Complete Guide to Consisting

by Don Fiehmann

Editor Note: Don has gone where no one has gone before in explaining consisting in DCC. He also explains why he did it. Thanks Don for a great effort!

This information is the result of my desire to investigate the details of DCC consisting. The DCC system manuals were not always much help. I started to do some experimentation and found out that there are more ways to consist than I realized. The first part deals with the different methods used to consist. Then a look at the ways different consists can work together. Moving a consist from one system to another system can be problem, but there is a solution. The last part investigates just how to test decoders to see what parts of consisting they support. Finally there is a way to setup a consist that can be moved to any DCC system without reprogramming the decoders. Consisting or MUing is an area of DCC that is not well understood. This feature is very flexible and powerful and over the years has been improved. That is the plus side, but on the negative side setting up a consist can be confusing.

Not all manufacturers implement the NMRA DCC Recommended Practices in the same way. They all work together as they should, but there are little dissimilarities in the way decoders operate that can cause something not work the way you think it should. There are also differences in the way DCC systems "help" you to setup consists. This help can sometimes be limiting in what you can do with a consist. Reminds me of the old TV ad where the woman said "Mother, I'd rather do it myself".

Here is a list of normal methods of consisting and some of the little differences.

BASIC CONSISTING

Basic consisting is the simplest way of controlling more than one locomotive or decoder with a single DCC command. This could be two units that are semi-permanently run together as a single unit. An example is an F7A and B unit that each have there own decoders. It could be a sound and a motor decoder in the same locomotive. For Basic Consisting all decoders are programmed with the same address. This is simple to setup but, not very flexible.

Since the DCC system "thinks" it is sending signals to a single locomotive the only limit is the DCC system's addressing capability. When you set up this type of consist each of the decoders should be separately programed.

UNIVERSAL CONSISTING

Universal Consisting is some times called BRUTE FORCE or OLD way of consisting. With this method the Command Station does all the work. The Command Station is programmed to run the consist by telling it which locomotives are in the consist and the direction of each locomotive in the consist. When the operator gives a command to the consist the Command Station sends out a command for each locomotive in the consist. Four locomotives would mean four command packets sent out for each single command from the operator. This is OK for a small layout with a few consists, but could slow things down with a lot of large consists. Depending on how your DCC system handles the consist, sound and lights may only be controlled in the lead unit. If a sound decoder was in one of the trailing units you could not control the bell and whistle while it is in the consist unless you used the trailing unit's address.

Consists are made up and broken down with the cab or throttle. The Command Station is the only place that "knows" which locomotives are in the consist.

There are limits to the number of locomotives in this type consist. Check the system manual for the maximum number of locomotives in a consist and number of consists the system can handle.

ADVANCE CONSISTING

Advance Consisting is a newer method and has added more flexible. It can also be the most confusing. This method uses the decoder to do all the work and the Command Station only sends out a single command for each operation. The key to Advance Consisting is CV-19. A decoder knows it is in a consist when the value in CV-19 is greater than zero. Advance consists use an address range of 1 to 127 (decimal). Some system only use 1 to 99. This is the same address range as used by 2 digit addressing. This can also cause a conflict if you have a locomotive on layout using the same 2 digit address as used by a consist. The consist address is stored in bits 0 to 6 of CV-19. Bit 7 is used for direction control of the locomotive while in the consist. Bit 7 has a "weight" of 128. If a consist address is 10 then a locomotive facing backward would have a value of (128 +10 =) 138 in CV-19. This is the way the decoder knows which direction to run when it receives a consist speed and direction command. Most systems will automatically add 128 to the address in CV-19 when a locomotive is reversed when you setup an Advanced Consist. If a locomotive is removed from a consist without changing CV-19 to 0, it will not respond to speed commands using the locomotives normal address, but the lights and sounds will work.

ADDED ADVANCE CONSIST FEATURES

There are four optional CVs that can further enhance Advance Consist operation. The are CV-21 to CV-24.

While in an Advanced Consist a locomotive will not respond to function commands at the consist address. CV-21 and CV-22 can be used to over come this limitation. These two optional CVs allow control the functions separately in each locomotive in the consist. A example would be a sound decoder in a trailing unit(s) that you would like to control the horn and bell using the consist address. The light on the end unit needed to be controlled when the consist runs backwards. These functions can be selectively activated in the consist by setting bits in CV21 and 22. CV-21 controls functions F1 to F8. (Bit 0 for F1 through to Bit 7 for F8.) CV-22 controls the lights (FL) and F9 to F12. (Bit 0 for forward light, bit 1 for reverse light and bit 2 to bit 5 for F9 through F12.) The CV bits must be set in the individual unit(s) that you wish to have activate at the consist address. Since these are an optional CVs the manufacturer can elect not to have them in their decoders or have just a couple of the CVs in the decoder.

One other item that can be controlled is the acceleration and deceleration rates of each locomotive in a consist. CV-23 is used for acceleration adjustment and CV-24 for deceleration adjustment. Adjustments are made to the rates set in CV-3 and CV-4.The value in CV-23 and CV-24 can vary from plus127 to minus 127. When bit 7 is off (0) the value in bits 0 to 6 is plus and when on (1) the value is negative. A value of 1 or higher would be added and a value of 129 or higher would subtracted The value in CV-23 is added to the value of CV-3 and the value in CV-24 is added to CV-4. If the number is negative in CV-23 or 24, it will be subtracted.

CV-23 and CV-24 are in the list of optional CVs in the NMRA DCC Recommended Practices. There is no requirement that these two CVs are only active when a decoder is in a consist. Some Decoder only activate these CVs in a consist, some do not! I've also found that some decoders will add CV-23 and CV-24 to the values in CV-3 and CV- 4,but do not use the subtract function. Browsing through an older Lenz manual showed that CV-23 and CV-24 need to be activated by setting a bit on in CV-50. In general the manuals were not much help with these CVs. The only way I found to determine which way a decoder works is by testing the decoder. (More on testing later.)

One big problem is most DCC systems do not setup these CVs. To set them up you need to do it yourself. We'll get into how to do this later.

NESTING CONSISTING

No, this is not a place for birds on the layout. Nesting is using a combination of the different types of consisting for one consist. An example would be two sets of locomotives in an Advanced Consist you would like to run as one consist. In this case you would use the Universal Consisting to consist the two Advanced Consists. To break up the two Advance Consists you can simply delete the Universal Consist and the two Advance Consists will still be consisted. The DCC system sees the two Advance Consists as two 2 digit addresses. The DCC system must have the ability to setup a Universal Consist to set up this type of consist.

SYSTEM TO SYSTEM MOVES

Basic Consists can be moved from system to system with no problems. Since all of the decoders use the same address the command station only needs to send out one command for the consist.

Universal consists are controlled by the Command Station. The information about the decoder addresses in the consist is stored in the memory of the Command Station and when moved the next DCC system it has no information about the consist. In this case you need to reestablish the consist when changing systems.

Advance Consists can be moved from system to system because the consist address is retained by the decoders and stays with the decoder until changed. This means that you can move an Advance Consist to another system and use that systems 2 digit addressing to run the moved consist. A decoder will respond to either an Advance consist 2 digit address(CV-19) or just a 2 digit address(CV-1). All of the decoders that I checked have implemented CV-19 for Advance Consisting. Even with Advance Consisting there is a problem when moved. Most DCC systems keep track of which locomotive is the lead unit and allow functions only on the lead locomotive to be controlled with the consist address.(CV-21 and CV-22 can fix this.)

Nesting Consists are a combination of types of consists and the Universal part must be reestablished when a consist is moved.

SPEED CONTROL

Regardless of the type of consisting you are doing the locomotives should run about the same speed when on the same speed step. You can have a "standard" locomotive then adjust the other locomotive speeds to match. The simple way is to use CVs-2,5,6. A more accurate way is to use the alternate speed table (CV67-94 with CV-29 bit 4 on). Even identical locomotives may not run at the same speeds.

CV-2 sets the start voltage for speed step 1, CV-5 sets the top speed (speed step 28) and CV-6 is used for the mid range. CV-2 is a Recommended CV while CV-5 and 6 are only Optional. Looking through a number of decoder manuals CV-2 is the most commonly used of these three CVs. The next most common is CV-5 and the least number of decoders also use CV-6.The range of values used varies with manufacturers. If you are going to use the alternate speed table I suggest using a computer program like Decoder Pro (free over the Internet). This allows you to set the alternate speed table using the mouse on your PC or Mac computer.

Speed matching can be done on either a loop of track or two parallel tracks. Run the standard locomotive and the test locomotive as a consist but not coupled together. When adjusting CVs you need to use the normal address of the test locomotive, then change the system back to the consist address.

You should be sure that all of the locomotives in a consist are set for the same number of speed steps.

BACK-EMF

Back-EMF is a great feature for keeping a locomotive running smoothly. There have been other cases where putting Back-EMF in has cured erratic operation in consists.

Be aware that in a few cases Back-EMF has cause some erratic operation as it tries to adjust to the consist speed. If this is a problem the first solution is to turn the Back-EMF off in the decoder. A few decoders have an optional adjustable "EMF Feedback Cutout" (CV-10) that can be used to cut this feature off above a set speed.

WORKING WITH DCC CONSISTING

After doing all of this research on the theory of DCC consisting I decided check it out on the layout. My layout is setup with the toggle switches left over from the ancient d.c. days. This allows me to switch between two DCC systems. One system is an NCE Powerhouse Pro and the other is a Digitrax Zephyr all-in-one package. I found there is a lot of differences between the way systems handle consisting and how decoders respond to the systems. This motivated me to figure out how to setup a consists that could be moved between systems and still work as consists.

NCE system

When setting up a consist the NCE system asks if it is a NEW or OLD type

consist. The OLD is Universal Consisting with a maximum of four locomotives. The locomotive addresses are entered in sequence and you have control of the functions in the lead unit only. The NEW way is Advanced Consisting. NCE uses the lead locomotive's address as the consist in the display (Like CON:1234) You still need to enter a 2 digit address for the rest of the consist. This sets up CV-19 to the consist address and allows control of the functions on the lead unit only. When a locomotive is backwards in the consist you push the direction switch when adding the unit.

Zephyr System

The Zephyr manual allow setting up of Universal Consists. A consist is setup with the first unit as the "TOP" unit and then units are added to this. For a locomotive to be in the backward direction you need to run it in reverse just before you start setting up the consist. This sets up like other Digitrax systems. There is a limit of 10 locomotives addresses or slots that the Zephyr can control.

The Zephyr manual mentions Advance consisting but does not explain how to set one up.

Lenz

The Lenz manual lists two different types of consisting. Double heading for two locomotives and multiunit consisting that Lenz calls Smart Consisting. Double heading setup up like the Digitrax consisting and Smart Consisting is Advanced Consisting.

PORTABLE CONSISTING

Since each system has a variation on the way to setup a consist it would be nice to have a way to setup a consist so all the functions in each unit can be used and the consist moved between system without having to reprogram the system or decoders. There is a way! The only place I found information on setting up this type consist was in a SoundTraxx Decoder manual.

What is common with all systems is the ability to operate 2 digit addresses and operate functions. OPS mode (On-the-fly) programming is also available on most systems. With these two basic operations a consist can be setup that will work with any DCC system. With CV-21 and CV-22 the functions in selected units can be individually controlled using the consist address. I call this Portable Consisting.

In order for this type of consisting to work you need to determine if CV-19, CV21 to 24 operate. Most of the decoders today incorporate at least CV-19.

The decoder manual is a help in determining which CVs it supports. But it may not indicate just how the decoder will respond. Another problem is finding the manual and do you know which decoder is installed in the locomotive? Testing can be used determine the how a decoder handles these CVs.

DECODER TESTING

Here is the procedure I used to check out my decoders. Note: You need to switch back and forth between a consist address and the normal locomotive address during this test. Two cautions, when using the program track, be sure that only the locomotive you wish to change in on the program track. With OPS mode programming the values in these CVs can be changed using locomotives address and not the consist address.

Even though a CV can be written and readback, it did not mean that the CV would function as described in the DCC Recommended Practices. I found that CV-23 and 24 may work, but that did not mean they would only be active when CV-19 indicated the decoder was in a consist. In some decoders these were active in or out of a consist. The decoders that most closely follow the DCC RP were sound decoders. For these tests I use a consist number of '7' and a locomotive address of '1234'. Replace this locomotive address with the locomotive you are testing. This can all be done with OPS mode programming. (All values are shown in decimal.)

TESTING CV-21 to 24

1. Using the locomotive's address (1234) program CV-19 to 7. Program CV-21 to a value of 255 and CV-22 to a value of 63.
2. Change the DCC system to a consist address (7).(You can use a 2 digit address.)
3. Next check out the sound and light functions to see if they work while using the consist address. If the functions work these CV-21 and CV-22 are supported.
4. Using the locomotive's address (1234) change CV-19 to 0.
5. Using the locomotive's address (1234) change CV-3 and CV-4 to a value of 1. (Read in the values of these CVs before changing so they can be returned at the end of the test.)
6. Check out the acceleration and deceleration rates while using the locomotive's address.
7. Set CV-23 and CV-24 to a value of 15.
8. Check the acceleration and deceleration rates using the locomotive's address. It should be the same as in step 6. If the rates are slowed down it means that the rates are not deactivated when out of a consist.
9. Program CV-19 to the consist address (7).
10. Using the consist address (7) checkout the rates again. If the rates slowed down these CVs are working.
11. Return CV-3 and CV-4 to their original settings and CV-19 to 0.
12. Be sure to write down your results down for future reference.

PORTABLE CONSISTING SETUP

Portable consisting uses the 2 digit addressing to control speed and direction of a consist. There is no difference between a 2 digit consist command and a 2 digit address command. CV-21 and CV-22 are used to control functions in the consist. This type of consist can be setup by programming the decoder and not using any consisting "help" from your DCC system. OPS mode programming is all that is needed.

Once a Portable Consist is setup the DCC system sees the consist as a 2 digit decoder with functions. The decoder responds as an Advance consist to the commands. Since all of the programming is done in the decoders it can be moved to any DCC system.

The first step is to select the locomotives that will be in the Portable Consist and a 2 digit address for the consist. Program the consist address to CV-19 of to each decoder. Add 128 to the address for any locomotive that is in reverse in the consist. With a consist of address of 10 a unit facing backward would have value of (10+128=) 138 in CV-19.

Next determine what functions you would like to have active in the consist for each unit. This would include lights and sounds functions. A sample would be a light in the lead unit sound in the next unit and the lights in the last unit. See the chart near the end for function and CV information. This chart is based on the typical functions now in use and information gathered from the Internet.

Here are a few samples of CV settings:

CV-21
Bell(1) +Horn/whistle(2)+ Mute(128)= 131
Steam Release/Dynamic Brake(8)+ Mute(128)= 136
CV-22
Headlight (1)+ Backup Light (2) = 3
Both lights (3) + Function F10(8) = 11
Backup Light only (2) =2

Note! Check your decoder manual as these functions may vary from the chart at the end used to generate this list. You can determine the value to put into CV 21 or 22 by checking the list and add up the bit weight of each function needed. Then using OPS programming to put that value into the CVs of the selected locomotive. A decoder's function mapping can be used to change the which function key controls which decoder output line.

I had fun setting up a consists with lights and sound. Three had sound and I could set it up the bell in one, whistle in the next and all sounds in the last sound unit. I also had it so F8 would mute the sound in all three. The last unit DCC Consisting Page 6 of 6 had ditch lights that would operate when the horn was sounded in the first unit. With Portable Consisting I could operate with either of my two DCC systems and the operation was the same on either system.

EXPERIMENTING

The best way to see how this consisting works is to give it a try on the layout. This is even more fun with sound. I setup four locomotives with sound so the horns and whistles would all turn on with the single function key. What a cacophonic sound! I quickly changed it back to a single whistle for the consist.

I think a statement in Digitrax Decoder manual applies here-"Experiment and ENJOY!"

Key	CV Bit	Bit Weight	Typical Function	Soundtraxx Tsunami		Broadway Limited Imp	
				Steam	Diesel	Steam	Diesel
F0(f)	CV-22.0	1	Headlight	Headlight	Headlight	Headlight	Headlight
F0(r)	CV-22.1	2	Backup Light	Backup Light	Backup Light	Backup Light	Backup Light
F1	CV-21.0	1	Bell	Bell	Bell	Bell	Bell
F2	CV-21.1	2	Whistle/Horn	Whistle	Air-Horn	Whistle	Air-Horn
F3	CV-21.2	4		Short Whistle	Short Horn	Coupler Sound	Coupler Sound
F4	CV-21.3	8		Steam Release	Dynamic Brake	Steam Blower	Fans
F5	CV-21.4	16		FX5	FX5		Dynamic Brake
F6	CV-21.5	32		FX6	FX6	Doppler/Startup	Doppler/Startup
F7	CV-21.6	64		Dimmer	Dimmer	Brake Squeal	Brake Squeal
F8	CV-21.7	128	Sound Mute	Sound Mute	Sound Mute	Sound Mute	Sound Mute
F9	CV-22.2	4		Water Stop	RPM+	Cruise/Shutdown	Cruise/Shutdown
F10	CV-22.3	8		Dynamo	RPM-	Reserved	Reserved
F11	CV-22.4	16		Brake Squeal	Brake Squeal	Reserved	Reserved
F12	CV-22.5	32		Coupler	Coupler	Hazard/Cab Light	Hazard/Cab Light