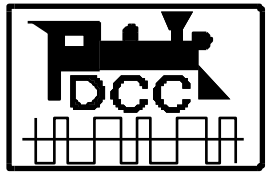
National Model Railroaders Association (NMRA)

Digital Command Control (DCC)



Command Station Test Procedures

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This template is based on the NMRA published versions of the Standards and RPs:
http://www.nmra.org/standards/DCC/standards_rps/DCCStds.html

Standard	Date	RP	Date	RP	Date	RP	Date
S-9.1	July 2004	RP-9.1.1	July 2003	RP-9.2.1	Aug 2006	RP-9.3.1	Jan 2007
S-9.2	July 2004	RP-9.1.2	July 2003	RP-9.2.2	July 2006	RP-9.3.2	July 2003
				RP-9.2.3	July 2003		
				RP-9.2.4	March 1997		

Test Rules and Assumptions

Rules for applying for a Digital Command Station (DCS) conformance seal or requesting conformance testing:

1) All applications for a DCS conformance seal must be accompanied by the following:

- **A.** A complete system for which conformance is to be tested. Including the command station, power booster, 2 cab units (if multiple cabs are supported) and all interconnecting cables.
- **B.** A complete set of user documentation.
- **C.** Certification that the attached test procedures has been successfully completed by the manufacture prior to submission for formal conformance testing.
- **D.** The manufacture must provide evidence that the DCS complies with the FCC Part 15 rules. Please attach a copy of the FCC report. NMRA no longer required evidence that the DCS complies. It is up to the manufacturer to determine the requirement for this compliance.
- **E.** A completed DCS Questionnaire (version xxx or later) for the system to be tested.
- **F.** **(Optional)** A DCC decoder with NMRA plug, suitable for HO scale, which supports all of the DCS functions.
- **G.** **(Optional)** A power supply that the manufacturer chooses that is capable of powering both the Command Station and the Power Station.

2) The NMRA may be petitioned to aid a manufacturer in the testing a potential system prior to formal conformance testing on a time available basis. If so petitioned, the manufacture must supply at a minimum the following:

- **A.** The DCS to be tested, a cab unit (if separate from the command station), and any unique cabling/connectors.
- **B.** A draft set of user documentation or notes on the proper use of the system.
- **C.** A completed DCS Questionnaire for the system to be tested.

Rules for achieving conformance

1) All Standards (S–9.1 and S–9.2) must be met in their entirety. Section A, RP-9.2.4 must also be met.
2) The implementations of the DCC Recommended Practices (RPs) are optional. These procedures apply to the following: (RP–9.1.1, RP–9.1.2, RP–9.2.1, RP–9.2.2, RP–9.2.3, RP–9.2.4, RP–9.3.1, RP–9.3.2)
3) If any aspects of one or more of the DCC RPs are implemented, the functions implemented must meet the standards set forth for that feature in the RP, while no aspect of the RP may be violated.

Determination of which RPs to test a DCS against, as per rule three (3) above, will include, but not be limited to, manufacturers claims for product features in advertising and the provided documentation.

4) Emerging Standards and Recommended Practices may be added to this test procedure as they mature. These that are not yet applicable to conformance and are highlighted in Yellow. These tests will be run for the benefit of the manufacturer and will not count towards conformance certification.

Assumptions:

Since all DCC systems must at one time or another be turned on for the first time, Section A of RP-9.2.4 will be assumed to be implemented by all manufacturers, and as such, all of RP 9.2.4 will be tested to Rule three (3) above for each DCS.
For those systems where the design incorporates a single unit integrated Command Station and Power station, the aspects of RP–9.1.2 for the interface between the Command Station and the Power Station will not apply. If the same integrated design provides an interface for the connection of additional Power Stations, then the provisions of RP–9.1.2 will be applied to that interface.

Summary of Testing

Command Station failed to meet NMRA standards in those areas that are checked in the “Failed” column. Testing stopped due to number of failures noted.

Test Setup

Unit under Test:

Manufacturer: _____

Serial Number: _____ Location of Test: _____

Model Number: _____ Software Version _____

Tester Name: _____ Testing Start Date: _____

Tester Signature: _____ Testing Completion Date: _____

Witness (optional): _____ Testing Start Date: _____

Witness Signature: _____ Testing Completion Date: _____

Comments/Notes:

Test Procedures

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
S-9.1	**Electrical Standard for Digital Command Control, all scales. - Command Station w/ Power Station**				
A: Bit Encoding Technique	DCS components shall transmit "1" bits with the first and last parts each having a duration of between 55 and 61 microseconds.	Measure one half of the "1" bit via oscilloscope, insure the measured half is between 55 and 61 microseconds in duration. (Scope at 5V 10µs)	**See Figure 1 "**Ones Bit Half Cycle". ***(Scope at 5V 10µs)***		
	In a "1" bit the first and last part shall have the same duration.	Measure the full cycle time of a "1" bit via oscilloscope, insure the total duration is between 110 and 122 microseconds. Subtract the value obtained in the previous step from the full cycle time to verify both halves are within (± 3 microseconds),	**See Figure 2 "**Ones Bit Full Cycle". ***(Scope at 5V 25µs)***		
	Zeros bit measurements in normal operations	Set all DCS and cab parameters for analog operations to full stop, off, or zero.			
	In a "0" bit, the duration of the first and last parts of each transition shall nominally be greater than or equal to 100 microseconds.	Measure one half of the "0" bit via oscilloscope, insure the measured half is greater than or equal to 100 microseconds in duration.	**See Figure 3 "**Zeros Bit Half Cycle". ***(Scope at 5V 25µs)***		
	The DC component of the total signal shall average zero when not controlling analog Locos.	Measure the full cycle duration of the "0" bit via oscilloscope, insure both halves are of equal duration. Subtract the value obtained in the step from the full cycle time to verify both halves are (± 3 microseconds)	**See Figure 4"**Zeros Bit Full Cycle". ***(Scope at 5V 50µs)***		
	Zeros bit measurements in Analog operations	Set all DCS and cab parameters for analog operations to full speed operations.			
	DCS components shall transmit "0" bits with the first and last parts each having a duration of between 95 and 9900 microseconds.	Measure the "0" bit via oscilloscope, insure both halves ≥ 95 ≤ 9900 microseconds in duration.	**See Figure 5** "Zeros Bit Fully Stretched"**.** ***(Scope at 5V 250µs)***		
	Total bit duration of the stretched "0" bit shall not exceed 12000 µsec	Measure the full cycle of the "0" bit via oscilloscope, insure duration ≤ 12000 µsec	**See Figure 5** "Zeros Bit Fully Stretched". ***(Scope at 5V 250µs)***		

Figure 1 Ones Bit First Half Cycle

Figure 2 Ones Bit Full Cycle

Figure 3 Zeros Bit First Half Cycle

Figure 4 Zero Bit Full Cycle

Figure 5 Zeros Bit Fully Stretched

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
B: Command Control Signal Shape	The slew rate from -4 volts to +4 volts shall occur at 2.5 volts per microsecond or faster	Measure the slew rate via an oscilloscope between ±4 volts at all rated load levels. Rate shall be ≥ 2.5 microvolts/sec.	**See Figures 6 "**Slew Rate Unloaded" **& Figure 7 "**Slew Rate Loaded"**.** ***(Scope at 2V 100ns)***		
	The signal may contain ripple at the zero crossing transitions, provided that this ripple shall have a frequency of no less than 100 kHz and an amplitude of no greater than 1/5th the total amplitude of the NMRA signal.	Measure the zero crossing ripple via an oscilloscope. Insure the ripple (if any) is of a frequency of 100 kHz or greater.	**See Figure 7 "**Slew Rate Loaded. ***(Scope at 2V 100ns)***		
	The exact shape of the NMRA digital signal shall be designed to minimize electro-magnetic radiation such that a large layout operated using this standard can meet applicable U.S. FCC electro-magnetic interference requirements.	Not tested by this procedure. Evidence of FCC certification is sufficient to pass this requirement.	**C&I Chairman to verify receipt of FCC conformance no longer required.**	---	---
C: Power Transmission and Voltage Limits for Transmitting Power Through the Rails	The RMS value of NMRA digital measured at the track shall not exceed by more than +2 volts, the voltage specified in Standard S-9 for the applicable scale. In no case should the peak amplitude of the command control signal exceed ±22 Volts. Measure each test case under zero and full load conditions. The minimum peak amplitude of the NMRA digital signal needed to provide power to the decoder shall be ±7 Volts measured at the track.	1) For DCS units with fixed outputs: Measure the RMS voltage of the NMRA digital signal at the track and insure the value is ≥7 Volts and ≤22 Volts RMS.	**See Figure 8 "**Peak to Peak Max Voltage". ***(Scope at 5V 100µs)***		
		2) Configure the DCS for operation with an "N" scale railroad if applicable. Measure the RMS voltage of the NMRA digital signal at the track and insure the value is ≥7 Volts and ≤22 Volts RMS.	**See Figure 8A "**Peak to Peak Max Voltage N-scale" if applicable. ***(Scope at 5V 100µs)***		
		3) Configure the DCS for operation with an "HO" scale railroad if applicable. Measure the RMS voltage of the NMRA digital signal at the track and insure the value is ≥7 Volts and ≤22 Volts RMS.	See Figure 8B "**Peak to Peak Max Voltage HO-scale" if applicable.** *(Scope at 5V 100µs)*		
		4) Configure the DCS for operation with a large scale (O or G) railroad if applicable. Measure the RMS voltage of the NMRA digital signal at the track and insure the value is ≥7 Volts and ≤22 Volts RMS.	**See Figure 8C "**Peak to Peak Max Voltage Large-scale" if applicable. ***(Scope at 5V 100µs)***		

Figure 6 Slew Rate Unloaded

Figure 7 Slew Rate Loaded

Figure 8 Peak to Peak Max Voltage with Supplied Power

Figure 8b Peak to Peak Max Voltage with 15 VDC Power

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
S-9.2	**Communications Standard for Digital Command Control, all scales. - Digital Command Stations (DCS)**				
A: General Packet Format	DCSs shall transmit to digital decoders via a standardized sequence of bits called a packet. All DCS transmissions shall send packets which conform to the following definition Preamble - A sequence of at least 14 bits, each of which have a value of "1".	Monitor packets transmitted by the DCS. Packets shall conform to the attached packet definition. A storage scope or some type of data capture device may be used to verify the DCS conforms to the NMRA packet standard.	22 preamble bits recorded by PRICOM		
	Packet Start Bit - The first bit with a "0" value which follows a valid preamble. Address Data Byte - First data byte, contains 8 bits (normally address information). The first transmitted	Send a command to loco address 122 to move forward at speed step 1. Note: A DCS is not required to be capable of addressing all 127 address, if not supported choose a high numbered even address. For loco 122 the Hex output from the packet capture device should be "C07A803A" for a long address "7A62xx" for the short address	See file S-9.2 Speed and Direction.txt Verified with PRICOM		
	Address bit is defined to be the most significant address bit of the byte. Address values of "00000000",	If the DCS supports extended addressing Go To RP-9.2.1 and verify proper operations for extended addressing.	**See RP 9.2.1 section for details**	**---**	**---**
	One or more of the following: Data Byte Start Bit - Precedes the Data Byte and has a value of "0". Data Byte - Contains 8 bits of data which can be address, instruction, data or error detection information. The first transmitted data bit is the most significant bit in the data byte. Packet End Bit - Marks the end of the Packet and has a value of "1"	Send a command to loco address 3 to move reverse at speed step 12. For loco 3 the Hex output from the packet capture device should be 14 Speed Decoder "034Cxx" 28 speed Decoder "0357xx"	See file S-9.2 Speed and Direction.txt		

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
B: Baseline Packets	It is the intentions of this Standard that, in order to conform: a *Command Station* must encode operator control input in conformance with the Baseline Packet semantics.				
	Speed and Direction Packets				
1. Byte One: Address Data Byte = 0AAAAAAA	Format: 1111111111 0 0AAAAAAA 0 01DUSSSS 0 EEEEEEEE 1 The address data byte contains the address of the intended recipient of the packet. It is acceptable for Digital Command Stations to restrict the number of valid addresses supported so long as this restriction is clearly and plainly labeled on the package and in the instructions.	Check the DCS documentation and insure the system is capable of generating speed and direction packets at the extremes and mid points of the documented range of addresses.			
2. Byte Two: Instruction Data Byte = 01DUSSSS	The instruction data byte is a data byte used to transmit speed and direction information to the locomotive Digital Decoder. Bits 0-3 provide 4 bits for speed (S) with bit 0 being the least significant speed bit. Bit four of the packet (U) can have a value of "1" or "0" and is not defined by the baseline.	Insure the bits 0-3 correspond with the commanded speed.	See file S-9.2 Speed and Direction.txt		
	Bit 5 provides one bit for direction (D). When the direction bit (D) has a value of "1" the locomotive should move in the forward direction. A direction bit with the value of "0" should cause the locomotive to go in the reverse direction.	Insure bit 5's setting corresponds with the commanded direction	See file S-9.2 Speed and Direction.txt		
	Bits 7 and 6 contain the bit sequence "01" which are used to indicate that this instruction data byte is for speed and direction	Insure bits 7 and 6 are set to values of "0" and "1" respectively			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
3. Byte Three: Error Detection Data Byte = EEEEEEEE	The error detection data byte is a data byte used to detect the presence of transmission errors. The contents of the Error Detection Data Byte shall be the bitwise exclusive OR of the contents of the Address Data Byte and the Instruction Data Byte in the packet concerned. (e.g. the exclusive OR of bit 0 of the address data byte and bit 0 of the instruction data byte will be placed in bit 0 of the error detection data byte etc.)	Test a representative packet for the proper coding of the Error Byte. (Note if this is coded improperly it should not be possible to operate a locomotive with a conformant Decoder since it will ignore all improperly formatted packets.)			
	Digital Decoder Reset Packets				
	Format: 1111111111 0 00000000 0 00000000 0 00000000 1 A three byte packet, where all eight bits within each of the three bytes contains the value of "0", is defined as a Digital Decoder Reset Packet. Following a Digital Decoder Reset Packet, a Command Station shall not send any packets with an address data byte between the range "01100100" and "01111111" inclusive within 20 milliseconds, unless it is the intent to enter service mode (see RP-9.2.3).	Insure the DCS does not send a packet within the specified range for the required time unless entering Service mode	No reset packet generated by Command Station		
	Digital Decoder Idle Packets				
	Format: 1111111111 0 11111111 0 00000000 0 11111111 1 A three byte packet, whose first byte contains eight "1"s, whose second byte contains eight "0"s and whose third and final byte contains eight "1"s, is defined as a Digital Decoder Idle Packet.	The Idle packet is a valid packet, which may or may not be used by the DCS.	No idle packet generated by Command Station		

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
C: Frequency Of Packet Transmission	Packets sent to Digital Decoders should be repeated as frequently as possible, as a packet may have been lost due to noise or poor electrical conductivity between wheels and rails. A Digital Decoder shall be able to act upon multiple packets addressed to it, provided the time between the packet end bit of the first packet and the packet start bit of the second packet are separated by at least 5 milliseconds.	Since the requirement for decoders to process a second packet addressed to it precludes back to back packets with different commands it is a requirement for the DCS not to send non identical packets back to back to the same address. (Note identical packets, address included, may be sent as a form of redundant communications to increase the reception reliability)			
	Digital Command Stations must maintain the timing accuracy such that the time between Packet Start Bits is less than to 30 milliseconds so Decoders do not switch to their alternate power source in the presence of the digital signal It shall be possible to configure Digital Command Stations to transmit packets more frequently than once every 30 milliseconds as measured from the time between packet start bits.	Measure the timing between packets and insure it is less than 30 milliseconds.	**See Figure 9** "Stretched 0 Packet Time". ***(Scope at 5V 5ms)***		

Figure 9 Stretched 0 Packet Time

RP-9.1.1	Electrical Interface and Wire Color Code. - Digital Command Stations (DCS)
This Recommended Practice does not apply to the DCS	

RP-9.1.2	Power Station Interface. - Digital Command Stations (DCS)				
Standard / RP	**Requirement**	**Test Action**	**System Response**	**Pass**	**Fail**
2.1 Common Characteristics	This section is applicable to DCSs that use separate Command Stations and Power Stations. This will be used for the purpose of certification of a command station independent of any particular power station.				
2.1.1 Command Station (signal generator) Output Signal	Command Station shall transmit "1" bits with the first and last parts each having a duration of between 57 and 59 μsec.	Measure one half of the "1" bit via oscilloscope, insure the half is between 57 and 59 microseconds in duration.	**See Figure 10 "**Ones Bit Half Cycle CS Output". ***(Scope at 5V 10μs)***		
	In a "1" bit the first and last part shall have the same duration.	Measure the full cycle time of a "1" bit via oscilloscope, insure the total duration is between 114 and 118 microseconds. Subtract the value obtained in the previous step from the full cycle time to verify both halves are within ± 2 microseconds	**See Figure 11 "**Ones Bit Full Cycle CS Output". ***(Scope at 5V 25μs)***		
	Zeros bit measurements in normal operations	Set all DCS and cab parameters for analog operations to full stop, off, or zero.			
	In a "0" bit, the duration of the first and last parts of each transition shall be greater than or equal to 97 μsec.	Measure one half of the "0" bit via oscilloscope, insure the measured half is greater than or equal to 97 μsec in duration.	**See Figure 12 "**Zeros Bit Half Cycle CS Output". ***(Scope at 5V 25ms)***		
	The DC component of the total signal shall average zero when not controlling analog Locos.	Measure the full cycle duration of the "0" bit via oscilloscope, insure both halves are of equal duration. Subtract the value obtained in the step from the full cycle time to verify both halves are ± 2 microseconds	**See Figure 13"**Zeros Bit Full Cycle CS Output". ***(Scope at 5V 50ms)***		
	Zeros bit measurements in Analog operations	Set all DCS and cab parameters for analog operations to full speed operations.			
	DCS components shall transmit "0" bits with the first and last parts each having a duration of between 97 and 9888 μsec.	Measure the "0" bit via oscilloscope, insure both halves ≥ 97 ≤ 9888 μsec in duration.	**See Figure 14** "Zero Bit Fully Stretched CS Output". ***(Scope at 5V 250ms)***		

Figure 10 Ones Bit Half Cycle CS Output

Figure 11 Ones Bit Full Cycle CS Output

Figure 12 Zeros Bit Half-Cycle CS Output

Figure 13 Zeros Bit Half-Cycle CS Output

Figure 14 Zeros Bit Fully Stretched CS Output

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
2.1.2 Power Station input signal	Power Station should not alter the signal from its Power Station Interface input to its track output terminal outside the range of 0.5 μsec of time delay and a distortion or ± 2 μsec.	Based on the measurements made in section 2.1.1 repeat all measurements in section 2.1.1 on the output of the Power Station. Alternatively both channels of the oscilloscope, one on the input to the Power Station, and one on the output of the Power Station			
	Command Station shall transmit "1" bits with the first and last parts each having a duration of between 57 and 59 μsec.	Measure one half of the Output "1" bit via oscilloscope, insure the half is within 2 μsecs of the input signal and delayed by less than 0.5 μsecs.	**See Figure 15 "**Ones Bit Half Cycle PS Output".		
	In a "1" bit the first and last part shall have the same duration.	Measure the Output full cycle time of a "1" bit via oscilloscope, insure the total duration is ± 2 μsec of the input signal. Subtract the value obtained in the previous step from the full cycle time to verify both halves are within ± 2 μsec and a total delay of less than 1 μsec.	**See Figure 16 "**Ones Bit Full Cycle PS Output".		
	Zeros bit measurements in normal operations	Set all Command Station and cab parameters for analog operations to full stop, off, or zero.			
	In a "0" bit, the duration of the first and last parts of each transition shall be greater than or equal to 97 μsec.	Measure one half of the Output "0" bit via oscilloscope, insure the measured half is greater than or equal to 95 μsec in duration.	**See Figure 17 "**Zeros Bit Half Cycle PS Output".		
	The DC component of the total signal shall average zero when not controlling analog Locos.	Measure the Output full cycle duration of the "0" bit via oscilloscope, insure both halves are of equal duration. Subtract the value obtained in the step from the full cycle time to verify both halves are ± 3 μsec	**See Figure 18 "**Zeros Bit Full Cycle PS Output".		
	Zeros bit measurements in Analog operations	Set all DCS and cab parameters for analog operations to full speed operations.			
	Command Station shall transmit "0" bits with the first and last parts each having a duration of between 97 and 9888 μsec.	Measure the "0" bit via oscilloscope, insure both halves ≥ 95 ≤ 9900 μsec in duration.	**See Figure 19** "Zero Bit Fully Stretched PS Output".		

Figure 15 Ones Bit Half Cycle PS Output

Figure 16 Ones Bit Full Cycle PS Output

Figure 17 Zeros Bit Half Cycle PS Output

Figure 18 Zeros Bit Half Cycle PS Output

Figure 19 Zeros Bit Fully Stretched PS Output

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
2.1.3 Power Station Interface Repeater Input and Output	A Power Station Interface repeater amplifies the Power Station Interface signals so that additional power stations can be powered. On input, the repeater has the same requirements of that power station (See section 2.1.2) but it must accept a reduced input voltage of ± 4.5V.	Based on the measurements made in section 2.1.1 repeat all measurements in section 2.1.1 on the output of the Power Station Repeater. Alternatively, use both channels of the oscilloscope, one on the input to the Power Station, and one on the output of the Power Station to simultaneously measure the input and output signals so they can be directly compared.			
2.1.4 Power Station Common	Power Stations must provide the ability to connect the common side of their DC power supplies together	Insure the manufacture has provided and documented a method of connecting the commons sides of their power supplies together.			
2.2 Opto-isolated (current) Interface	The opto-isolated interface type is characterized by the Power Station input connected to the LED portion of an opto-coupler. It is not required to be implemented with an opto-coupler	This type of interface is not required but if implemented this section will be used to verify compliance.			
2.2.1 Command Station Output Signal	A bipolar signal must appear differentially on a two-wire cable with a signal amplitude of no less than ± 8 Volts and no greater than ± 22 Volts.	Measure the signal across a 1K Ohm load via an oscilloscope. The Command Station must supply a minimum of ± 8 Volts into the 1K load			
	A Unipolar signal must appear on a two-wire cable, one signal, one ground with a signal amplitude of no less than + 8 Volts and no greater than + 22 Volts.	Measure the signal across a 1K Ohm load via an oscilloscope. The Command Station must supply a minimum of + 8 Volts into the 1K load	**See Figure 20** "Peak to Peak voltage across a 1K load"		
	The output current should be limited to no greater than 1000mA to reduce the hazards in case of a short circuit in the Power Station Interface.	Test the output for short circuit protection. With and ammeter verify the current to a 1K ohm load does not exceed 1000mA.			

Figure 20 Peak-to-Peak Voltage across a 1K load

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
2.2.2 Power Station Input signal	A Power Station must accept as a valid input a bipolar, or unipolar signal with an amplitude of at least + 2.5 V and should be capable of accepting signals with an amplitude of + 12V without damage.	Attempt to load the Power Station input such that the input voltage is +2.5V and insure the output has stayed within normal operations.			
	A Power Station should reject signals of less than 2 volts or noise signals of less then 2mA of current	Attempt to load the Power Station input such that the input voltage is +2.0V and insure the Power Station has discontinued output			
3.0 Safety	To prevent dangerous heat buildup in the Power Station Interface no device shall be capable of acting as a Power Station Interface ground with the capability of conducting more than 500mA of current.	Using an ammeter between the Power Station ground connection and an earth ground, verify that the current does not exceed 500mA.			
4.0 Physical Medium	This section is not applicable for conformance testing				
5.0 Topology	This section is not applicable for conformance testing				
6.0 Labeling	Command Stations and Power Stations that are designed to follow the RP shall be clearly labeled. A standard method of labeling should be applied to Command Stations and Power Stations to let end user know how many devices may be connected.	Verify all Command Stations are labeled with the amount of current they can provide to a Power Station Interface. Verify all Power Stations are labeled with the amount of current required to drive its Power Station Interface.			
	All devices will clearly label all Power Station Interface wires and also which lead is intended for Positive polarity of both the Power Station Interface and the output rail.	Verify all connections are clearly labeled including which lead is the positive lead.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
RP-9.2.1	**Extended Packet Formats For Digital Command Control, All Scales. - Digital Command Stations (DCS)**				
A: Address Partitions	The first byte of an extended packet format packet contains the primary address. This primary address is subdivided into the following Address Partitions: Address (0) - Broadcast Address Addresses (1-127) - 7 Bit Addresses Addresses (128-191) – Basic Accessory Decoders with 9 Bit Addresses and Extended "Accessory Decoders with 11 bit Addresses Addresses (192-231) - Multi Function Decoders with 14 Bit Addresses Addresses (232-254) - Reserved for Future Use Address (255) - Idle Packet	Test DCS output for addresses in the proper partitions. Test DCS output for addresses outside of their intended partitions.			
B: Broadcast Command for Multi Function Digital Decoders	This single instruction has the same definition as defined by the Multi Function Digital Decoder packet and can be 1, 2, or 3 bytes in length depending on the instruction.	If the DCS implements the use of the Broadcast address insure it is in the packet format of {preamble} 0 00000000 0 {instruction byte} 0 EEEEEEEE 1			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
C: Instruction Packets for Multi Function Decoders	Multi Function Digital Decoders are used for the purpose of controlling one or more motors and/or accessories.	If the DCS implements the use of the Multi Function Digital Decoders Instruction packets insure its outputs are in the packet format of: {preamble} 0 AAAAAAAA 0 [{instruction byte}] 0 EEEEEEEE 1			
	If the most significant bits of the first byte (Bits #6 & #7) are "11" then a second address byte must immediately follow. When 2 bytes of address information are present they are separated by a "0" bit. The most significant bit of the 2 byte address is bit 5 of the 1st byte	If the DCS implements extended addressing send a command to an extended address loco (address > 127) and insure the two addressing bytes are properly ordered.	See file RP-9.2.1 Speed & Direction.txt		
	Instruction bytes are used by the DCS to send commands to Multi Function Digital Decoders. Each instruction (indicated by {instruction byte} created by a DCS, must be of the Format: CCCDDDDD, CCCDDDDD 0 DDDDDDDD, or CCCDDDDD 0 DDDDDDDD 0 DDDDDDDD Where : CCC = 3 bit instruction type and DDDDD and DDDDDDDD are 5 and 8 bit data fields respectively.	Insure all to Multi Function Decoder Instruction packets conform to this specification			
	The last byte of the packet is the Error Detection Byte, which is, calculated the same as is done in the baseline packet using all address and instruction bytes.	See S-9.2 for Error Detection Byte tests. (If the DCS has passed the S-9.2 error byte tests this does not need to be repeated.)			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Decoder and Consist Control Instruction (000)	With the exception of the decoder acknowledgment function (00001111), only a single decoder and consist control instruction may be contained in a packet	Inspect Decoder and Consist Control Instructions and insure only single instructions are contained within a single packet except as noted.	See file RP-9.2.1 Consist control.txt		
	Decoder Control (0000) These instructions have the format of: 0000CCCD Where : CCC = 001, 010, 100, and 110 are reserved for future use	Insure all Decoder Instructions created by the DCS conform to the format and that the reserved settings are not used.			
	Consist Control (0001) These instructions have the format of: 0001CCCC 0 0AAAAAAA Where : The value of "1" in bit #7 of the second byte is reserved for future use. All values of CCCC other than 0010 and 0011 are reserved for future use	Insure all Decoder Instructions created by the DCS conform to the format and that the reserved settings are not used.			
Advanced Operation Instructions (001)	Only a single Advanced Operation Instruction may be contained in a packet	Inspect Advanced Operation Instructions and insure each packet contains only one instruction.	See file "RP-9.2.1 Adv Ops Instruct.txt"		
	Instruction format: 001CCCCC 0 DDDDDDDD Where : The value of "1" in bit #7 of the second byte is reserved for future use. All values of CCCCC other than 11111 and 11110 are reserved for future use The data byte value of U0000000 is reserved for Stop and, the data byte value of U0000001 is reserved for Emergency Stop	Insure all Advanced Operations Instructions created by the DCS conform to the format and that the reserved settings are not used.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
128 Speed Step Control	The 5 Bit Sub-command CCCCC allows for 32 separate Advanced Operations Sub-Instructions CCCCC = 11111:128 Speed Step Control - Instruction is used to send 1 of 126 Digital Decoder speed steps. The subsequent single byte shall define speed and direction with bit 7 being direction. (“1” is Forward “0” is Reverse) and the remaining bits indicate speed. The most significant speed bit is bit 6. A data byte value of U000000 is used for Stop, and a data byte value of U000001 is used for Emergency Stop. This allows for 126 speed steps. CCCCC = 11110:Restricted Speed Step - Instruction used to restrict the maximum speed of a decoder bit 7 of the subsequent byte is used to enable (“0”) or disable (”1”) restricted speed operation. Bits 0-5 are the speed steps defined in S-9.2	Set the Command Station to allow 128 Speed Step mode. Insure the packets sent are of the proper format and correspond to the values selected on the user input device.			
		If supported by the command station send an enable restricted Speed Step packet. Verify the enable Restricted Speed packet is sent as commanded.			
		If supported by the command station send a disable Restricted Speed Step packet. Verify the Disable Restricted Speed packet is sent as commanded.			
Speed and Direction Instructions	The format of these instruction is: Reverse Operation: 010DDDDD Forward Operation :011DDDDD Where speed step defined by DDDDD The data field value of U0000 is reserved for Stop and, the data field value of U0001 is reserved for Emergency Stop	Insure all Speed and Direction Instructions created by the DCS conform to the format and that the reserved settings are used properly.	See file “S-9.2 File.txt”		
	56 speed mode	If the DCS implements 56 speed mode, check the output packets for speed commands which alternate between two adjacent speed steps after the speed had been commanded to increase by a single speed step.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Function Group One Instruction (100DDDDD)	Up to 5 auxiliary functions (functions FL and F1-F4) can be controlled by the Function Group One instruction. Bits 0-3 shall define the value of functions F1-F4 with function F1 being controlled by bit 0 and function F4 being controlled by bit 3. A value of "1" shall indicate that the function is "on" while a value of "0" shall indicate that the function is "off".	Use a known locomotive or a test box to confirm the DCS can correctly command FL and F1-F4 to both the on and off states.	See file "RP-9.2.1 Fun Grp Packets.txt"		
	If Bit 1 of CV#29 has a value of one (1), then bit 4 controls function FL, otherwise bit 4 has no meaning.	Inspect CV #29 for the proper operation as described.			
Function Group Two Instruction (101SDDDD)	Up to 8 additional auxiliary functions (F5-F12) can be controlled by a Function Group Two instruction. Bit 4 defines the use of Bits 0-3. When Bit 4 (S) is '1', Bits 0-3 shall define the value of functions F5-F8 with function F5 being controlled by bit 0 and function F8 being controlled by bit 3. When Bit 4 (S) is '0', Bits 0-3 shall define the value of functions F9-F12 with function F9 being controlled by bit 0 and function F12 being controlled by bit 3.A value of "1" shall indicate that the function is "on" while a value of "0" shall indicate that the function is "off".	Use a known locomotive or a test box to confirm the DCS can correctly command F5-F8 to both the on and off states.	See file "RP-9.2.1 Fun Grp Packets.txt"		
		Repeat test for F9-12.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Future Expansion (110)	The format of this two byte instruction is: 110DDDDD 0 DDDDDDDD and at the current time is reserved for future expansion.	Insure this reserved command is not being generated by the DCS under test.			
Configuration Variable Access Instruction (111)	The Configuration Variable Access instructions are intended to set up or modify Configurations Variables either on the programming track or on the main line. There are two forms of this instruction. The short form is for modifying selected frequently modified Configuration Variables. The long form is for verifying or modifying any selected Configuration Variable. Only a single configuration variable access instruction may be contained in a packet	Inspect Configuration Variable access Instructions and insure each packet contains only one instruction.	See File" RP-9.2.1 CV Access Instruct.txt"		
	Configuration Variable Access Instruction - Short Form This instruction has the format of 1111CCCC 0 DDDDDDDD The 8 bit data DDDDDDDD is placed in the configuration variable identified by CCCC according to the following table. * CCCC = 0000 - Not available for use * CCCC = 0010 - Acceleration Value (CV#23) * CCCC = 0011 - Deceleration Value (CV#24) The remaining values of CCCC are reserved and will be selected by the NMRA as needed	Insure the Non-available and reserved values are not generated by the DCS.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
	Configuration Variable Access Instruction - Long Form The long form allows the direct manipulation of all CVs. This instruction is valid both when the Digital Decoder has its long address active and short address active. Digital Decoders shall not act on this instruction if sent to its consist address. The format of the instructions using Direct CV addressing is: 1110CCAA 0 AAAAAAAA 0 DDDDDDDD	Verify the DCS will allow the manipulation of the Long Form Configuration Variable Access Instructions when the short or long address is active.	See File" RP-9.2.1 CV Access Instruct.txt"		
	The actual Configuration Variable desired is selected via the 10-bit address with the two-bit address (AA) in the first data byte being the most significant bits of the address. The Configuration variable being addressed is the provided 10-bit address plus 1. For example, to address CV#1 the 10 bit address is "00 00000000".	Verify the proper offset is being applied when manipulating CVs directly (i.e., set the address of a decoder to a different value and insure it was properly changed by controlling the loco at the new address)	See File" RP-9.2.1 CV Access Instruct.txt"		
	The defined values for Instruction type (CC) are: * CC=00 Reserved for future use * CC=01 Verify byte * CC=11 Write byte * CC=10 Bit manipulation	Insure the reserved values are not generated by the DCS and the proper code is generated for the service requested.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
D: Accessory Digital Decoder Packet Formats	Accessory Digital Decoders are intended to control a number of simple functions such as switch machine control or turning on and off lights. It is permissible to develop Digital Decoders that respond to multiple address so that more devices can be controlled by a single Digital Decoder				
Basic	Packet Format: {preamble} 0 10AAAAAA 0 1AAACDDD 0 EEEEEEEE 1 Accessory Digital Decoders can be designed to control momentary or constant-on devices, the duration of time each output is active being controlled by configuration variables CVs #515 through 518. Bit 3 of the second byte "C" is used to activate or deactivate the addressed device. Accessory Decoder Packet Format The format for packets intended for Accessory Digital Decoders is:	Address an accessory device and inspect the generated packet for the proper format.	Tested with exiting known Accessory Decoders		
Advanced	Packet Format: {preamble} 0 10AAAAAA 0 0AAA0AA1 0 XXXXYYYY 0 EEEEEEEE 1 The Extended Accessory Decoder Control Packet is included for the purpose of transmitting aspect control to signal decoders or data bytes to more complex accessory decoders. Each signal head can display one aspect at a time. Control of two signal heads is included in each packet transmission. XXXX is for head 1 and YYYY is for head 2. A value of 0000 for XXXX or YYYY indicates the absolute stop aspect. All other values for XXXX and YYYY are determined by the signaling system used and the prototype being modeled. **The value of '1110' is illegal for XXXX.**	Address an accessory device and inspect the generated packet for the proper format.	Tested with exiting known Accessory Decoders		

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Broadcast Command For Accessory Digital Decoders	There are two forms of Broadcast commands for Accessory Digital Decoders, Basic and Extended.				
Basic	{preamble} 0 10111111 0 1000CDDD 0 EEEEEEEE 1 This packet shall be executed by all accessory decoders. CDDD is defined as specified in the paragraph on basic Accessory Digital Decoders.	Perform a Basic Accessory Broadcast and inspect the generated packet for the proper format.	Not supported		
Extended	{preamble} 0 10111111 0 10000111 0 XXXXYYYY 0 EEEEEEEE 1 All accessory decoders shall execute this packet. XXXXYYYY is defined as specified in the paragraph on Extended Accessory Digital Decoders.	Perform an Extended Accessory Broadcast and inspect the generated packet for the proper format.	Not supported		
Configuration Variable Access	Accessory Digital Decoders can have their configurations variables changed in the same method as locomotive decoders using the Configuration Variable Access instruction – Long form instruction for basic and extend as defined below:				
Basic	{preamble} 0 10AAAAAA 0 1AAACDDD 0 EEEEEEEE 1 For the purpose of this instruction the accessory decoder's address is expanded by two bytes in the following manner. {preamble} 0 10AAAAAA 0 1AAACDDD 0 (1110CCAA 0 AAAAAAAA 0 DDDDDDDD) EEEEEEEE 1	Modify an accessory configuration variable in a Basic Accessory Decoder, verify the packet corresponds to the accessory decoder and configuration variable selected.			
Extended	{preamble} 0 10AAAAAA 0 1AAACDDD 0 EEEEEEEE 1 For the purpose of this instruction the accessory decoder's address is expanded by two bytes in the following manner. {preamble} 0 10AAAAAA 0 1AAACDDD 0 (1110CCAA 0 AAAAAAAA 0 DDDDDDDD) EEEEEEEE 1	Modify an accessory configuration variable in an Extended Accessory Decoder, verify the packet corresponds to the accessory decoder and configuration variable selected.			

E: Operations Mode Acknowledgement	The advanced acknowledgment mechanism as defined in RP-9.2.3 is the only valid acknowledgement in operations mode. Whenever an acknowledgment is requested, the decoder shall respond using this mechanism.	See RP-9.2.3 for Operations Mode See RP-9.2.3 Section for details Acknowledgment

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
RP-9.2.2	**Configuration Variables For Digital Command Control, All Scales. - Digital Command Stations (DCS)**				
General	This Recommended Practice provides a map and descriptions for Digital Decoder Configuration Variables. Configuration Variables allow the decoder to be custom-zed for each locomotive, or other mobile or stationary devices. See Table 1 below.	Insure the DCS can read/write CVs as described in the associated documentation. Further insure when using system that calls out CVs by name (i.e., acceleration) the values are being store in the proper locations (CVs)	Only CV1 can be changed. However, CV1 cannot be read.		
Appendix A :	This standard is not applicable to the DCS				
Appendix B :	This standard is not applicable to the DCS				

Table 1 Configuration Variables as of July 2006

CV Name	CV #	Required	Default Value	Read Only	Uniform Spec	Dynamic (Volatile)	Additional Comments
Multi-function Decoders:							
Primary Address	1	M					
Vstart	2	R					
Acceleration Rate	3	R					
Deceleration Rate	4	R					
Vhigh	5	O					
Vmid	6	O					
Manufacturer Version No.	7	M					Manufacturer defined version info
Manufactured ID	8	M					Values assigned by NMRA
Total PWM Period	9	O					
EMF Feedback Cutout	10	O					
Packet Time-Out Value	11	R					
Power Source Conversion	12	O					Values assigned by NMRA
Alternate Mode Function Status F1-F8	13	O					
Alternate Mode Function. Status F_L,F9-F12	14	O					
Decoder Lock	15-16	O					Under re-evaluation see topic 0305051
Extended Address	17+18	O					
Consist Address	19	O					
	20	-					Reserved by NMRA for future use
Consist Addr Active for F1-F8	21	O					
Consist Addr Active for FL-F9-F12	22	O					
Acceleration Adjustment	23	O					
Deceleration Adjustment	24	O					
Speed Table/Mid-range Cab Speed Step	25	O					
	26						Reserved by NMRA for future use
Decoder Automatic Stopping Configuration	27	O					Under re-evaluation – see details
Bi-Directional Communication Configuration	28	O					Under re-evaluation – see details
Configuration Data #1	29	M[1]					
Error Information	30	O					
Index High Byte	31	O					Primary index for CV257-512 00000000 - 00001111 reserved by NMRA for future use.
Index Low Byte	32	O					Secondary index for CV257-512
Output Loc. FL(f), FL(r), F1-F12	33-46	O					
Manufacturer Unique	47-64	O					Reserved for manufacturer use
Kick Start	65	O					
Forward Trim	66	O					
Speed Table	67-94	O					
Reverse Trim	95	O					
	96-104	-					Reserved by NMRA for future use
User Identifier #1	105	O					Reserved for customer use
User Identifier #2	106	O					Reserved for customer use
	107-111	-					Reserved by NMRA for future use
Manufacturer Unique	112-256	O					Reserved for manufacturer use
Indexed area	257-512						Indexed area - see CV# 31,32 Index values of 0-4095 reserved by NMRA
	513-879	-					Reserved by NMRA for future use
	880-891						Reserved by NMRA for future use
Decoder Load	892	O					
Dynamic Flags	893	O					
Fuel/Coal	894	O					
Water	895	O					
SUSI Sound and Function Modules	896-1024	O					See TN-9.2.3

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

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
RP-9.2.3	**Service Mode For Digital Command Control, All Scales. - Digital Command Stations (DCS)**				
A: Introduction	This section is not applicable to DCS				
B Service Mode Environment	Given that Service Mode is designed for testing and customization of Digital Decoders, it is recommended that: 1) Service Mode operations should occur on an isolated section of track, 2) Only one Digital Decoder at a time should be present on the track used for Service Mode operations. 3) Service Mode operations should be performed in an environment with limited energy to prevent damage to decoders during programming. For the purpose of this RP limited energy is defined as 250mA, sustained for more than 100ms. A Programmer may further limit the energy via a current limiting resistor, if it is clearly documented that all compatible DCC devices may be programmed by this programmer.	Test to ensure that the current provided in service mode is limited.	Not supported, programming done on main only and only CV1 can be changed.		
C: Digital Decoder Entry to and Exit from Service Mode	This section is not applicable to DCS				
D: Decoder Acknowledgment Mechanism	Service Mode operations provide for an acknowledgment mechanism from the decoder to the command station/programmer. Acknowledgment refers to the ability of the Digital Decoder to respond to a Service Mode instruction issued by a Programmer. Service Mode instructions can be executed regardless of whether or not the acknowledgment mechanism is detected by the command station/programmer. Two Acknowledgment mechanisms are available: • Basic Acknowledgment • Advanced Acknowledgment				

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Basic Acknowledgment	Basic Acknowledgement is defined by the Digital decoder providing an increased load (positive –delta) on the programming track of at least 60 mA for 6ms +/- 1ms. It is permissible to provide this increased load by applying power to the motor or similar device controlled by the Digital Decoder.	Test to see that command station can detect Basic ack from a number of manufacturer's decoders (if this feature is provided by the command station) Test attempts to introduce minimal load on the track to detect load.			
Advanced Acknowledgment	**See RP-9.3.1 and RP-9.3.2**				
General Acknowledgement timing	During Service Mode the Programmer should scan for any Acknowledgment current pulse(s) in the Acknowledgment time window starting at the Packet End bit of the second service mode instruction packet and extending through the required number of instruction packets and, in the case of write operations, through the specified decoder-recovery-time. A Command Station/Programmer may not stop sending packets to the programming track (which turns off power to the decoder) until the end of the Decoder-Recovery-Time.	Verify the DCS does not discontinue packet transmissions until the end of the Decoder-Recovery-Time.			
E: Service Mode Instruction Packets	Service Mode supports four different methods for access to Configuration Variables (CVs): Direct Configuration, Address-Only, Physical Register, and Paged Addressing. The Service Mode instruction packet sequences are defined from a Command Station/Programmer perspective.	This section of the tests must include a packet capture of each of the modes supported. The packet capture results must be checked against the RP for conformance.			
Long Preamble	In Service Mode the Command Station/Programmer will increase the preamble of the packet from the minimum 10 bits (per S-9.2) to at least 20 bits to allow extra time for the Digital Decoder to process the packets. This is designated as "long-preamble".	Check to ensure long preamble.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Power On Cycle	Upon applying power to the track, the Command Station/Programmer must transmit at least 20 valid packets to the Digital Decoder to allow it time to stabilize before any Service Mode operations are initiated. During this time a current load of greater that 250mA sustained for more than 100ms of initiation of packet transmission shall be interpreted as an over current fault condition for the decoder being programmed. After the power up sequence, a decoder with all outputs turned off shall not draw more than 100 ma of current except for when processing an acknowledgement.	Test DCS on entry to service mode for 20 or more reset packets. Also see RP-9.2.4 Measure the current draw on the program track; attempt to raise the draw to exceed the 250 mA. Verify the programmer ceases sending packets to protect the decoder.			
Decoder Recovery Time	Command Station/Programmer shall send the same service mode write packets or reset packets during the Decoder-Recovery-Time until the specified packet time has been met or the until the command station/programmer has received a valid acknowledgment	Test for the retransmission of packets for the specified time or conditions listed in the requirement.			
Direct Mode	Direct Mode service mode instruction packets support accessing Configuration Variables by their configuration variable number. To determine if a Digital Decoder supports Direct Configuration Variable Addressing, the Full-Feature Command Station/Programmer should perform two bit verifies, one verify for a bit value of '0', one verify for a bit value of '1' to the most significant bit within CV #8 (Manufacturer's ID).	Capture packet sequence for both a verify and a write operation in both bit mode and in byte mode, check that the command station checks to see that the decoder supports this mode before sending the packets. Within a verify or write sequence, the Command Station/Programmer may cease sending packets and continue with the next step in the sequence when either a decoder acknowledgment is successfully received or the number of packets specified to be transmitted is completed.			
	A Command Station/Programmer which supports Direct Mode must implement all three instructions types (Verify Byte, Write Byte and Bit Manipulation)	If the DCS is indicated to be a full function programmer in documentation, advertising or by implementation, verify that the DCS supports the full range of CVs (0 - 1024)			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Address only mode	Address-only service mode instruction packets support access to Configuration Variable #1, the Digital Decoder's short address. When a new short address (CV #1) is written using any method, a decoder must reset the extended addressing bit in the Configuration Register (CV #29) to have a value of '0', and clear the consist address (CV #19).	Ensure that the packet sequence is correct, and that the number of packets for both the verify and write operation are correct. Pay special attention to the number of packets after a verify operation for decoder reset.			
	Within a verify or write sequence, the Command Station/Programmer may cease sending packets and continue with the next step in the sequence when either a decoder acknowledgment is successfully received or the number of packets specified to be transmitted is completed.	Test for the retransmission of packets for the specified time or conditions listed in the requirement.			
Register Mode	Physical Register addressing supports access to a limited number of Configuration Variables by using the internal "Registers" of a decoder. The following table shows the packet sequence.	Perform Packet Capture of this mode, Look for page reset command. Ensure that verifies and Writes to CV #1 follow address mode, test to ensure you can write all 256 values to the registers and that you can read and verify all 8 registers.			
	Within a verify or write sequence, the Command Station/Programmer may cease sending packets and continue with the next step in the sequence when either a decoder acknowledgment is successfully received or the number of packets specified to be transmitted is completed.	Test for the retransmission of packets for the specified time or conditions listed in the requirement.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
	It is recommended that a Command Station/Programmer provide full read and write access to the 8 Physical registers (000) to (111) for all values of 8 bit data. This allows a user to directly manipulate Physical registers 1 (000) to 8 (111) and CV data in any manner. The Command Station/Programmer documentation should indicate the numbering or name scheme in use, and how these correspond to the 8 Physical Registers.	If the DCS is indicated to be a full function programmer in documentation, advertising or by implementation, verify that the DCS supports the full range of CVs (1024)			
Page Mode	Implementations that require access to a larger number of Configuration Variables than possible using just the 8 Physical Registers, can use an extended 3 byte programming format called Paged CV addressing. If a decoder does not implement Paged CV addressing, it must not respond to Paged CV programming commands when the page register has a value greater than 1.	Perform packet capture and verify that sequence as is specified. Check that page register is reset to a value of 1 after page mode operation. Check to see that the calculation of CV addresses is correct, check to see that all 256 values can be read and written			
	Within a verify or write sequence, the Command Station/Programmer may cease sending packets and continue with the next step in the sequence when either a decoder acknowledgment is successfully received or the number of packets specified to be transmitted is completed.	Test for the retransmission of packets for the specified time or conditions listed in the requirement.			
	It is recommended that a Command Station/Programmer provide full read and write manipulation for all values of 8 bit data.	If the DCS is indicated to be a full function programmer in documentation, advertising or by implementation, verify that the DCS supports the full range of CVs (1024)			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
	To ensure compatibility with earlier Command Station/Programmers, a Command Station/Programmer should set the Page Register (101) to 'Page 1' (a data value of 1) at the end of programming. It is also recommended that decoders provide a mechanism to automatically reset their page registers to have a value of 1 after programming is completed	test the value of the page register after programming is completed and watch the packet capture sequence to insure the page register is being reset to a value of 1 and at the appropriate			
Decoder Factory Reset	From time to time it may be desirable to request that the decoder reprogram all its CVs to a factory default condition. The following command sequence shall be used for this purpose. The packet sequence for this command is identical to the packet sequence specified for Service Mode Instruction Packets for Physical Register Addressing. {long preamble} 0 01111111 0 00001000 0 01110111 1				
	It will take multiple power on cycles for the decoder to rewrite all it CVs. A Value of 255 will be place in CV8 until such time that the decoder had successfully rewritten all CVs of their factory default condition	Read the contents of CV8 immediately after sending the Factory Reset command. Verify a value of 255 is there.			
F: Methods of programming required	To conform with this RP, Command Station/Programmers must implement one of the following groups of programming methods. The manufacturer must clearly label, using the RP defined terms, which form(s) of programming are supported	To pass this RP the command station must support the modes required for the class of command station. Starting 01 Aug 2002 all command Stations or Programmers submitted for conformance must implement direct mode. …support for paged mode is strongly encouraged			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
Limited-Feature Command Station / Programmers	**Address-Only Programmers** program CV #1 via Address-Only Mode **Select CV Programmers** program a selected subset of CVs via Physical Register or Paged Addressing, subset must include CV #1 **Register & Paged Programmers** program the full set of CVs via Physical Register and Paged Addressing	Determine the type of programmer under test and verify the required capabilities exist.			
Appendix A:	The Address Query instruction is used in older Digital Decoders to verify a specific decoder address, CV #1. The format of the instruction is Long preamble 0 AAAAAAAA 0 11111001 0 EEEEEEEE 1	If Address query is used check to see that it only is used for addresses less than 112.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
RP-9.2.4	**Configuration Variables For Digital Command Control, All Scales. - Digital Command Stations (DCS)**				
A:Initialization of the DCC system	Upon initialization of the DCC system two possible conditions exist: * - the Digital Command Station has retained information about the previous state of the system * - the Digital Command Station has no information about the previous state of the system				
	In the case where there is no information about the previous state of the system, the Digital Command Station shall send a minimum of twenty (20) digital decoder reset packets to the layout followed by five (5) idle packets. These packets shall be sent prior to sending any packets that contain operating instructions	Insure the sequence of at least 20 reset packets followed by at least 5 idle packets is sent prior to any operational packets. If possible set throttles to non-zero values before test initiation.	**See File** "RP-9.2.4 Startup Sequence.txt"		
B: Converting Between Power Modes	Not applicable to the DCS				
C: Occurrence of Error Conditions	While in digital operations mode each Multi Function Digital Decoder shall have a Packet Update time-out value. While in digital operations mode, if the packet time-out value is exceeded, the Multi Function Digital Decoder will bring to a stop all controlled devices. The purpose of this time-out is to insure that each Multi Function Digital Decoder receives a periodic update from the Digital Command Station and thereby help prevent runaway conditions. The user should be able to define the value for this time-out within these restrictions: * - a value of 0 disables the time-out (i.e., the user has chosen not to have a timeout) * - A value range of 1 through TIMEOUT_MAX sets the time-out to the chosen value. The minimum value of TIMEOUT_MAX will be 20 seconds. It may be longer at the manufacturer's discretion.	Insure the DCS does not exceed the Minimum value for TIMEOUT_MAX (20 Secs.) when controlling the maximum number of locos and accessories as stated in the manufacture's documentation.			

Standard / RP	Requirement	Test Action	System Response	Pass	Fail
RP-9.3.1	**Electrical Specifications for Digital Command Control Decoder Transmission All Scales.**				
A: Technique for Transmitting and Receiving Bits	Not applicable to Command or Power Stations				
B: Transmitting & Receiving Bytes	Not applicable to Command or Power Stations				
C: Packet Transmission & Timing	A bi-directional data transmission can be sent and received after each NMRA DCC packet transmitted to the layout. The specifications for the contents of the data transmission are contained in RP-9.3.2 In order to communicate, a receiver/detector (or PowerStation) must interrupt power from being transmitted to the layout between the DCC packets. This power interruption should not occur unless the power cutout device can reasonably expect that the command station will transmit a minimum of 12 preamble bits to complete the preamble after the completion o the inter packet transmission cutout.				
Cutout Device Timing	The cutout for bi-directional communications occurs in the inter packet time that occurs after the packet end bit and before the start of the next preamble. During the cutout period, power must be disconnected from the rails, the rails shorted to each other such that the detector load is in series with the decoder current source.	Capture the cutout on the oscilloscope and measure the Gap Start time, T_{GS}, and the Gap End time, T_{GE}. Name Min Nom Max Units T_{GS} 36 42 45 µs T_{GE} 448 µs	See Figure 21 Gap Start Time See Figure 22 Gap End Time		
D: Electrical Specifications for Devices	During the power interruption, mobile decoders under load must not sink more than 0.1 mA of current or source more than 0.1 mA of current unless transmitting a zero bit. All other devices connected to the track must not source or sink more than 0.1 mA of current during the power interruption. The cutout device must not develop more than 10 mV across its terminals at currents up to 34 mA.				

Figure 21 Gap Start Time

Figure 22 Gap End Time

RP-9.3.2	**Communications Standard for Digital Command Control, Basic Decoder Transmission All Scales.**
	This recommended practice is not applicable to Command or Power Stations