Programming Your First DCC Decoder
(For NCE and Wangrow System One Users)
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Revision C 6/28/2007

Digital Command Control (DCC) decoder programming is what makes your DCC decoder installation unique to your locomotive. By this, I mean, once a decoder has been properly installed in a locomotive, the locomotive can operate on any DCC system right then and there, without any need make any changes to the decoder "programming". Each decoder comes preprogrammed with a default short address of 3 and directional front and rear headlights. However, in order to "personalize" your locomotive, e.g. use a long address that matches you locomotive number or enable special lighting affects, more work is necessary. The work comes in the form of programming the decoder, or basically changing manufacturer-provided configuration variables (CVs) to match your specific needs. Please note that not every decoder has every CV on each and every decoder, however, there are a series of base CVs that must be made available by the DCC decoder manufacturer in order to meet the NMRA guidelines to provide portability between the various DCC system vendors. Also note that this paper basically applies to NCE and Wangrow System One DCC system designs, which for the most part are almost identical but not exact copies of one another.

I'll start by pointing out a nice little protection feature on both systems, which can save you from letting the smoke out of the decoder. Both the NCE and Wangrow DCC systems have two different modes, a **Run** mode and a **Program** mode. In Program mode, also commonly referred to as Service Mode, the main layout power is disconnected and no trains can be operated. It is in this mode that you must have your decoder-equipped locomotive on the dedicated programming track to conduct any type of two-way communication with your locomotive. If the dedicated programming track can also be used as part of normal layout operations, then you must set a "Program/Run" selector switch to "Program". Program mode only permits a small amount of electrical "communication" current to the locomotive while it is on the program track, which will help in determining if you have serious problem with the wiring inside your locomotive. In other words, should you incorrectly install your decoder in your locomotive and place it on a section of track with the system in Run mode, you could toast the decoder and it's a trip back to decoder manufacturer's factory for repair. However, in program mode, even if the decoder wiring is not correct, the amount of "communication" or "programming" current flowing is not enough to damage the decoder. Therefore, you should **NEVER** place a new decoder installation on a live track until you have tried to communicate with the decoder on the programming track with the DCC system in program mode first.

Also note that you can program a decoder while the system is in Run mode, however, this only allows one-way communication with the decoder. This programming method is known as "Ops Mode" programming". You write to the selected CVs on a selected locomotive, however, you cannot read back what values are currently programmed in those CVs.

Before you begin programming, it is always a good practice to have the decoder manufacturer's instruction sheet sitting next to you while programming your decoder as it contains a list of all the available CVs and their respective default values and acceptable ranges. It also lists the function features for the various lighting schemes. If you lost the decoder paperwork, most decoder manufacturers have the decoder instructions available for download on their website. Now enough of this chit-chat, lets get on to actually programming the decoder!

Step 1. Continue pressing the <Prog> button in the lower left hand corner of the master cab to toggle through the various system menus. The different menus will be displayed in the master cab LCD screen as you press the <Prog> button. Stop when you get to the "USE PROGRAM TRK" menu, and then press the <Enter> button to put the system into *Program Mode* and begin the programming operation. **Note: The main track power will be OFF until you exit programming mode.**

Step 2. Once you enter programming mode, the system will immediately prompt you to enter the type of programming you wish to undertake. Options are: 1 = STD (Standard Programming), 2 = CV (Only program a selected CV) or 3 = REG (Register Mode Programming). Select <1> to begin the standard decoder programming operation.

Step 3. The system *(NCE ONLY)* will then prompt you to select which type of programming packets you wish to use. Options are: 1 = PAGED or 2 = DIRECT. These two modes refer to the method in which you want the Service Mode (Programming Mode) communication packets to be sent to the decoder. The most common communications mode is "Paged" mode. Some oddball decoder manufactures only support "Direct", but these decoders are rare, therefore, select <1>, for PAGED, and press the <Enter> button to go to the next step.

Step 4. The command station will then attempt to read the decoder manufacturer's ID (CV8), e.g. NCE manufacturer ID is 11.   You will see the word "MANUFACTURER:" appear on the master cab LCD display. The decoder manufacturer's ID is a two or three digit number that is unique to each DCC decoder manufacturer. It usually takes several seconds for the system to return a value. If the system detects some kind of fault, usually one of two messages will appear in the master cab screen, "Cannot Read CV" or "Short Detected". *Cannot read CV* can have several meanings; some are serious and some are not. **It usually means that there is an open circuit between the decoder and the DCC system or the decoder has been installed incorrectly.** An open circuit could be something as simple as the wheels on the loco are not making good contact because they are dirty or a wire has become disconnected inside the loco. A serious meaning could be that the decoder is defective and needs to be replaced. In either case, it is up to you to troubleshoot the reason why you cannot communicate with the decoder. The *Short Detected*

message is basically just that, a short circuit is present in the loco wiring. In either case, you should **stop immediately** and repair what is causing the warning message to appear. If you get a valid return value containing the manufacture's ID as specified in the supplied decoder instruction sheet, then chances are that your decoder installation is correct and that the decoder is not "brain-dead". Press <Enter> to go to the next step.

Step 5. The system will now try to read the revision number of the installed decoder (CV7). You will see the words "DECODER VER:" appear on the master cab LCD display. Since decoder model numbers generally stay the same from revision-to-revision, manufacturers change the revision number in the decoder's software to keep track of the hardware and firmware changes on each decoder model. The same errors messages can appear as in step 4, however, they are highly unlikely if a valid return value was received in the previous step. Press <Enter> if a valid return code has been received to go on to the next step.

Step 6. The DCC command station will now attempt to go out and read the decoder's short address (CV1). You will see the words "SHORT ADDR:" appear on the master cab LCD display. The short address is a legacy CV that is carried over from the early days off DCC when only 127 addresses were available. Decoder manufacturers always set the short address to 3 by default from the factory, so this is the value that you should expect to read back on the first attempt to program the loco. Once the system returns the current short address, you can now input a new value, or just leave the default value. If you decide to change the short address, enter the new short address in the range of 1 – 127 and press <Enter> for the new short address.

Step 7. The system will now attempt to read back the decoder's long address (CV17/18). You will see the words "LONG ADDR:" appear on the master cab LCD display. Please note that since the system is reading back two CV values instead of just one, as in the previous entries, it will take a little longer for the system to execute this task. Just wait for the system to respond with the default long address value for this system, which is usually always 0000. If you wish to program this decoder with a long address (generally the engine number), then enter the new long address now and press <Enter>. Please note that you do not need to enter a four-digit number, you may enter any number in the range of 1 – 9999 that you wish. However, if you enter a value less than 128, you must enter a leading zero when you call up that address to run the locomotive, e.g. <Select Loco> 054 <Enter> or <Select Loco> 09 <Enter>. Also note that **you must set the *long address bit* in CV29 in order for the decoder to start using the long address you just programmed into the decoder and not the default short address** *(see step17)*. Decoders come from the manufacturer preprogrammed to respond to the **short address by default**.

Step 8. The system will now read the acceleration value (CV3). You will see the word "ACCELERATION" appears on the master cab LCD display. The acceleration is just like momentum in analog days. The higher the value, the longer it will take for the loco to get up to speed. See the decoder data sheet for the default value and the acceptable CV3 range. Just press <Enter> to accept the default value (recommended) and move on to the next step or enter the new desired value and press <Enter>.

Step 9. The system will now read the deceleration value (CV4). You will see the word "DECELERATION" appears on the master cab LCD display. Deceleration is just like reverse momentum in analog days. The higher the value, the longer it will take for the loco to slow down to a given speed. See the decoder data sheet for the default value and the acceptable CV4 range. Just press <Enter> to accept the default value (recommended) and move on to the next step or enter the new desired value and press <Enter>.

Step 10. The system will now attempt to read the start voltage (CV2). The start voltage value basically shifts the entire **default speed curve** up or down. See the decoder data sheet for the default value and the acceptable CV2 range. If you want to have the loco start moving at a lower throttle setting, then you would enter a higher value for this CV. Just press <Enter> to accept the default value (recommended) and move on to the next step or input the new desired value and then press <Enter>.

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CV29 Explained

Before going on to the actual programming of CV29, let's go over the structure of CV29, since it has an entirely different meaning than all the other CVs we've encountered thus far. First, let's clarify that CV29 is same for all decoder manufacturers. It is part of the NMRA DCC decoder specification. Every CV is made up of a group of 8-bits. Think of a bit as a single-pole single-throw toggle switch, which has only two states. These states are either ON or OFF. In the case of all the previous CVs, we didn't really care about the individual bits since we are just programming up a single numeric value, such as a loco's address. However, in the case of CV29, each bit has a unique meaning. Here is a listing of the bit meanings:

- Bit 0   ON   [1] = Direction of operation is reversed
             OFF [0] = Direction of operation is normal
- Bit 1   ON   [1] = 28 Speed Step Mode (should always be enabled)
- Bit 2   ON   [1] = Analog mode operation enabled
             OFF [0] = Analog mode disabled
- Bit 4   ON   [1] = Alternate Speed Curve Active
             OFF [0] = Use table defined by CV 2, 5 and 6
- Bit 5   ON   [1] = Use long address in CV17/18
             OFF [0] = Use short address defined in CV1
- Bits 3, 6 and 7 are ignored by the DCC system firmware.

Now to transfer the state of all of the individual bits as a single numeric value is where the confusing part comes into play. What is required is a little binary mathematics to calculate the final numeric value but even that is pretty easy once you know how to do it. First, start by reading a bit string from **right to left**. As you move to each successive bit to the left, you will notice that the bit value doubles from the previous bit value.

Here's a table that defines each bit value:

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Bit Value	128	64	32	16	8	4	2	1

Now to figure out the numeric equivalent for bits that are ON, just add **ONLY** the respective values for the bits that are enabled [ON]. For example, if you wish to enable bits 1, 2 and 5, e.g. enable 28 speed step mode, analog operation and use long address, then to get the equivalent decimal value you would add 0 + 0 + 32 + 0 + 0 + 4 + 2 + 0 = 38. As you can see when the bits are OFF, just place a zero in the formula for that bit. Therefore, in this example, CV29 would have a value of 38 programmed into it. Now the folks at NCE and System One made it easy for us by making each bit that we need to worry about in CV29 a Yes [<1>] or No [<Enter>] question, and so we just answer the questions in the SET CFG section and they take care of doing the binary math for us in the DCC system firmware.

Step 11. The system will now ask if you want to set the configuration CV (CV29). You will see the words "SET CFG?" appears on the master cab LCD display. Press <Enter> to skip configuration process or press <1> to enter the configuration menu. **It is recommended that you always enter the configuration menu, since this is the path you must take to enable the long address bit.** If you chose to skip the set configuration CV, then jump to Step 19.

Step 12. Once you enter the configuration CV menu, you will be asked to if you want to set the direction bit. You will see the words "DIR BIT?" appears on the master cab LCD display. The direction bit is a software method of changing the forward and reverse directions of the locomotive without modifying the wiring to the loco's motor. If you opt to enable the direction bit, be aware that the directional headlights do not follow along with this bit change. Therefore, it is always better to just swap the two wires connected to the motor if the locomotive's forward direction does not match the display on the throttle. On the first go around of programming, you will not know if the direction is correct or not until you actually run the locomotive, so it is recommended to accept the default <Enter> and go on to the next step. **NOTE: Due to a bug in the current NCE/SYS1 command station firmware, THIS FEATURE DOES NOT WORK AT THIS POINT IN THE PROGRAMMING SEQUENCE. However, you can enable this bit manually by calculating the numeric value for CV29 longhand (see *CV29 Explained on page 5*) and then write the calculated value to CV29 directly (See Step 19).**

Step 13. The system will then ask you if you want to choose the speed step. You will see the words "SPD STEP?" appears on the master cab LCD display. This is a legacy carryover from the olden days when some DCC systems only supported 14-step speed control throttles (very course and choppy speed granularity) therefore, locomotives equipped DCC decoders could only operate on these legacy systems if their decoders were set to 14-step speed control. Every system available on the market today supports 28-step speed control, so always accept the default <Enter> and go on to the next step.

Step 14. The system will then ask you if you want to enable DC Mode. You will see the words "DC MODE?" appears on the master cab LCD display. Enabling DC mode will allow you to operate your decoder equipped loco on an analog power pack, however, be aware that the loco will not operate on DC system exactly as it did in the past. It may not even operate at all depending on the type of DC throttle that you are using, since some DC throttles have pulses embedded in the DC output. These pulses can end up looking like a choppy DCC signal and cause the loco to practically do back flips on you. Enabling DC mode has also been attributed to "runaways" on DCC layouts when short circuits occur elsewhere on the railroad. If at all possible, it is best to leave

this "feature" disabled; therefore it is recommended you select the default <Enter> and go on to the next step.

Step 15. The system *(NCE ONLY)* will then ask you if you want to enable the Advanced Acknowledge bit. You will see the words "ADV ACK?" appears on the master cab LCD display. Advanced Acknowledgement refers to a feature that is not yet available in most decoders and command stations. As a matter fact, the NMRA standards for Advanced Acknowledgement are still undergoing refinement. Basically, Advance Acknowledgement has to do with receiving feedback from the decoder when transmitting "Ops Mode" (Run Mode) programming packets. **Since this feature is more-or-less still vaporware, select <Enter> = NO and go on to the next step.**

Step 16. The system will then ask you if you want to choose the alternate speed table. You will see the word "SPEEDTBL?" appears on the master cab LCD display. Enabling the speed table bit tells the decoder you want to use a custom 28-step speed table that contains 28 custom speed table entries that **you** program one-at-a-time into the decoder. This is a very time consuming task, and for the most part, the default speed curve entered into the decoder by the decoder manufacturer are pretty smooth right out of the box. Therefore, it is recommended that you select the default speed table by just pressing <Enter> and go on to the next step. **Note: If you enable this alternate speed curve bit, the Start Voltage value programmed in CV2 (See step 10) will no longer have any affect on the operation of the loco, since the custom speed curve is now in total command.**

Step 17. The system will then ask you if you want to enable the short or long address. You will see the word "ADDRESS?" appears on the master cab LCD display. Enabling the long address bit is necessary if you wish for the loco to respond to a long address. **Even if you entered a long address back in Step 7, the loco will still only respond to the short address (CV1) unless you enable this bit.** Press <1> to tell the decoder to respond to the long address or just press <Enter> to resume using the short address programmed in CV1.

Step 18. The system will then ask you if you want to enter a custom 28-step speed curve. You will see the words "SPD TBL?" appears on the master cab LCD display. It is recommended that you select NO or <Enter> at this time and go onto the next step, since this is long arduous task and really designed for advanced DCC users who want to "tweak" the decoders speed curve. If you do wish to input a custom 28-step table and you want to use it, then remember to enable alternate speed table bit (Bit-4) in CV29 as outlined in Step 16.

Step 19. At this point, the system has completed configuring CV29 and will then just ask a generic question to program any individual CV you wish. You will see the words "PROG CV NUM:" appear on the master cab LCD display. You will use this step later to program your advanced function features, e.g. lighting, however, it is recommended that you just push the <Enter> key at this time to exit out of Program mode so you can test run the loco to see that it operates properly with the new decoder installed. Once you press the <Enter> button, the system will switch from Program mode back to Run mode and you can once again run trains on the layout. At this time, remove the loco from the programming track, and place it on a live running track. After you completed test running the locomotive, you can re-enter program mode and select option #2 in Step 2 to jump straight to the programming of individual CVs section for setting up advanced lighting and sound features if the decoder is equipped with them.

Step 20. The Master Cab should now have the typical system startup text in the LCD display. Push the <Select Loco> button, then enter your loco's correct address, be it the long or short address you programmed the loco to respond to, then press <Enter>. Advance the throttle to see if the loco responds as expected. Now is also a good time to check to see if the loco's forward and reverse directions are the same as those selected on your handheld throttle.

From here on out, you are on your own simply because there are just way too many variables from one decoder model to another regarding lighting and sound options now available in the DCC marketplace to even attempt to cover them in any single document. Besides, the decoder instruction sheets, which accompany the decoder, are generally quite thorough when it comes to information on setting up lighting and sound features available with the decoder.

Congratulations, you just programmed your first DCC decoder!

Disclaimer: No animals were hurt during the creation of this document, however, the kelpie next door is living on borrowed time.