

**Electrical Specifications for Digital
Command Control Decoder Transmission,
All Scales**

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RP-9.3.1 DRAFT

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This Recommended Practice covers the transmission method for information transmitted from a Digital Decoder to a communication receiver connected to the rails.

As a prerequisite for this Recommended Practice, a Digital Command Station transmits information to Digital Decoders by sending a series of bits using the NMRA digital signal described in S-9.1. This sequence of bits, termed a packet, is used to encode one or more instructions that the Digital Decoder operates upon as described in S-9.2 [and](#), [RP-9.2.1](#), [and RP-9.2.2](#).

This Recommended Practice specifies how a Digital Decoder transmits in response to this received NMRA packet by generating a series of pulses during a specified absence of track power. This series of pulses is received by an external device called a detector. [To successfully accomplish this transmission, and conform to this RP, the Digital Decoder must satisfy both the Electrical Specifications \(Physical Layer\) contained in this document and the General Feedback Packet Format specifications specified in RP 9.3.2.](#) ~~The meaning and encoding of this series of pulses is described in other Recommended Practice(s).~~

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A: Technique for Transmitting and Receiving Bits

Bits are transmitted using a current loop technique. Current is supplied to the track from the decoder's internal power supply during a specified period (see section B below). During this interval, a "cutout device" connects the rails so that the decoder and detector are effectively in series.

To transmit a '0' bit, the decoder must source 30 +/-6 mA to the rails. The positive current should be directed into the track via the red decoder lead, and removed from the black decoder lead, where the lead colors are defined by the color assignments of Recommended Practice 9.1.1 To transmit a '1' bit, the decoder must neither sink nor source more than 0.1 mA of current. For conformance testing purposes, these current values will be measured at a decoder temperature of 25°C.

Transmitted bits are 4μs +/- 2% long. The transmitter's transition times between 10% and 90% or between 90% and 10% of its '0' bit current level must be less than 0.5μs.

¹ Note: Parties wishing to utilize this intellectual property for other applications, and/or without applying for and receiving an NMRA Conformance Warrant on each specific product that incorporates this intellectual property, should contact the licensor directly to make appropriate licensing arrangements.

45 The decoder must be able to source the '0' bit current when the voltage across the decoder's track inputs is from zero to 2.2 volts. ~~The current output must remain within the acceptable current limits during the middle 2.5µs of the bit time, regardless of inductive or capacitive characteristics of the track load.~~

The decoder current source must be protected against unexpected return of full track voltage during a cutout period.

50 A detector must detect a current of greater than 10 mA during the entire center 2µs of the bit time as '0' bit, and must detect a current of less than 6 mA during the entire center 2µs of the bit time as a '1' bit.

55 The voltage across the input of each detector must not exceed 55 mV at currents up to 34mA- when a cutout device has removed power, and has shorted the rails as specified in section C (below) during the cutout interval. A detector must be clearly labeled with the maximum current that it is capable of handling.

60 The voltage across the input of a cutout device must not be more than 10 mV at currents up to 34mA when a cutout device has removed power, and has shorted the rails as specified in section C (below) during the cutout interval. A cutout device must be clearly labeled with the maximum current that it is capable of handling.

65 The cutout device must cease shorting the rails if track voltage is applied to its output terminals from another power source.

B: Transmitting & Receiving Bytes

70 A byte consists of 8 data bits. Each byte transmitted or received is framed by a start bit ('0'), and a stop bit ('1'), The least-significant bit of each byte is transmitted first. The detector must accept bytes in which the bits are transmitted at 250Kb/s +/- 2.5%.

Each message consists of two bytes. The time between the end of a stop bit and the beginning of the start bit of sequential bytes within a message must be less than 8.5µs.

75 The specifications for the contents of data transmitted in each message are provided in ~~other~~ Recommended Practice(s) RP-9.3.2.

C: Packet Transmission & Timing

80 An interval for transmitting data is provided after each NMRA DCC packet on the layout.

85 To prevent interference with the transmission current, power on the layout must be interrupted between the DCC packets. This interruption is called a 'cutout'. The device that performs this is called a 'cutout device'. During the cutout period, power must be disconnected from the rails, and the rails shorted to each other such that the detector and the decoder current source form a series loop circuit.

90 The transmission interval is divided into two portions, called channels. Each channel can be used independently for transmission.

A transmission within a channel consists of one or more messages.

Two lengths for the cutout are defined: A "~~short~~ Channel 1 Cutout" and a "~~long~~ Channel 2 Cutout". Cutout devices must have the ability to be configured for no cutout, or a cutout of either specified length.

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All time values in this section are relative to the trailing edge of the second half of the packet end bit. The timing is referenced to the first zero-volt crossing in that edge, as specified in S-9.1, line 52.

Table 1 provides the timing values for the cutout, and transmission and detection of the message(s). The various timing values are defined below. Figure 1 is illustrative of their relationships, and is not definitive.

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Cutout Device Timing

Time T_{CS} (Cutout Start) specifies the start of the cutout. The cutout device determines the value of T_{CES} (Cutout End for the ~~Short~~ Channel 1 Cutout) and T_{CEL} (Cutout End for the ~~Long~~ Channel 2 Cutout) from the length of the "1" bits in the waveform being generated by the command station. ~~T_{CES} must be $2 \times$ ("1" bit time) T_{CD} , where the duration T_{CD} is specified in Table 1. T_{CEL} must be $4 \times$ ("1" bit time) T_{CD} .~~

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When determining the end time, the cutout device may assume that all "1" bits transmitted by the command station are the same length, and that the length of the "1" bits is stable over time. A device must start the cutout between the minimum and maximum T_{CS} . A device must end the cutout based the "1" bit time (T_{CES} or T_{CEL}) of the command station it is designed to work with. For maximum backward compatibility with existing equipment, support of all five ranges of T_{CES} & T_{CEL} is strongly encouraged. If a limited number of ranges of T_{CES} and T_{CEL} are supported, the command stations supported must be clearly documented.

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Detector Timing

The detector must not accept transmissions starting at-before time T_{DS} (Detector Start). A zero level whose leading edge starts before this time must not be interpreted as a start bit. Detectors must reject bytes that were not completely received when track power was restored. ? Detectors must not accept transmissions after the detector end time T_{DE} , which is defined as the end of the cutout period currently in use.

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Decoder Transmission Timing

This Recommended Practice allows different decoders to transmit in channel 1 and channel 2 following a single DCC packet.

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Transmission in channel 1 must not start before time T_{TS1} (Transmission Start channel 1). The last stop bit of the last message in channel 1 must be completely transmitted by time T_{TC1} (Transmission Complete channel 1).

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Transmission in channel 2 must not start before time T_{TS2} (Transmission Start channel 2). The last stop bit of the last message in channel 2 must be completely transmitted by time T_{TC2} (Transmission Complete channel 2).

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The time between transmitting messages within a channel must be at least $30\mu s$. This time is defined as from the end of the stop bit of the first message to the beginning of the start bit of the second.

Command Station Timing

140 Standard S-9.2 requires that a command station provide at least 14 preamble bits before a packet start bit.
This is both necessary and sufficient for a command station to conform to this Recommended Practice.

145 | In order to be labeled as providing “NMRA extended bidirectional DCC”, the command station must not
start transmission of the last 12 preamble bits before a time T_{PS} (Preamble Start) after each packet end bit.

Draft for Discussion

Note: All times are in μ s.

<u>Parameter</u>	<u>Name</u>	<u>Minimum</u>	<u>Nominal</u>	<u>Maximum</u>
<u>Cutout Start</u>	<u>T_{CS}</u>	<u>28</u>	<u>30</u>	<u>32</u>
<u>Detector Start</u>	<u>T_{DS}</u>	<u>60</u>	<u>64</u>	<u>64</u>
<u>Transmission Start - Channel 1</u>	<u>T_{TS1}</u>	<u>68</u>	<u>85</u>	
<u>Transmission Complete - Channel 1</u>	<u>T_{TC1}</u>			<u>178</u>
<u>Cutout End [Channel 1 Cutout]</u> <u>(1 bit time \leq 118μs)</u>	<u>T_{CES(1)}</u>	<u>200</u>	<u>204</u>	<u>208</u>
<u>Cutout End [Channel 1 Cutout]</u> <u>(1 bit time $>$ 118μs)</u>	<u>T_{CES(2)}</u>	<u>225</u>	<u>228</u>	<u>232</u>
<u>Preamble Start from Command Station</u> <u>[Channel 1 Cutout]</u>	<u>T_{PS}</u>	<u>Nominal 2 X "1" bit time</u>		
<u>Transmission Start - Channel 2</u>	<u>T_{TS2}</u>	<u>208</u>	<u>215</u>	
<u>Transmission Complete - Channel 2</u>	<u>T_{TC2}</u>			<u>4336</u>
<u>Cutout End [Channel 2 Cutout]</u> <u>(1 bit time \leq 114.5μs)</u>	<u>T_{CEL(1)}</u>	<u>436</u>	<u>437</u>	<u>438</u>
<u>Cutout End [Channel 2 Cutout]</u> <u>(1 bit time $>$ 114.5 and \leq 119.5 μs)</u>	<u>T_{CEL(2)}</u>	<u>448</u>	<u>450</u>	<u>452</u>
<u>Cutout End [Channel 2 Cutout]</u> <u>(1 bit time $>$ 119.5μs)</u>	<u>T_{CEL(3)}</u>	<u>470</u>	<u>472</u>	<u>474</u>
<u>Detector End</u>	<u>T_{DE}</u>		<u>See text</u>	
<u>Preamble Start from Command Station</u> <u>[Channel 2]</u>	<u>T_{PS}</u>	<u>Nominal 4 X "1" bit time</u>		

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Table 1: Timing Specifications^{2 3}

Starting the transmission in channel 1 later then the minimum provides more time to ensure that the ringing of the layout has ended.

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⁺ Starting the transmission in channel 2 later then the minimum increases the minimum dead time between channel 1 and channel 2

² Starting the transmission in channel 1 later then the minimum provides more time to ensure that the ringing of the layout has ended.

³ Starting the transmission in channel 2 later then the minimum increases the minimum dead time between channel 1 and channel 2.

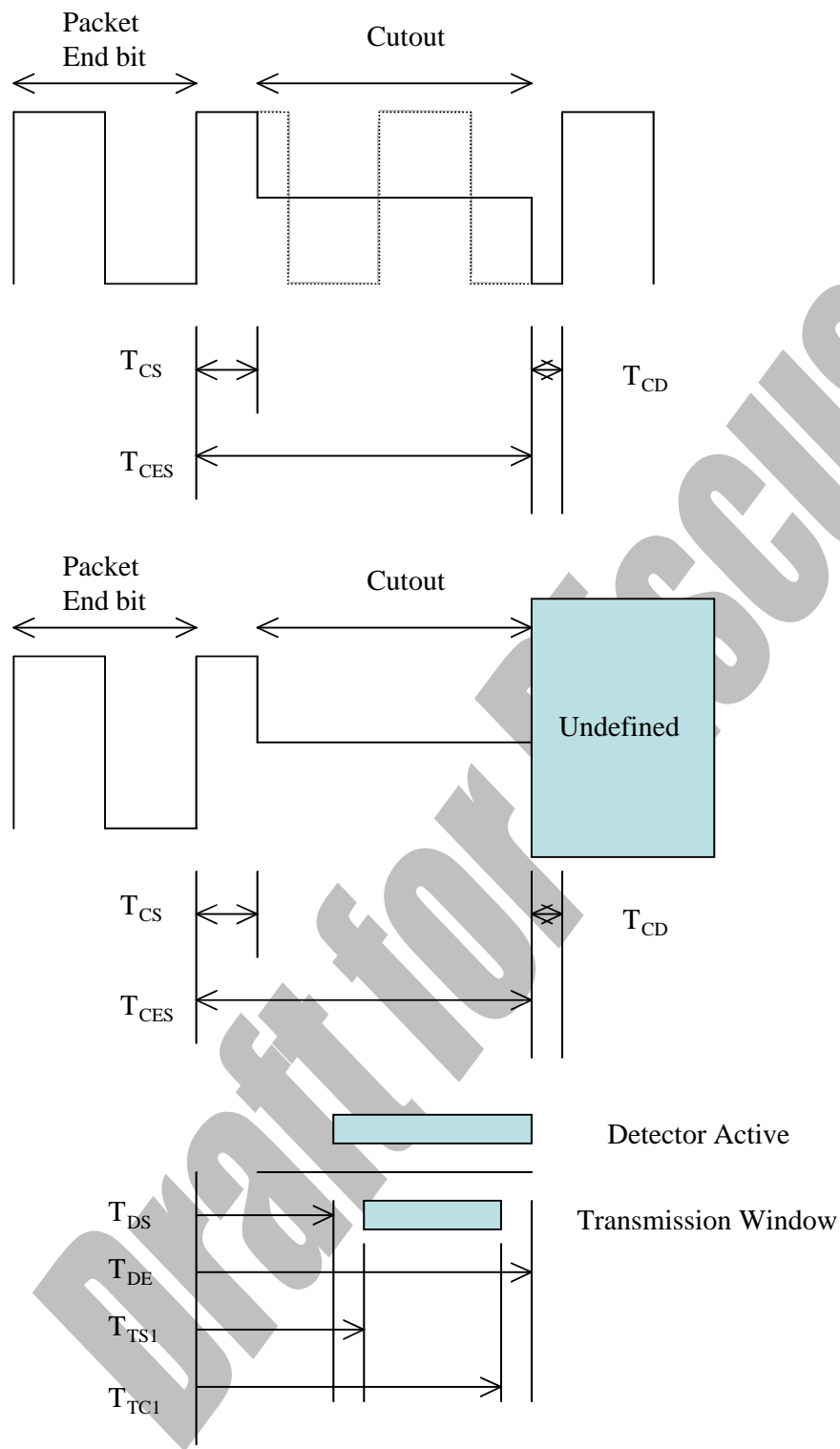


Figure 1: Timing diagram

160 | The upper part shows a schematic track signal and timing relationships for a [short Single-Channel](#) cutout when the command station is sending a sequence of DCC "1" bits. The middle part shows the more general case where the command station is sending an arbitrary waveform after the cutout period. The lower part shows the decoder and detector timing.

D: Electrical Specifications for Devices

165 Mobile decoders measured under load must not sink more than 0.1 mA of current or source more than 0.1 mA of current during the cutout unless transmitting a '0' bit. For conformance testing purposes, these current values will be measured at a decoder temperature of 25°C.

170 Electrical equipment that is intended to connect to the rails must neither source nor sink more than 0.1 mA during the cutout interval at all voltage levels from 0 to 2.2 volts. This equipment must be able to survive the power interruption during the cutout without losing any of its internal state(s), nor have any operational problems after power is restored.

E: Conformance Compatibility and Subsets

175 To be compatible with decoders that use this Recommended Practice to transmit information, all types of equipment intended to be electrically connected to the rails must conform to Section D: Electrical Specification.

180 For conformance, DCC components, including command stations, decoders and other devices, must conform to all sections of this Recommended Practice including the prerequisite Standards and RPs and other conformance requirements as specified in the preamble to this RP.