	Switch address A10 to A7 and switch control bits.

d5 Direction. 1 means closed/green, and 0 means thrown/red.
d4 Output. 1 means on, and 0 means off.
d3 A10.
d2 A9.
d1 A8.
d0 A7.

Byte 3:

0	n	n	n	n	n	n	n	<CHK> Checksum.

Response:

Ack if command failed, otherwise no response.

<LOPC>	<ACK1>	Meaning
0x30	0x00	Command failed.

Signature:

Byte 0:

1	0	1	1	0	0	0	0	0xB0

Byte 2:

0	0	×	×	×	×	×	×

Notes:

The on power on the command station sends a sequence of OPC_SW_REQ messages with the following values of SW1 and SW2:

SW1	SW2	Purpose
0x78	0x27	
0x79	0x27	
0x7A	0x27	
0x7B	0x27	
0x78	0x07	Interrogate all PM4 inputs?
0x79	0x07	Interrogate all BDL16 input reports?
0x7A	0x07	Interrogate all SE8 input reports?
0x7B	0x07	Interrogate all DS64 input reports.

1.4.60 SwState

Description:

Request state of switch. *** NEED TO CHECK ***

Group:

4-Byte Message

Opcode:

OPC_SW_STATE

Type:

Message?

Encoding:

Byte 0:

1	0	1	1	1	1	0	0	0xBC	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SW1>	Switch address A6 to A0.

Byte 2:

0	0	d5	d4	d3	d2	d1	d0	<SW2>	Switch address A10 to A7 and switch control bits.

d5 Direction. 1 means closed/green, and 0 means thrown/red.
d4 Output. 1 means on, and 0 means off.
d3 A10.
d2 A9.
d1 A8.
d0 A7.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

Ack

Signature:

Byte 0:

1	0	1	1	1	1	0	0

0xBC

Byte 2:

0	0	×	×	×	×	×	×

Notes:

This needs to be tested to see what the real purpose is.

1.4.61 TransRep

Description:

Transponder input report.

Group:

6-Byte Message

Opcode:

OPC_TRANS_REP

Type:

Broadcast

Encoding:

Byte 0:

1	1	0	1	0	0	0	0	0xD0	Opcode.

Byte 1:

0	n	n	n	n	n	n	n		A value of 0x20 means the positive detection of a transponder, 0x00 means no longer detected.

Byte 2:

0	0	0	0	n	n	n	n	<ZONE#>	Zone indicator (0x0 = A, 0x2 = B, 0x4 = C, 0x6 = D).

Byte 3:

0	n	n	n	n	n	n	n	<ADR>	Locomotive address low bits.

Byte 4:

0	n	n	n	n	n	n	n	<ADR2>	Locomotive address high bits.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

None.

Signature:

Byte 0:

1	1	0	1	0	0	0	0

0xD0.

*** THERE SHOULD BE MORE ***

Notes:

None.

1.4.62 UnlinkSlotsP1

Description:

This command unlinks slot SL1 from slot SL2.

Protocol:

1

Group:

Variable-Byte Message

Opcode:

OPC_UNLINK_SLOTS

Type:

Command

Encoding:

Byte 0:

1	0	1	1	1	0	0	0	0xB8	Opcode.

Byte 1:

0	n	n	n	n	n	n	n	<SL1>	Slot number in the range 0x00 to 0x77.

Byte 2:

0	n	n	n	n	n	n	n	<SL2>	Slot number in the range 0x00 to 0x77.

Byte 3:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

Returns **LocoSlotDataP1** or **Ack**

Signature:

Byte 0:

1	0	1	1	1	0	0	0	0xB8

Byte 1:

0	n	n	n	n	n	n	n

less than 0x78

Byte 2:

0	n	n	n	n	n	n	n

less than 0x78

Notes:

None.

1.4.63 UnlinkSlotsP2

Description:

This command unlinks slot SL1 from a consist. The command station sets SL_CONUP/DN flags appropriately. If the command was successful then a **LocoSlotDataP2** response will be returned. An invalid link will return a **Ack** with a response code of 0x00.

Protocol:

2

Group:

6-Byte Message

Opcode:

OPC_D4_GROUP (Unofficial mnemonic)

Type:

Command

Encoding:

Byte 0:

1	1	0	1	0	1	0	0	0xD4	Opcode.

Byte 1:

0	0	1	1	1	d2	d1	d0	<SL1P>	Bits d2 to d0 contain the SL1 slot page number in the range 0x0 to 0x7.

Byte 2:

0	n	n	n	n	n	n	n	<SL1#>	Slot number SL1 in the range 0x00 to 0x77.

Byte 3:

0	1	0	1	0	d2	d1	d0	<SL1P>	Bits d2 to d0 contain the SL1 slot page number in the range 0x0 to 0x7. This is the same value as byte 1.

Byte 4:

0	n	n	n	n	n	n	n	<SL1#>	Slot number SL1 in the range 0x00 to 0x77. This is the same value as byte 2.

Byte 5:

0	n	n	n	n	n	n	n	<CHK>	Checksum.

Response:

LocoSlotDataP2 or **Ack**.

Signature:

Byte 0:

1	1	0	1	0	1	0	0	0xD4

Byte 1:

0	0	1	1	1	×	×	×	

Byte 2:

0	n	n	n	n	n	n	n	less than 0x78

Byte 3:

0	1	0	1	0	×	×	×	

Byte 4:

0	n	n	n	n	n	n	n	less than 0x78

Notes:

None.

Chapter 2

Fast Clock

2.1 Summary

The command station provides a system fast clock and parameters are stored in slot #123 (0x7B). Use OPC_WR_SL_DATA to write new clock information, The current slot information can be read using OPC_RQ_SL_DATA. This will return an OPC_SL_RD_DATA message containing the fast clock information. This message is called the "sync". Other throttles will update to this sync. Note that all attached display devices keep a current clock calculation based on this sync read value, i.e. devices must not continuously poll the clock slot to generate time, but use this merely to restore sync and follow current rate etc. The clock slot is typically "pinged" or read every 70 to 100 seconds, by a single user, so all attached devices can synchronise any phase drifts. Upon seeing a sync read, all devices should reset their local sub-minute phase counter and invalidate the sync update ping generator.

2.2 Slot #123 Encoding

Byte 0:

0	1	1	1	1	0	1	1	0x7B	Slot number.

Byte 1:

0	n	n	n	n	n	n	n	<RATE>	Clock rate. 0x00 means freeze clock, 0x01 means 1:1 rate, 0x0A means 10:1, etc. The maximum value 0x7F means 128:1.

Byte 2:

0	n	n	n	n	n	n	n	<FRACL>	Sub-minute counter low bits.

Byte 3:

0	n	n	n	n	n	n	n	<FRACH>	Sub-minute counter high bits.

The implementation and meaning of FRACL and FRACH depend upon the specific clock generator. These values should not be used externally. These values are reset when a valid sync message is seen.

That said, the following timing was derived for the DCS240.

Get:

maxTick = 0xBFF

ticks = maxTick - (0x3FFF - ((<FRACL> & 0x7F) — ((<FRACH> & 0x7F) << 7)))

seconds = 60.0 * ticks / (maxTick + 1)

Set:

temp = ticks - maxTick + 0x3FFF

<FRACL> = temp & 0x7F

<FRACH> = (temp >> 7) & 0x7F

Byte 4:

0	n	n	n	n	n	n	n	<MINS>	Fast clock minutes. This is encoded.

Get:

temp = ((255 - <MINS>) & 0x7F) mod 60

minutes = (60 - temp) mod 60

Set:

<MINS> = (255 - (60 - minutes)) & 0x7F

Byte 5:

0	d6	d5	d4	d3	d2	d1	d0	<TRK>	Global system track status.

d6 Reserved. Set to 0.
d5 Reserved. Set to 0.
d4 Reserved. Set to 0.
d3 1 means the programming track is busy.
d2 1 means this master implements the Network version 1.1 capability, 0 means the master is a DT200.
d1 0 means the track is paused, broadcast an emergency stop.
d0 1 means the DCC packets are on in the master, global power up.

Byte 6:

0	n	n	n	n	n	n	n	<HRS>	Fast clock hours. This is encoded.

Get:

temp = ((256 - <HRS>) & 0x7F) mod 24

hours = (24 - temp) mod 24

Set:

<HRS> = (256 - (24 - hours)) & 0x7F

Byte 7:

0	n	n	n	n	n	n	n	<DAYS>	Fast clock days. Number of 24 hour clock rolls.

Byte 8:

0	d6	0	0	0	0	0	0	<CNTRL>	The bit d6 indicates valid clock information. 1 means good and 0 means ignore.

Byte 9:

0	n	n	n	n	n	n	n	<ID1>	Device ID low bits.

Byte 10:

0	n	n	n	n	n	n	n	<ID2>	Device ID high bits.

ID1 and ID2 indicate the device that last set the clock. 0x00, 0x00 means that not set has happened. 0x7F, 0x7X are reserved for computer use.

Chapter 3

Updating Firmware

3.1 Bootloader Protocol 1

3.2 Bootloader Protocol 2

1. The IPL Setup message is sent twice to initiate the download.

2. Each block is sent,

3. The IPL End Operation message is sent.

A block consists of an IPL Address message following by 1 or more IPL Data messages.

3.3 Firmware Parameters

PC	Device	DT	BV	HV	SV	CK	DL	OP	PB	EB	ED	DC
0x01	LNRP	09OCT15	1	0	3	64	8	1	64	64	8	0x50
0x04	UT4											
0x06	UT6	05APR21	2	0	1	64	11	2	512	4096	40	0x2E
0x0C	WTL12											
0x14	DB210O	06MAR20	2	1	2	64	7	2	512	4096	25	0x08
0x15	DB210	06MAR20	2	1	2	64	7	2	512	4096	25	0x08
0x16	DB220	06MAR20	2	1	2	64	7	2	512	4096	25	0x08
0x1A	DCS210+											
0x1B	DCS210	06MAR20	2	1	3	64	5	2	256	2048	40	0x2C
0x1C	DCS240	06MAR20	2	1	3	64	5	2	256	2048	40	0x2C
0x23	PR3	12FEB14	1	0	8	64	5	1	-	1024	-	0x14
0x24	PR4	05JAN18	0	0	0	64	5	2	256	2048	60	0x1C
0x2A	DT402	10OCT16	1	0	17	64	15	1	64	64	15	0x73
0x2A	DT402	05AUG16	1	0	17	64	15	1	64	64	15	0x4B
0x32	DT500	10OCT16	1	0	1	64	15	1	64	64	15	0x0E
0x33	DCS51	06OCT14	1	0	5	64	12	1	-	-	-	0x0E
0x34	DCS52	17JUN21	2	0	1	64	11	2	512	4096	40	0x2C
0x3E	DT602	15JUL21	2	0	1	64	11	2	512	4096	40	0x30
0x51	BXPA1	18JUN21	2	0	1	64	6	2	512	4096	41	0x0A
0x58	BXP88	21OCT17	2	0	2	64	50	2	256	2048	100	0x18
0x5C	UR92	07DEC15	0	1	8	64	16	1	64	64	16	0x24
0x5D	UR93	30AUG21	2	0	0	64	5	2	512	4096	25	0x0A
0x63	LNWI	11MAR21	2	1	2	64	5	2	512	4096	25	0x12

EBS	LNRP	DT402	DT500	DCS51	DCS52
32	0x20	0x65	0x1B	-	0x00
64	0x50	0x73	0x0E	0x0E	0x00
128	0x28	0x3A	0x47	-	0x00
192	0x1B	0x7C	0x05	-	0x2B
256	0x14	0x5D	0x64	-	0x40
1024	0x05	0x18	0x19	-	0x30
2048	0x03	0x0C	0x0D	-	0x58
4096	0x02	0x06	0x07	-	0x2C
8192	0x01	0x03	0x04	-	0x16
16384	-	0x02	0x02	-	0x0B
32768	-	0x01	0x01	-	0x06
65536	-	-	-	-	0x03

3.4 DMF File Format

The manufacturer's DMF file format is a modified form of the Intel Hexadecimal Object File Format. Character encoding is ASCII. The file consists of multiple "records" each terminated by an ASCII linefeed character (0x0A). There are four types of record and they appear in the file in the following order:

1. Sync records
2. Parameter records
3. Data records
4. End of File record

3.4.1 Sync Records

Sync records are used to identify the file as a DMF file. There are six sync records each consisting of a single ASCII # character (0x23).

Example:

```
#
#
#
#
#
#
```

3.4.2 Parameter Records

PARAM MARK	PARAMETER NAME	NAME TERMINATOR	VALUE
! (0x21) <SPC> (0x20)	ASCII text	: (0x3A) <SPC> (0x20)	decimal value
2 bytes	variable bytes	2 byte	variable bytes

PARAMETER RECORD FORMAT

Parameter records start with a two byte PARAM MARK. This consists of the ASCII code for the exclamation mark (0x21) followed by the ASCII code for the space character (0x20). The PARAMETER NAME is next. The PARAMETER NAME is ASCII encoded text identifying the parameter. The PARAMETER NAME may include spaces. It is terminated by the NAME TERMINATOR which consists of the ASCII code for a colon

(0x3A) followed by the ASCII code for a space character (0x20). The last field is the VALUE field. This is a decimal numeric value encoded as ASCII text.

The following parameters have been identified and they are presented in the following order (it is not known if the order is significant):

1. Bootloader Version
2. Manufacturer Code
3. Product Code
4. Hardware Version
5. Software Version
6. Chunk Size
7. Delay
8. Options
9. First Address
10. Last Address
11. Prog Blk Size
12. Erase Blk Size
13. Erase Dly

Example:

```
! Bootloader Version: 2
! Manufacturer Code: 0
! Product Code: 88
! Hardware Version: 0
! Software Version: 2
! Chunk Size: 64
! Delay: 50
! Options: 2
! First Address: 24576
! Last Address: 73728
! Prog Blk Size: 256
! Erase Blk Size: 2048
! Erase Dly: 100
```

3.4.3 Data Records

RECORD MARK (:)	RECLEN	LOAD OFFSET	RECTYP	DATA	CHKSUM
1 byte	2 bytes	6 bytes	2 bytes	n bytes	2 bytes

DATA RECORD FORMAT

The data record provides a set of hexadecimal digits that represent the ASCII code for data bytes that make up a portion of a memory image.

Each data record begins with a RECORD MARK field containing the ASCII code for the colon (:) character (0x3A).

Each record has a RECLEN field which specifies the number of bytes of data which follows the RECTYP field of the record. Note that one data byte is represented by two ASCII characters. The maximum value of the RECLEN field is hexadecimal "FF" or 255. Although the maximum is 255, the manufacturer seems to prefer 64.

Each record has a LOAD OFFSET field which specifies the 24-bit starting load offset of the data bytes.

The RECTYP field for data records is "00".

Each record has a variable length DATA field, it consists of zero or more bytes encoded as pairs of hexadecimal digits.

Each record ends with a CHKSUM field that contains the ASCII hexadecimal representation of the two's complement of the 8-bit bytes that result from converting each pair of ASCII hexadecimal digits to one byte of binary, from and including the RECLEN field to and including the last byte of the DATA field. Therefore, the sum of all the ASCII pairs in a record after converting to binary, form the RECLEN field up to and including the CHKSUM field, is zero.

The contents of the individual fields within the record are:

RECORD MARK	This field contains 0x3A, the encoding of the ASCII colon (:) character.
RECLEN	The field contains two ASCII hexadecimal digits that specify the number of data bytes in the record. The maximum value is "FF" or 0x4646 (255 decimal).
LOAD OFFSET	This field contains six ASCII hexadecimal digits representing the address at which the first byte of the data is to be placed. Most significant digit is presented first.
RECTYP	This field contains 0x3030, the hexadecimal encoding of the ASCII characters "00", which specifies the record type to be a data record.
DATA	This field contains pairs of ASCII hexadecimal digits, one pair for each data byte.
CHKSUM	This field contains the check sum on the RECLEN, LOAD OFFSET, RECTYP, and DATA fields.

Example:

```
:400060000057AAC3880FAAC388559AC38855AAC388553AC38855AAC38855AAC3884A0
0C38855AAC38855AAC3882DFCC38861B8C3882DFCC38861B8C3882DFCC38861B8C3886D
```

3.4.4 End of File Record

RECORD MARK (:)	RECLEN "00"	LOAD OFFSET "000000"	RECTYP "01"	CHKSUM "FF"
1 byte	2 bytes	6 bytes	2 bytes	2 bytes

END OF FILE RECORD FORMAT

The End of File Record specifies the end of the file.

The contents of the individual fields within the record are:

RECORD MARK	This field contains 0x3A, the encoding of the ASCII colon (:) character.
RECLEN	The field contains 0x3030, the hexadecimal encoding of the ASCII characters "00". Since this record does not contain any DATA bytes, the length is zero.
LOAD OFFSET	This field contains 303030303030H, the hexadecimal encoding of the ASCII characters "000000", since this field is not used for this record.
RECTYP	This field contains 0x3031, the hexadecimal encoding of the ASCII characters "01", which specifies the record type to be an End of File Record.
CHKSUM	This field contains the check sum on the RECLEN, LOAD OFFSET, and RECTYP fields. Since all the fields are static, the check sum can also be calculated statically, and the value is 4646H, the hexadecimal encoding of the ASCII characters "FF".

Example:

```
:0000000001FF
```

Chapter 4

Programming Configuration Variables (CVs)

4.1 Introduction

The decoders installed in your locomotives provide you with the ability to create a more realistic operating experience through the configuration variables (CVs for short). The network protocol supports configuration of up to 1024 CVs.

It is a good idea to run your decoders with the default CV values that come pre-programmed in your decoders until you get used to the performance characteristic and how they work on your layout. Once you are comfortable with running the trains, then you can begin customizing locomotive characteristics.

Each CV (configuration variable) controls a specific characteristic of the decoder, which in turn controls how the locomotive performs. See your decoder manual for a list of the most commonly used CVs and their meanings. Each decoder comes pre-programmed from the factory with the default settings outlined in your decoder manual. You can change your decoder's performance characteristics by changing the CV values entered in the CVs you want to change. Each of these CVs can be set up when your command station is in the programming mode. The CVs are remembered in the decoder until it is reprogrammed to with a different CV value. Please refer to your mobile decoder manual for a complete listing of the CVs supported by each decoder.

Programming decoder CVs is usually done on an isolated programming track.

There are four programming modes:

- Paged mode
- Physical register mode
- Direct mode
- Operations mode

4.1.1 Paged Mode Programming

4.1.2 Physical Register Programming

Physical Register Mode can only read CV01-CV08. You should not rely on values in the display for CVs above 08 when reading back in physical register mode.

4.1.3 Direct Mode Programming

This is the preferred programming mode.

4.1.4 Operations Mode Programming

Operations mode programming lets you program CVs in locomotives equipped with Extended Packet Format decoders while they are on the mainline. A typical use for Ops mode programming would be to change the acceleration rate (CV03) or the deceleration rate (CV04) of your locomotives to simulate the weight and braking capability of the train to compensate for changing the number of cars or power units on a train.

Operations Mode read back can only be used with decoders that are capable of operations mode read back when there is a device attached to the network that supports operations mode read back. Digitrax transponding decoders and the DCS210 or DCS240 command stations would allow operations mode read back.

4.2 Programming Mobile Decoder Addresses

Be sure that only the loco you want to program is on the programming track. If you are using operations mode programming, the loco you want to program can be anywhere on the layout but it must have a decoder that is capable of operations mode programming installed.

There are two addressing methods - short and long. The short addresses can take a value between 0 and 127, and long addresses a value between 128 and 9983. The bit 5 of mobile decoder's configuration register (CV29) determines what addressing method is used. If bit 5 is set to 1 then long addresses are used, and when bit 5 is 0 then short addresses are used. Short addresses are stored in CV1, and long addresses in CV17 and CV18. The address values stored in CV17 and CV18 are not the high and low bytes of the address value. The CV17 and CV18 values must be calculated from the address value as follows:

TEMP = address + 49152

CV18 = TEMP & 0xFF

CV17 = TEMP >> 8

Example:

address = 4007

TEMP = 49152 + 4007 = 53159 = 0xCFA7

CV18 = 0xA7 = 167

CV17 = 0xCF = 207

read cv

```
Read CV
unknown
   65830.9ms
<D0> 0xef 0b11101111 <- OPC_PROG
<D1> 0x0e 0b00001110 <- Message Length
<D2> 0x7c 0b01111100 <- Special programming slot number
<D3> 0x2b 0b00101011 <- PCMD

d7 0
d6 0 - read
d5 1 - byte mode
d4 0 - TV1
d3 1 - TV0
d2 0 - service mode on programming track
d1 1 - unknown
d0 1  - unknown

Direct mode byte read on service track
```

```
<D4> 0x00 0b00000000 - 0x00
<D5> 0x00 0b00000000 - HOPSA - Ops mode programming - 7 high address bits of Loco to pro
<D6> 0x0e 0b00001110 - LOPSA - Ops Mode programming - 7 low address bits of loco to prog
<D7> 0x00 0b00000000 - TRK - normal track status for command station - this doesn't look
<D8> 0x00 0b00000000 - CVH
<D9> 0x00 0b00000000 - CVL
<D10> 0x0f 0b00001111 - DATA
<D11> 0x6d 0b01101101 - Throttle serial number
<D12> 0x52 0b01010010 - Throttle serial number
<D13> 0x77 0b01110111

response
    1722.5ms
<D0> 0xe7 0b11100111 <- Opcode
<D1> 0x0e 0b00001110 <- length
<D2> 0x7c 0b01111100 <- Programming slot
<D3> 0x2b 0b00101011 <- PCMD
<D4> 0x00 0b00000000 <- PSTAT - success
<D5> 0x00 0b00000000 <- HOPSA
<D6> 0x02 0b00000010 <- LOPSA should be 0
<D7> 0x47 0b01000111 <- TRK
<D8> 0x02 0b00000010 <- CVH : 0, 0, CV9, CV8, 0, 0, D7, CV7
<D9> 0x04 0b00000100 <- CVL - CV5
<D10> 0x16 0b00010110  <- low 7 bits of value
<D11> 0x6d 0b01101101 <- SN
<D12> 0x52 0b01010010  <- SN
<D13> 0x2b 0b00101011 <- CHK
```

value displayed is 150 10010110

PCMD

d7	0
d6	1 = write, 0 = read
d5	1 = byte operation, 0 = bit operation (if possible)
d4	TV1
d3	TV0
d2	1 = Ops mode on mainlines, 0 = service mode on programming track
d1	0 - reserved
d0	0 - reserved

Byte Mode	Ops Mode	TV1	TV0	Meaning
1	0	0	0	Paged mode byte read/write on service track
1	0	0	1	Direct mode byte read/write on service track
0	0	0	1	Direct mode bit read/write on service track
×	0	1	0	Physical register byte read/write on service track
×	0	1	1	Service track reserved function
1	1	0	0	Ops mode byte program no feedback
1	1	0	1	Ops mode byte program with feedback
0	1	0	0	Ops mode bit program no feedback
0	1	0	1	Ops mode bit program with feedback

```
ack
<D0> 0xb4 0b10110100
<D1> 0x6f 0b01101111
<D2> 0x01 0b00000001
<D3> 0x25 0b00100101

unknown
    1731.6ms <D0> 0xe7 0b11100111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x2b 0b00101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x02 0b00000010
<D7> 0x47 0b01000111
<D8> 0x00 0b00000000
<D9> 0x00 0b00000000
<D10> 0x0f 0b00001111
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x34 0b00110100

ack
      10.6ms <D0> 0xb4 0b10110100
<D1> 0x3b 0b00111011
<D2> 0x00 0b00000000
<D3> 0x70 0b01110000

Read CV 2
unknown
```

```
    6772.5ms <D0> 0xef 0b11101111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x2b 0b00101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x0e 0b00001110
<D7> 0x00 0b00000000
<D8> 0x00 0b00000000
<D9> 0x01 0b00000001
<D10> 0x0f 0b00001111
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x76 0b01110110

ack
      15.5ms <D0> 0xb4 0b10110100
<D1> 0x6f 0b01101111
<D2> 0x01 0b00000001
<D3> 0x25 0b00100101

unknown
    1720.8ms <D0> 0xe7 0b11100111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x2b 0b00101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x02 0b00000010
<D7> 0x47 0b01000111
<D8> 0x00 0b00000000
<D9> 0x01 0b00000001
<D10> 0x07 0b00000111
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x3d 0b00111101

------------------- CV2
unknown
   11836.0ms <D0> 0xef 0b11101111
<D1> 0x0e 0b00001110
```

```
<D2> 0x7c 0b01111100
<D3> 0x2b 0b00101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x0e 0b00001110
<D7> 0x00 0b00000000
<D8> 0x00 0b00000000
<D9> 0x01 0b00000001
<D10> 0x07 0b00000111
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x7e 0b01111110

ack
       6.1ms <D0> 0xb4 0b10110100
<D1> 0x6f 0b01101111
<D2> 0x01 0b00000001
<D3> 0x25 0b00100101

unknown
    1730.2ms <D0> 0xe7 0b11100111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x2b 0b00101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x02 0b00000010
<D7> 0x47 0b01000111
<D8> 0x00 0b00000000
<D9> 0x01 0b00000001
<D10> 0x07 0b00000111
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x3d 0b00111101

<- failure nothing on prog track

<D0> 0xe7 0b11100111 <- opcode
<D1> 0x0e 0b00001110 <- length
<D2> 0x7c 0b01111100  <- prog slot
<D3> 0x2b 0b00101011 <- PCMD
```

```
<D4> 0x01 0b00000001 <- PSTAT
<D5> 0x00 0b00000000
<D6> 0x01 0b00000001
<D7> 0x47 0b01000111
<D8> 0x02 0b00000010
<D9> 0x04 0b00000100
<D10> 0x16 0b00010110
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x29 0b00101001

PSTAT

d7 0 - reserved
d6 0 - reserved
d5 0 - reserved
d4 0 - reserved
d3 1 = user aborted command
d2 1 = failed to detect read compare ack from decoder
d1 1 = no write ack from decoder
d0 - 1 = service mode programming track empty - no decoder detected


-----> write 150 to CV5

unknown
    7846.9ms

<D0> 0xef 0b11101111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x6b 0b01101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x0e 0b00001110
<D7> 0x00 0b00000000
<D8> 0x02 0b00000010
<D9> 0x04 0b00000100
<D10> 0x16 0b00010110
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
```

```
<D13> 0x28 0b00101000

ack
       4.6ms
<D0> 0xb4 0b10110100
<D1> 0x6f 0b01101111
<D2> 0x01 0b00000001
<D3> 0x25 0b00100101

unknown
     894.9ms
<D0> 0xe7 0b11100111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x6b 0b01101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x02 0b00000010
<D7> 0x47 0b01000111
<D8> 0x02 0b00000010
<D9> 0x04 0b00000100
<D10> 0x16 0b00010110
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x6b 0b01101011

---> write 150 to CV5 nothing on prog track

unknown
   11349.0ms <D0> 0xef 0b11101111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x6b 0b01101011
<D4> 0x00 0b00000000
<D5> 0x00 0b00000000
<D6> 0x0e 0b00001110
<D7> 0x00 0b00000000
<D8> 0x02 0b00000010
<D9> 0x04 0b00000100
<D10> 0x16 0b00010110
<D11> 0x6d 0b01101101
```

```
<D12> 0x52 0b01010010
<D13> 0x28 0b00101000

ack
       6.0ms <D0> 0xb4 0b10110100
<D1> 0x6f 0b01101111
<D2> 0x01 0b00000001
<D3> 0x25 0b00100101

unknown
     723.9ms <D0> 0xe7 0b11100111
<D1> 0x0e 0b00001110
<D2> 0x7c 0b01111100
<D3> 0x6b 0b01101011
<D4> 0x01 0b00000001
<D5> 0x00 0b00000000
<D6> 0x02 0b00000010
<D7> 0x47 0b01000111
<D8> 0x02 0b00000010
<D9> 0x04 0b00000100
<D10> 0x16 0b00010110
<D11> 0x6d 0b01101101
<D12> 0x52 0b01010010
<D13> 0x6a 0b01101010
```

4.3 List of Common CVs

The NMRA Standard "Configuration Variables For Digital Command Control" provides descriptions for Digital Decoder Configuration Variables (CVs). CVs 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. CVs defined by the NMRA are marked below as Mandatory, Recommended or Optional. CVs identified as Mandatory must be implemented in order to conform to the Standard, while those marked as Recommended are strongly encouraged but not mandatory, and those marked Optional are at the manufacturer's discretion. CVs marked as Read-Only indicates a CV whose value should be set by the manufacturer and which the user cannot modify.

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 CV marked as Uniform Spec indicates a CV which requires implementation by manufacturers according to a common specification. CVs marked as Dynamic are used for Unsolicited Decoder Initiated Transmission.

CV	Name	Description	Range	Default
1	Primary Address	NMRA: Mandatory, Uniform Spec. 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 CV1 is 0 then the decoder will go out of NMRA digital mode and convert to the alternate power source as defined by CV12. This setting will not affect the Digital Decoder's ability to respond to service mode packets. The default value for this CV is 3, if the decoder is not installed in a locomotive or other unit when shipped from the manufacturer. ESU: For Multiprotocol decoders: Range 1-255 for Motorola.	1 - 127	3
2	Vstart	NMRA: Required 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 equal to zero, there shall be zero voltage applied to the motor. When it is at maximum, 255, the full available rectified voltage shall be applied.	0 - 255	
3	Acceleration Rate	NMRA: Required Determines the decoder's acceleration rate. The formula for the acceleration rate shall be equal to (the contents of CV3 $\times$ 0.896) / (number of speed steps in use). For example, if the contents of CV3 equals 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. ESU: This value multiplied by 0.25 is the time from stop to maximum speed. For LokSound 5 DCC the unit is 0.896 seconds	0 - 255	
4	Deceleration Rate	NMRA: Required Determines a decoders braking rate, in the same fashion as CV3. ESU: This value multiplied by 0.25 is the time from maximum speed to stop. For LokSound 5 DCC: The unit is 0.896 seconds.	0 - 255	
5	Vhigh	NMRA: Optional 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 of CV5 equals 255, the full available rectified voltage shall be applied. Values of 0 or 1 shall indicate that Vhigh is not used in the calculation of the speed table.	0 - 255	

CV	Name	Description	Range	Default
6	VMid	NMRA: Optional 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 0 or 1 shall indicate that Vmid is not used in the calculation of the speed table. ESU: Medium speed of the engine. Use only if 3-point speed table is enabled. For LokSound 5 DCC only.		
7	Manufacturer Version Number	NMRA: Mandatory, Read-Only This is reserved for the manufacturer to store information regarding the version of the decoder. ESU: Internal software version of decoder	-	-
8	Manufacturer ID	NMRA: Mandatory, Read-Only, Uniform Spec. CV8 shall contain the NMRA assigned id number of the manufacturer of this decoder. ESU: Writing value 8 in this CV triggers a reset to factory default values	151	-
9	Total PWM Period	NMRA: Optional The value of CV9 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 × 4) × 2 EXP ,Where MANTISSA is in bits 0-4 bits of CV9 (low order) and EXP is bits 5-7 for CV9. If the value programmed into CV9 falls outside a decoder's capability, it is suggested (but not required) that the decoder "adjust" the value to the appropriate highest or lowest setting supported by the decoder. ESU: Motor PWM frequency as a multiple of 1000 Hz.	10 - 50	40
10	EMF Feedback Cutout	NMRA: Optional Contains a value between 1 and 128 that indicates the speed step above which the back EMF motor control cuts off. When 14 or 28 speed steps are used the LSB's of the value are truncated appropriately.		
11	Packet time-out Value	NMRA: Required Contains the maximum time period that the decoder will maintain its speed without receiving a valid packet.		
12	Power Source Conversion	NMRA: Optional, Uniform Spec. Contains the identity of the alternate power source to which the decoder will be converted should CV1 contain zero. This is also the primary alternative power source selected should the decoder perform power source conversion. The currently assigned Power Source Conversion codes areas follows: 0b00000001 Analog Power Conversion 0b00000010 Radio 0b00000100 Zero-1 0b00001000 TRIX 0b00010000 CTC 16 / Railcommand 0b00100000 FMZ (Fleischmann)		

CV	Name	Description	Range	Default
13	Alternate Mode Function Status	NMRA: Optional, Uniform Spec. Indicates the status of each function (F1 through F8) 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. Bit 0 corresponds to F1, while Bit 7 corresponds to F8.		
		ESU: Status of functions F1 to F8 in analogue mode	0-255	1
14	Alternate Mode Function 2 Status	NMRA: Optional, Uniform Spec. 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 corresponds to F12.		
		ESU: Status of function F0, F9 to F12 in analogue mode	0-63	1
15 & 16	Decoder Lock	NMRA: Optional, Uniform Spec. 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 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 to be changed will be changed. If the values in CV15 and CV16 are different, the update will be ignored.		
17 & 18	Extended Address	NMRA: Optional, Uniform Spec. The Extended Address is the locomotives address when the decoder is set up for extended addressing (indicated by a value of 1 in bit 5 of CV29). CV17 contains the most significant bits of the two byte address and must have a value between 0b11000000 and 0b11100111, inclusive, in order for this two byte address to be valid. CV18 contains the least significant bits of the address and may contain any value.		
19	Consist Address	NMRA: Optional, Uniform Spec. Contains a seven 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 0b0000000 the unit is not in a consist.		
		ESU: Additional address for consist operation. Value 0 or 128 means: consist address is disabled. 1 – 127 consist address active, normal direction. 129 – 255 consist address active reverse direction.	0-255	0

CV	Name	Description	Range	Default
21	Consist Address Active for F1-F8	NMRA: Optional, Uniform Spec. 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. 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.		
		ESU: Status of functions F1 to F8 in Consist mode. Meaning of the bits as in CV13	0-255	0
22	Consist Address Active for FL and F9-F12	NMRA: Optional, Uniform Spec. Defines for function FL 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. 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.		
		ESU: Status of functions FL, F9 to F12 in Consist mode. Meaning of the bits as in CV14.	0-63	0
23	Acceleration Adjustment	NMRA: Optional, Uniform Spec. This Configuration Variable contains additional acceleration rate information that is to be added to or subtracted from the base value contained in CV3 using the formula (the contents of CV23 × .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.		
		ESU: Factor for adjusting Acceleration CV3. Values from 0 to 127 are added to CV3. If the values are to be subtracted, additionally set bit 7 (value 128). The unit is 0.896 seconds.	0 - 127	0
24	Deceleration Adjustment	NMRA: Optional, Uniform Spec. This Configuration Variable contains additional braking rate information that is to be added to or subtracted from the base value contained in CV4 using the formula (the contents of CV24 ×.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.		
		ESU: Factor for adjusting the deceleration CV4. Values from 0 to 127 are added to CV3. If the values are to be subtracted, additionally set bit 7 (value 128). The unit is 0.896 seconds.	0 - 127	0

CV	Name	Description	Range	Default
25	Speed Table/Mid Range Cab Speed Step	NMRA: Optional, Uniform Spec. A value between 2 and 127 shall be used to indicate 1 of 126 factory preset speed tables. A value of 0b00000010 indicates that the curve shall be linear. A value between 128 and 154 defines the 28-speed step position (1-26) which will define where the mid range decoder speed value will be applied. 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 0 or 1 shall indicate that this CV is not used in the calculation of the speed table.		
27	Decoder Automatic Stopping Configuration	NMRA: Optional, Uniform Spec. Used to configure which actions will cause the decoder to automatically stop. Bit — Function d7 — Reserved d6 — Reserved d5 — Enable/Disable Auto Stop in the presence forward polarity DC. 0 = Disabled 1 = Enabled d4 — Enable/Disable Auto Stop in the presence of reverse polarity DC. 0 = Disabled 1 = Enabled d3 — Reserved d2 — Enable/Disable Auto Stop in the presence of an Signal Controlled Influence cutout signal. 0 = Disabled 1 = Enabled d1 — Enable/Disable Auto Stop in the presence of an asymmetrical DCC signal which is more positive on the left rail. 0 = Disabled 1 = Enabled d0 — Enable/Disable Auto Stop in the presence of an asymmetrical DCC signal which is more positive on the right rail. 0 = Disabled 1 = Enabled		

CV	Name	Description	Range	Default
		ESU: Allowed (enabled) Brake modes Bit Function d7 Loco brakes with constant brake distance if Speed=0 d6 Selectrix brake diode, rakes if polarity is like driving direction d5 Selectrix brake diode, brakes if polarity is against driving direction d4 Brake on DC, if polarity like driving direction d3 Brake on DC, if polarity against driving direction d2 ZIMO® HLU brakes active d1 ABC braking, voltage higher on the left hand side d0 ABC braking, voltage higher on the right hand side		
28	Bi-Directional Communication Configuration	NMRA: Optional, Uniform Spec. Used to configure decoder's Bi-Directional communication characteristics when CV29-Bit 3 is set Bit Function d7 Reserved d6 Reserved d5 Reserved d4 Reserved d3 Reserved d2 Enable/Disable Initiated Broadcast Transmission using Signal Controlled Influence Signal. 0 = Disabled 1 = Enabled d1 Enable/Disable Initiated Broadcast Transmission using Asymmetrical DCC Signal. 0 = Disabled 1 = Enabled d0 Enable/Disable Unsolicited Decoder Initiated Transmission. 0 = Disabled 1 = Enabled		
		ESU: RailCom® Configuration Bit Function d7 Enable/Disable RailCom® Plus automatic loco recognition. 0 = Disabled 1 = Enabled d1 Enable/Disable Data transmission on Channel. 0 = Disabled 1 = Enabled d0 Enable/Disable Channel 1 Address broadcast. 0 = Disabled 1 = Enabled	131	

CV	Name	Description	Range	Default
29	Configurations Supported	NMRA: Mandatory, Uniform Spec. Bit Function d7 Accessory Decoder: 0 = Multifunction Decoder, 1 = Accessory Decoder (see CV541 for a description of assignments for bits 0-6) d6 Reserved d5 0 = one byte addressing, 1 = two byte addressing (also known as extended addressing), d4 Speed Table: 0 = speed table set by CV2, CV5, and CV6, 1 = Speed Table set by CV66 to CV95 d3 Bi-Directional Communications: 0 = Bi-Directional Communications disabled, 1 = Bi-Directional Communications enabled. d2 Power Source Conversion: 0 = NMRA Digital Only, 1 = Power Source Conversion Enabled, See CV12 for more information. d1 FL location: 0 = bit 4 in Speed and Direction instructions control FL, 1 = bit 4 in function group one instruction controls FL. d0 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. ESU: This register contains important information, some of which are only relevant for DCC operation. Bit Function d5 0 = Short addresses (CV 1) in DCC mode 1 = Long addresses (CV 17 + 18) in DCC mode d4 0 = Speed curve through CV 2, 5, 6 (LokSound 5 DCC ONLY). 1 = Speed curve through CV 67 - 94 (Multiprotocol) d3 0 = Disable RailCom® 1 = Enable RailCom® d2 0 = Disable analog operation 1 = Enable analog operation d1 0 = 14 speed steps DCC 1 = 28 or 128 speed steps DCC d0 0 = Normal direction of travel 1 = Reversed direction of travel		12
30	Error Information	NMRA: Optional, Uniform Spec. 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.		

CV	Name	Description	Range	Default
31	Index High Byte	NMRA: Optional, Uniform Spec. The Indexed Address is the address of the indexed CV page when the decoder is set up for indexed CV operation. CV31 contains the most significant bits of the two byte address and may have any value between 0b00010000 and 0b11111111 inclusive. Values of 0b00000000 thru 0b00001111 are reserved by the NMRA for future use. (4096 indexed pages) CV32 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.		
32	Index Low Byte	NMRA: Optional, Uniform Spec. See CV31		
33-46	Output Locations 1-14 for Functions FL(f), FL(r), and F1-F12	NMRA: Optional. Uniform Spec. 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 CV33, FL (r) in CV34, F1 in CV35, to F12 in CV46. 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 38-42 control outputs 4-11 CVs 43-46 control outputs 7-14. The defaults is that 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.		
47-64	Manufacturer Unique			
47	Protocol selection	ESU: Which protocols are active. Bit — Function d3 — Enable/Disable Selectrix® protocol (Not for LokSound 5 DCC). 0 = Disabled 1 = Enabled d2 — Enable/Disable Motorola® protocol (Not for LokSound 5 DCC). 0 = Disabled 1 = Enabled d1 — Enable/Disable M4 protocol (Not for LokSound 5 DCC). 0 = Disabled 1 = Enabled d0 — Enable/Disable DCC protocol. 0 = Disabled 1 = Enabled	0 - 255	13

CV	Name	Description	Range	Default
49	Extended Configuration #1	ESU: Bit Function d7 Märklin® Consecutive addresses, "High"-Bit. d6 Reserved d5 Enable/Disable LGB® function button mode. 0 = Disabled 1 = Enabled d4 Enable/Disable Automatic DCC speed step detection. 0 = Disabled 1 = Enabled d3 Märklin® Consecutive addresses, "low"-Bit d2 Reserved d1 Reserved d0 Enable/Disable Load control (Back-EMF). 0 = Disabled 1 = Enabled	0-255	19
50	Analogue mode	Selection of allowed analogue modes Bit Function d2 Enable/Disable QSI Quantum Engineer DC Support. 0 = Disabled 1 = Enabled d1 Enable/Disable DC Analogue mode. 0 = Disabled 1 = Enabled d0 Enable/Disable AC Analogue Mode. 0 = Disabled 1 = Enabled	0 - 3	3
51	K Slow Cutoff	Inernal Speedstep, until K Slow is active	0 - 255	10
52	BEMF Param. K Slow "K" -	Portion of the PI-Controller valid for lower speed steps	0 - 255	10
53	Control Reference voltage	Defines the Back EMF voltage, which the motor should generate at maximum speed. The higher the efficiency of the motor, the higher this value may be set. If the engine does not reach maximum speed, reduce this parameter	0 - 255	130
54	Load control Parameter K	K–component of the internal PI-controller. Defines the effect of load control. The higher the value, the stronger the effect of Back EMF control.	0 - 255	50
55	Load control Parameter I	I–component of the internal PI-controller. Defines the momentum (inertia) of the motor. The higher the momentum of the motor (large flywheel or bigger motor), the lower this value has to be set.	0 - 255	100
56	BEMF Influence at VMin	0-100%. Defines the "Strengh" of the BEMF at minimum speed step	1 - 255	255
57	Steam chuff synchronisation #1	Defines the steam chuff synchronisation.	1 - 255	30
58	Steam chuff synchronisation #2	Defines the steam chuff synchronisation.	1 - 255	20
63	Sound volume "Master"	Master volume for all sounds.	0 - 192	128
64	Brake sound threshold "Brake On"	If the actual loco speed step is smaller than or equals the value indicated here, the brake sound is triggered.	0 - 255	60

CV	Name	Description	Range	Default
65	Brake sound threshold "Brake Off"	If the actual loco speed step is smaller than the one indicated here (up to 255), the brake sound will be switched off again. Compare chapter 13.4.	0 - 255	7
66	Forward Trimm	Divided by 128 is the factor used to multiply the motor voltage when driving forward. The value 0 deactivates the trim.	0 - 255	128
67-94	Speed table	Defines motor voltage for speed steps. The values "in between" will be interpolated.	0 - 255	-
95	Reverse Trimm	Divided by 128 is the factor used to multiply the motor voltage when driving backwards. Value 0 deactivates the trim.	0 - 255	128
101	Shunting Mode Trimm	Divided by 128, this gives the factor by which the motor voltage is multiplied when the shunting gear is active. See section 10.1.2.	0 - 128	64
102	Brake Mode Exit Delay	Time as a multiple of 16 milliseconds that must pass before a detected braking distance is left again. See section 10.4.6.	0 - 255	12
103	Load adjustment "Optional Load"	Divided by 128, this gives the factor that changes CV3, CV4 and the sound when "Optional Load" is active. See section 10.7.	0 - 255	0
104	Load adjustment "Primary Load"	Divided by 128, this gives the factor that changes CV3, CV4 and the sound when "Primary Load" is active. See section 10.7.	0 - 255	255
105	User CV #1	Free CV. Here you are able to save what ever you want.	0 - 255	0
106	User CV #2	Free CV. Here you are able to save what ever you want.	0 - 255	0
111	Gearbox backlash	Time as a multiple of 16 mS, for which the motor runs at minimum speed after reversing the direction to prevent gear box jerking.	0 - 255	0
112	Frequency for Flashing light effects	Flashing frequency for Strobe lighting effects. Multiple of 0.065536 seconds. See section 12.5.4.	0 - 255	20
113	Power Fail Bypass	The time that the decoder bridges via the PowerPack after an interruption of voltage. Unit: A multiple of 0.032768 sec. See section 6.12.2.	0 - 255	32
116	Slow speed BEMF Sampling period	Frequency of BEMF measurement in 0.1 milliseconds at speed step 1	50 - 200	50
117	Full speed BEMF Sampling period	Frequency of BEMF measurement in 0.1 milliseconds at speed step 255	50 - 200	150
118	Slow speed BEMF	Measurement gap length VMin Length of the BEMF measuring gap in 0.1 milliseconds at speed step 1	10 - 20	150
119	Full speed BEMF	Measurement gap length Vmax Length of the BEMF measuring gap in 0.1 milliseconds at speed step 255	10 - 20	15
123	ABC Mode "Slow drive"	Speed which is valid in the slow driving section during ABC braking.	0	-

CV	Name	Description	Range	Default
124	Extended Configuration #2	Additional important settings for decoders Bit Function d7 Reserved d6 Enable/Disable Automatic parking Brake. 0 = Disabled 1 = Enabled d5 Enable/Disable Motor is switched off for a few seconds when blocked to avoid burnout. 0 = Disabled 1 = Enabled d4 0 = Enable Output AUX9 (LokSound 5 H0 only). 1 = Enable Wheel Sensor input (LokSound 5 H0 only) d3 Enable/Disable SUSI protocol. 0 = Disabled 1 = Enabled d2 Enable/Disable prime mover startup delay. 0 = Disabled 1 = Enabled d0 Enable/Disable Decoder lock with CV 15 / 16. 0 = Disabled 1 = Enabled		21
125	Start voltage	Analog DC See section 10.8.	0 - 255	90
126	Maximum speed	Analog DC See section 10.8.	0 - 255	130
127	Start voltage	Analog AC See section 10.8.	0 - 255	90
128	Maximum speed	Analog AC See section 10.8.	0 - 255	130
129	Analog Functions	"Hysterese" Offset voltage for functions in analogue mode. Chapter 10.8.	0 - 255	15
130	Analog Motor	"Hysterese" Offset voltage for motor functions in analogue mode. Chapter 10.8.	0 - 255	5
132	Grade Crossing Hold Time	Grade Crossing holding time. See chapter 12.5.3.	0 - 255	80
133	Sound Fader	Volume when sound fader is active. See chapter 13.5.	0 - 255	128
134	ABC-Mode "Sensibility"	Threshold, from which asymmentry on ABC shall be recognised.	4 - 32	10
138	Smoke Unit Trim Fan	Divided by 128, this gives the factor by which the fan speed of synchronized smoke units can be adjusted.	0 - 255	128
139	Smoke Unit Trim Temperature	Divided by 128, this gives the factor by which the temperature of synchronized smoke units can be adjusted.	0 - 255	128
140	Smoke TimeOut	Time until automatic shutdown of the smoke unit.	0 - 255	255
141	Smoke Chuff Min	Minimum duration of a steam chuff of an external smoke unit in 0.041 seconds resolution.	0 - 255	10
142	Smoke Chuff max	Maximum duration of a steam chuff of an external smoke unit in 0.041 seconds resolution.	0 - 255	125
143	Smoke Chuff Length	Divided by 128, this gives the factor by which the duration of the steam chuffs can be adjusted relative to the trigger pulses.	0 - 255	100
144	Smoke Pre Heat Temperature	Preheating temperature in degrees Celsius for secondary smoke generators (cylinder smoke unit)	0 - 255	150

CV	Name	Description	Range	Default
149	ABC Shuttle Train Holdtimet	Time in seconds, which has to be passed for ABC shuttle train operation, before the direction of travel is changed. See section 10.4.4.3.	0 - 255	255
150	HLU Speedlimit 1	HLU Speed limit 1. Internal speedstep.	0 - 255	42
151	HLU Speedlimit 2	(U) HLU Speed limit 2 (U). Internal speedstep.	0 - 255	85
152	HLU Speedlimit 3	HLU Speed limit 3. Internal speedstep.	0 - 255	127
153	HLU Speedlimit 4	(L) HLU Speed limit 4 (L). Internal speedstep.	0 - 255	170
154	HLU Speedlimit 5	HLU Speed limit 5. Internal speedstep.	0 - 255	212
155 -170	Sound CV 1 - Sound CV 16	16 CVs for selecting sounds that can be assigned within sound projects. Please note the documentation for the sound project.	0 - 255	0
179	Brake Function 1	Deceleration Value of which 33% of CV 4 will be deducted if the Brake Function 1 is active. See section 10.6.	0 - 255	80
180	Brake Function 2	Deceleration Value of which 33% of CV 4 will be deducted if the Brake Function 2 is active. See section 10.6.	0 - 255	40
181	Brake Function 3	Deceleration Value of which 33% of CV 4 will be deducted if the Brake Function 3 is active. See section 10.6.	0 - 255	40
182	Brake Function 1 max.	Speed Highest speed step that can be reached when Brake function 1 is active.	0 - 126	0
183	Brake Function 2 max.	Speed Highest speed step that can be reached when Brake function 1 is active.	0 - 126	126
184	Brake Function 3 max.	Speed Highest speed step that can be reached when Brake function 1 is active.	0 - 126	126
246	Automatic decoupling Driving speed	Speed of the loco while decoupling; the higher the value, the faster the loco. Value 0 switches the automatic coupler off. Automatic decoupling is only active if the function output is adjusted to “pulse” or “coupler”.	0 - 255	0
247	Decoupling - Removing time	This value multiplied with 0.016 defines the time the loco needs for moving away from the train (automatic decoupling).	0 – 255	0
248	Decoupling - Pushing time	This value multiplied with 0.016 defines the time the loco needs for pushing against the train (automatic decoupling).	0 – 255	0
249	Minimum steam chuff distance	Minimum distance of two steam chuffs, independant from sensor data. Compage chapter 13.3.	0 – 255	0
250	Secondary steam chuff trigger	Defines the distance between two consecutive steam chuffs for the secondary steam chuff generator. The value indicates the promilles the steam chuff distances of the secondary steam chuff generator ought to be shorter then those of the primary steam chuff generator. It is needed.for steam locos with two independent boogies, such as “Big Boy” or “Mallet”.	0 – 255	0

CV	Name	Description	Range	Default
253	Constant brake mode	Determines the constant brake mode. Only active, if CV254 > 0 Function CV 253 = 0: Decoder stops linearly CV 253 > 0: Decoder stops constantly linear	0 – 255	0
254	Constant braking distance forward	A value > 0 determines the way of brake distance it adheres to, independent from speed.	0 – 255	0
255	Constant braking distance backward	Constant braking distances during reverse driving. Only active, if value > 0, otherwise the value of CV 254 is used. Useful for reversible trains.	0 – 255	0

Appendix A

Reference Tables

LSD	MSD 0000	0 000	1 001	2 010	3 011	4 100	5 101	6 110	7 111
0	0000	NUL	DLE	SPC	0	@	P	‘	p
1	0000	SOH	DC1	!	1	A	Q	a	q
2	0010	STX	DC2	”	2	B	R	b	r
3	0011	ETX	DC3	#	3	C	S	c	s
4	0100	EOT	DC4	$	4	D	T	d	t
5	0101	ENG	NAK	%	5	E	U	e	u
6	0110	ACK	SYN	&	6	F	V	f	v
7	0111	BEL	ETB	’	7	G	W	g	w
8	1000	BS	CAN	(	8	H	X	h	x
9	1001	HT	EM	)	9	I	Y	i	y
A	1010	LF	SUB	*	:	J	Z	j	z
B	1011	VT	ESC	+	;	K	[	k	{
C	1100	FF	FS	,	<	L	\	l	|
D	1101	CR	GS	-	=	M	]	m	}
E	1110	SO	RS	.	>	N	^	n	~
F	1111	SI	US	/	?	O	_	o	DEL

TABLE A-1. ASCII Character Set (7-Bit Code)

Appendix B

Revision History

Release Date	Changes
25 Jan 2022	Appendix B - Revision History added. Index added. Glossary added.
23 Jan 2022	Baseline.

Glossary

address is the numeric identification code by which a decoder recognises commands directed specifically to it. 4, 5

command station is the electronic device that generates DCC commands based upon inputs it receives and transmits them to decoders. 1

Common is a locomotive slot state that indicates that the slot is not currently in-use by a throttle but it is still being refreshed by the command station. A slot with a state of Common can be selected by any throttle on the network. 6

DCC stands for Digital Command Control. 1

Global System Track Status means the byte 7 of a LocoSlotDataP1 or LocoSlotDataP2 response. 2

locomotive slot is a memory location in the command station which holds information about a locomotive's decoder and current state. 2

Loconet is the peer-to-peer local area network system architecture used by Digitrax to carry DCC and other commands across Digitrax command control systems. 1

mobile decoder means an electronic device installed in a locomotive that receives a signal from the command station through the track, decodes it and tells the locomotive what to do. 1

opcode means the first byte of a network message. The opcode indicates the purpose and length of the message. 2

peer-to-peer is a network communication scheme where messages between devices are not managed or controlled by a central controller or server. 1

physical throttle means an electronic input device, often hand-held, that is used to tell the command station what commands to send to the decoders. 4

polled is the process of interrogating a device to see if it has information or commands to send to the system. 1

polling is the process by which devices are interrogated sequentially, one after the other, to see if they have information or commands to send to the system. 1

Slot Status 1 means byte 3 of a LocoSlotDataP1 response or byte 4 of a LocoSlotDataP2 response. 3

slot state means the current state of a locomotive slot. A locomotive slot can be in one the following states: Free, New, In-Use, Common or Idle. 3

software throttle means a software application that is used to tell the command station what commands to send to the decoders. 4

stationary decoder means an electronic device for a turnout or other accessory that receives a signal from the command station through the track, decodes it and tells the turnout or accessory what to do. 1

system slot is a memory location in the command station which holds system information. 2

throttle means a physical throttle or a software throttle. 3

Throttle ID means a pair of 7-bit numbers that identify (hopefully uniquely) the throttle to the command station. 4, 5

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