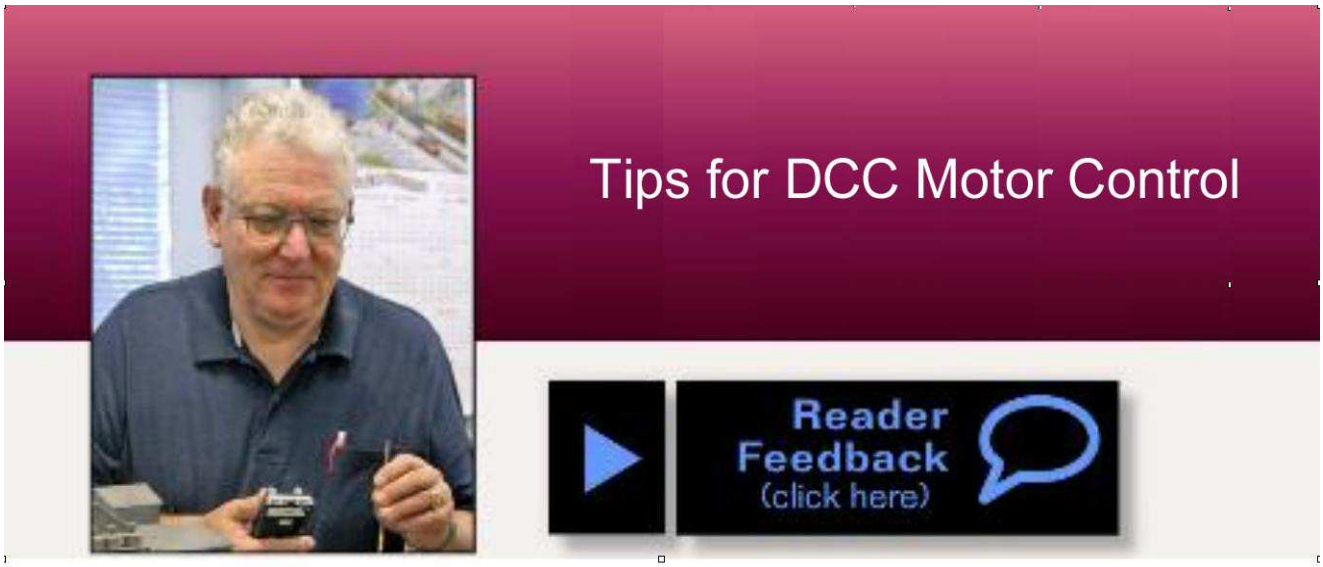


DCC Impulses Column

by Bruce Petrarca
photos and illustrations by the author

How to tame you locomotive

A reader requested a column on how to optimize motor control, so here comes a pretty technical column without a lot of pretty pictures. This subject is scale independent. I've used these techniques in all major scales from Z (1:220) to Fn3 (1:20.3), including N, HO, S, O and G. I'm going to share some concepts and include some comments about specific decoders. Remember to read the literature that came with your decoder and what the manufacturer has online before you try these adjustments. What specific CVs do may vary between manufacturers. That's why I only mention NMRA standard CVs (ones that are common between all manufacturers) in this column.

My goal with DCC is to provide immediate and precise control of my locomotive. When I crack the throttle, I expect the loco to start to crawl. Opening the throttle wider, I expect a smooth transition to running speed. I don't want slot-car style top speeds. If the decoder includes sound, I expect realistic sound response, too. See the video of my garden loco after being set up (http://www.youtube.com/watch?v=cWfZLyCuy_k).

Frequently, prototypes have a top speed in the 25 to 40 MPH range, by capability or by rule, so I try to match it in scale. Examples include:

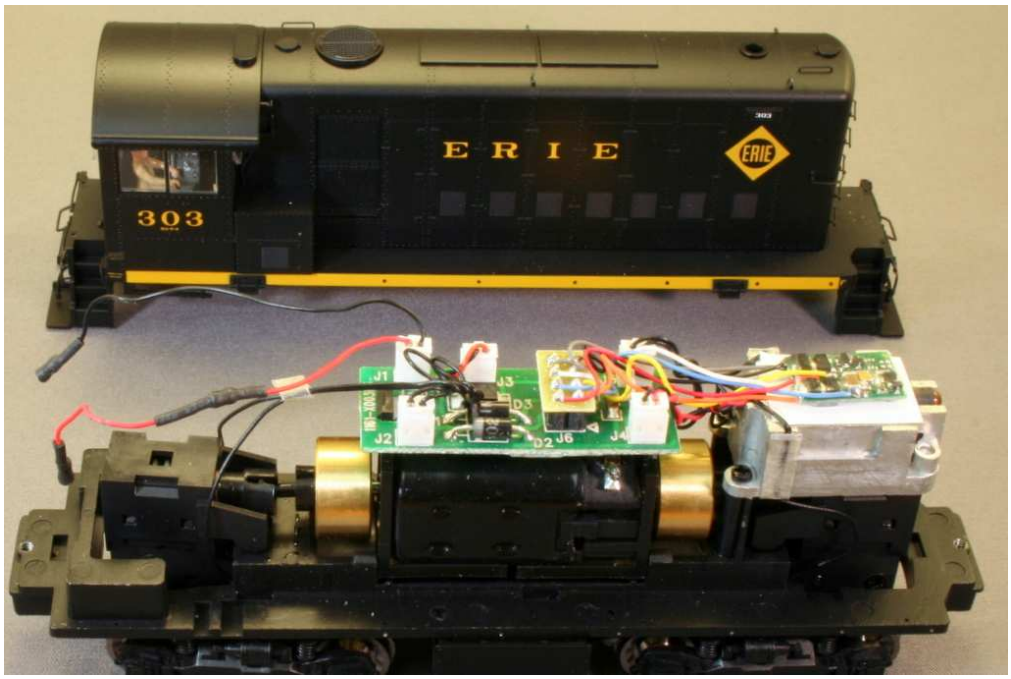
- Branch lines, like my HO Santa Maria Valley (mrhmag.com/url/layouts-smvrr)
- Narrow gauge, like my Fn3 Rocky Mountain Pacific (mrhmag.com/url/layouts-rep)
- Yard switchers - be they older switchers or road switchers

For now, let's just look at what we can do with our decoders to provide realistic motor control. The sound effects can come along later, once we have the motor response we want.

GETTING YOUR LOCO STARTED

Isaac Newton described inertia (a body at rest tends to stay at rest, etc.). Well, model locomotives have that in spades. Not only do they have intrinsic mechanical inertia, but also we intentionally add inertia, in the form of flywheels, when we can.

In addition, when surfaces, even metal, sit in contact for a period of time, they develop **stiction**. This is a word derived from **sticking** and **friction** to describe the physical mechanism behind the need to give things a shove to get them moving.



1: Locomotive drive line with flywheels (HO Atlas HH660)

Even a small switcher, such as the HO-scale HH660 shown in figure 1 has two flywheels and lots of bearing surfaces. While Nano-Oil (mrhmag.com/url/nano-oil) may help, there may still be starting stiction issues.

To get your loco rolling, you need to overcome both the inertia of the drive system and the stiction.

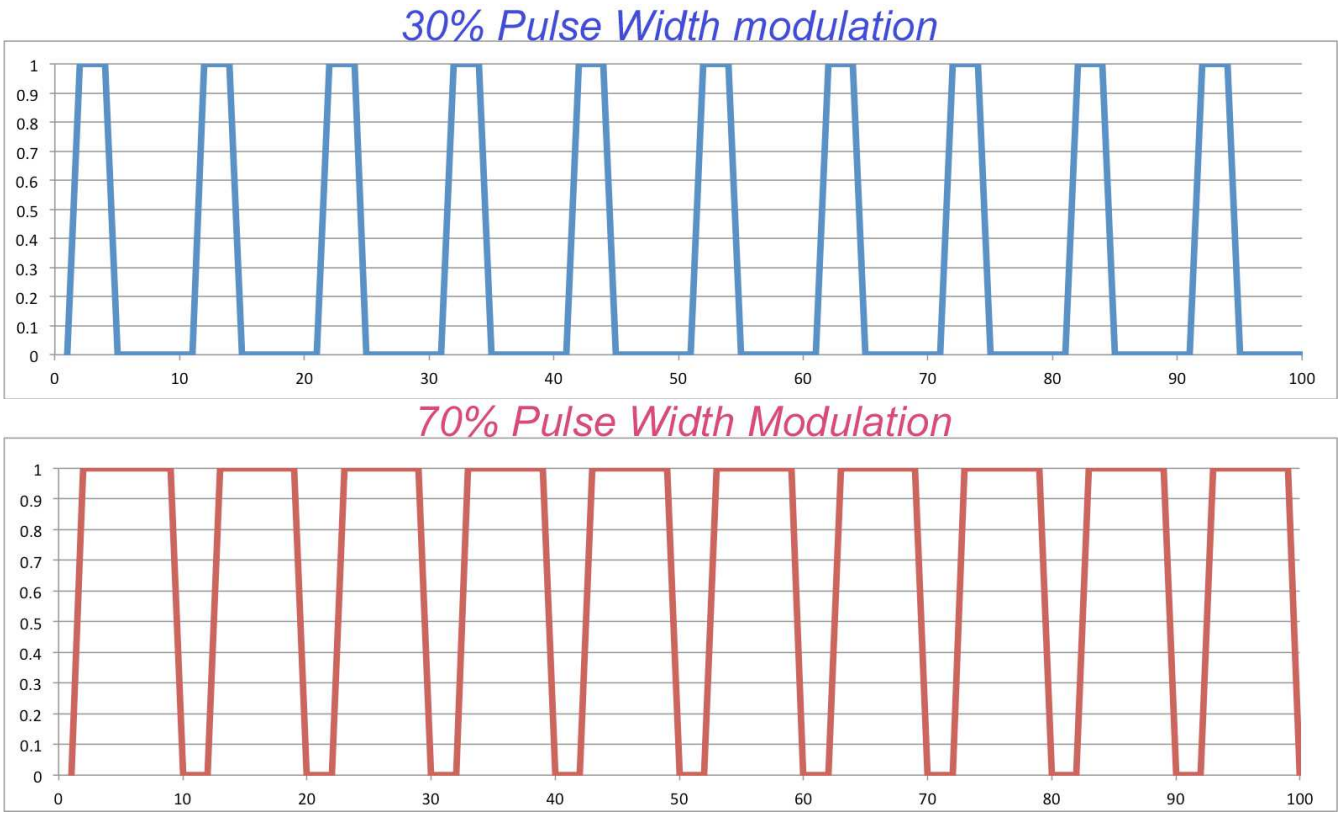
SOME BACKGROUND

Since this discussion revolves around a lot of electronic terminology, you may wish to review my column on basic electronics in the December 2012 issue (mrhmag.com/dec-2012-dcc-impulses) before you press on with this column.

In the DC (analog) days, fancy power packs had a pulse mode that was an attempt to provide that shove to get the loco moving. At low speeds some pulses of voltage were added to the low-level DC, in an attempt to overcome inertia and stiction.

In some of the power packs, pulse mode was used throughout the speed range, as folks found they had smoother operation that way. Pulse mode used throughout the entire speed range is actually pulse width modulation (PWM).

PWM is where full voltage is always applied. The voltage to the motor is turned on and off in repetitive pulses. The longer the pulses, the faster the motor runs. If you want the motor to run at half speed, the full voltage is applied for about half the time and zero voltage the rest of the time. Thus, you control the motor speed, not by changing the applied voltage, but by varying the time that it is applied (that is, the Width of the Pulses).



2: PWM – full voltage, variable time driving a motor at 30% and 70%

When DCC was created, PWM was selected for many reasons as the motor control method. Also, part of the basic DCC design was the ability to adjust the amount of power provided to the motor at the starting speed step (CV 2), at the middle (CV 6) and at the top (CV 5).

Some decoder manufacturers opted to include a feature to overcome the stiction and inertia by providing additional power at low throttle settings for a bit of time. They

frequently called it **kick-start**. It gave much of the same effect as the early pulse power packs and is adjustable, in some brands.

As DCC became popular and more and more locos began running with decoders, folks began to notice that the locomotive would hum at the frequency of the pulses, usually in the octave below middle C, for the musicians in the crowd. Decoder manufacturers responded with **high frequency drive** (mrhmag.com/url/dcc-hi-freq-drive) where the pulses were so rapid that any "singing" of the motor was beyond human hearing, some as high as 30 kHz. Each manufacturer has its own marketing moniker for this design.

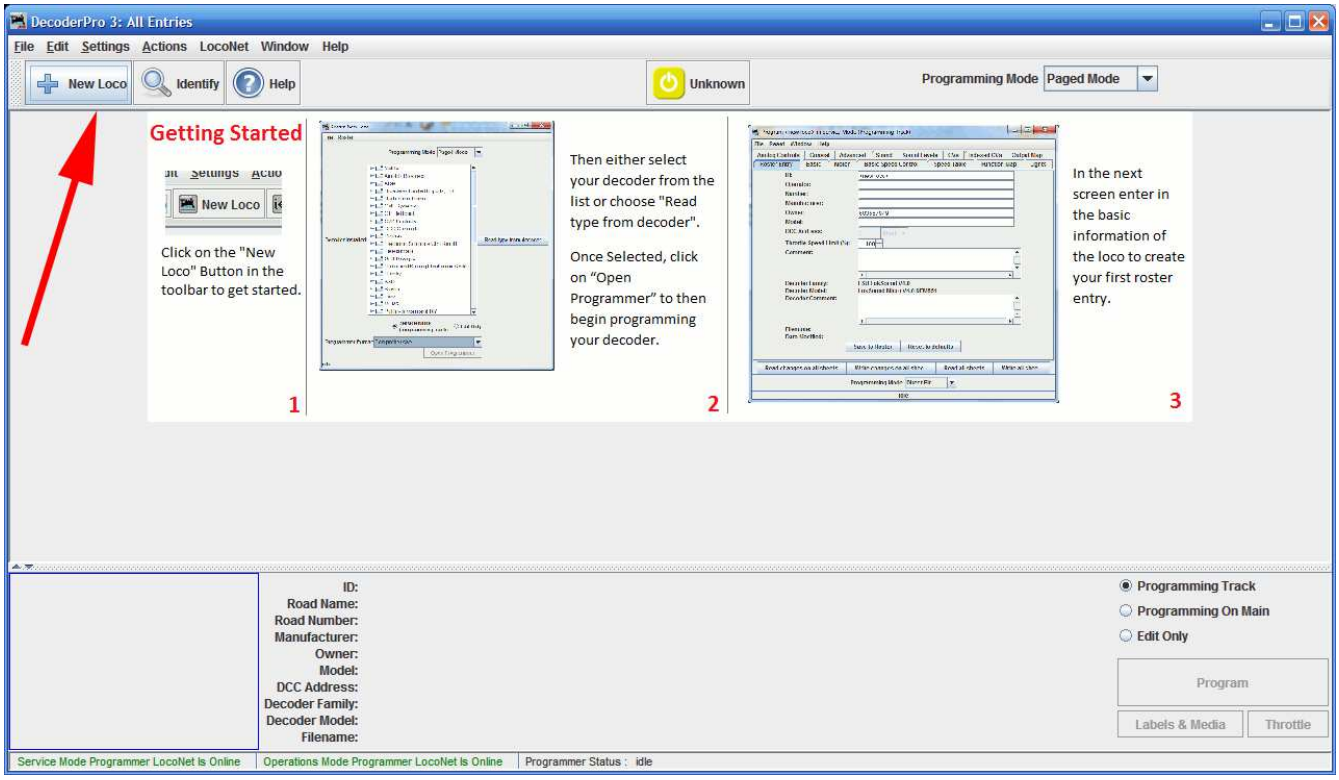
With high frequency drive, came another issue. When a motor is driven at a high frequency, it looses torque at low speeds, making the start-up issue worse. Again technology came to the rescue, when decoder manufacturers added pulses or shifted the frequency of the pulses as the motor started. Train Control Systems (TCS) was one of the pioneers of this technique, which they called **dither**. Digitrax calls it **torque compensation**.

Another technique was developing a following. Using the Back EMF (reverse voltage) developed by the motor, a **BEMF** style decoder (mrhmag.com/url/dcc-back-emf) is able to sense the motor speed during the time that the decoder is not driving power through the motor. Being able to sense motor speed allows the decoder to track trends, such as slowing down, and correct for them. Modern sound decoders, in addition to motor control, use this BEMF data to adjust sounds for load, chuff rate, etc.

Getting started with DecoderPro

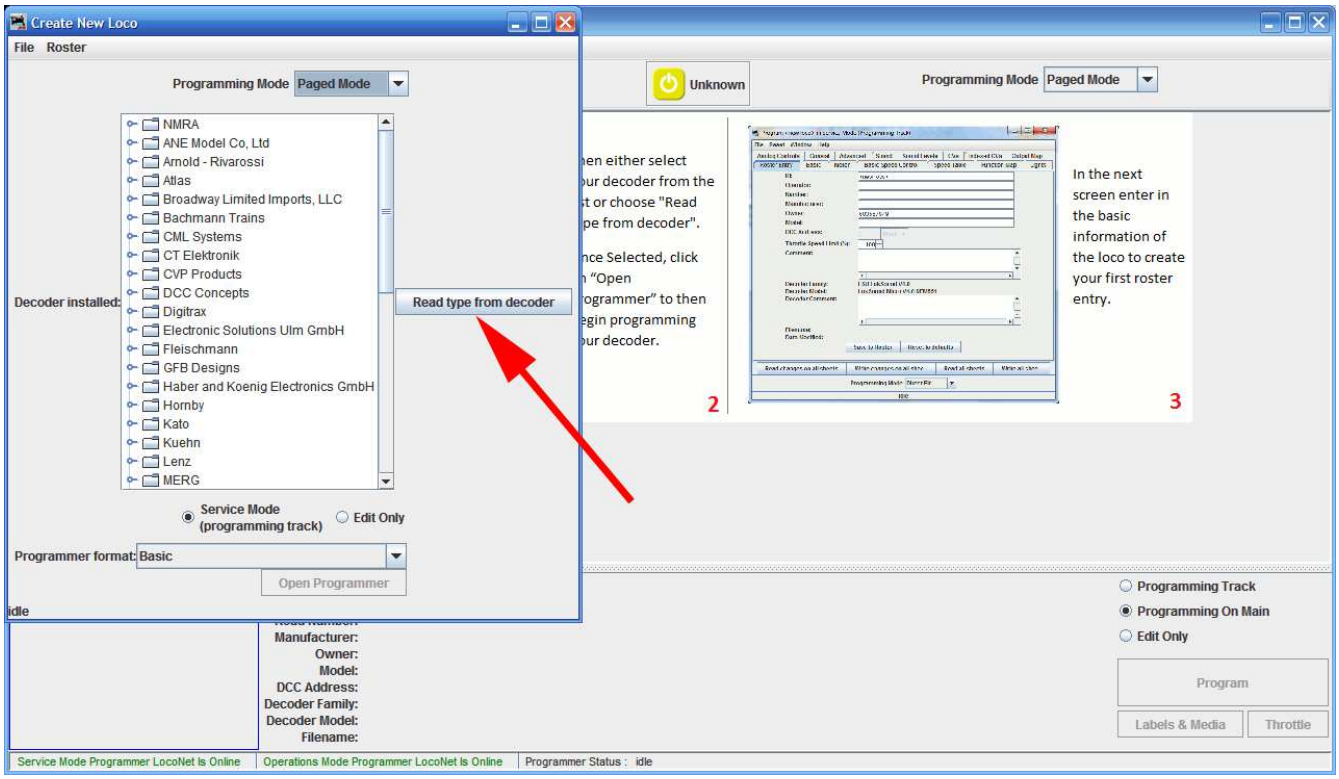
I highly recommend DecoderPro (see my July 2012 column – NEED MRH URL) for this tweaking. Every time I mention DecoderPro, or some other aspect of JMRI, I try to remind folks to donate to the cause. Even a $10 bill a year from all the users would make a huge difference. Do so now, while you are thinking of it. Just click on the link: (http://www.decoderpro.com/donations.shtml).

Assuming you have done nothing with DecoderPro before, you start by putting the loco on the programming track. Open DecoderPro. Select NEW LOCO, see figure 3.



3: DecoderPro screen: Starting a new loco with the NEW LOCO button

Then READ TYPE FROM DECODER, see figure 4.

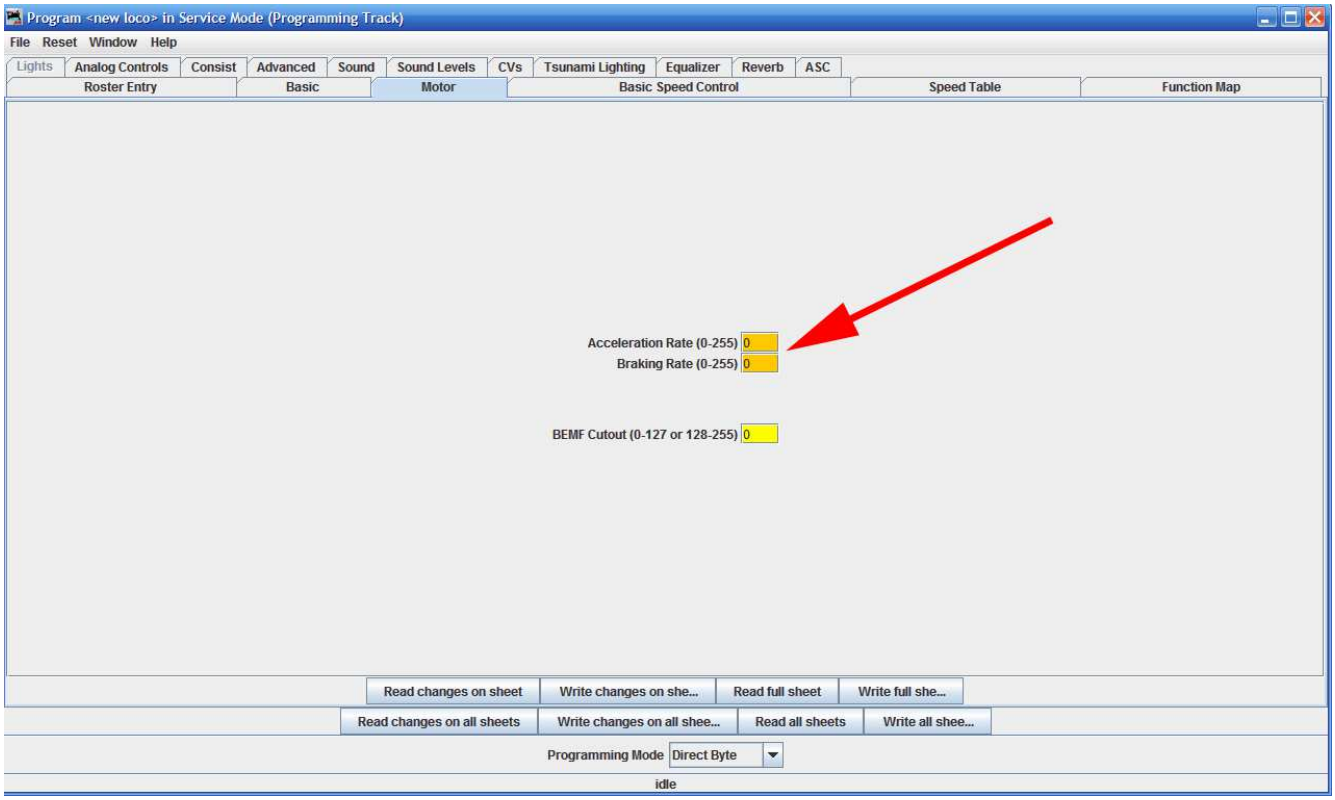


4: DecoderPro screen: READ TYPE FROM DECODER

Once you have the decoder selected correctly, make sure COMPREHENSIVE display mode is selected and open the file in the PROGRAMMING TRACK mode.

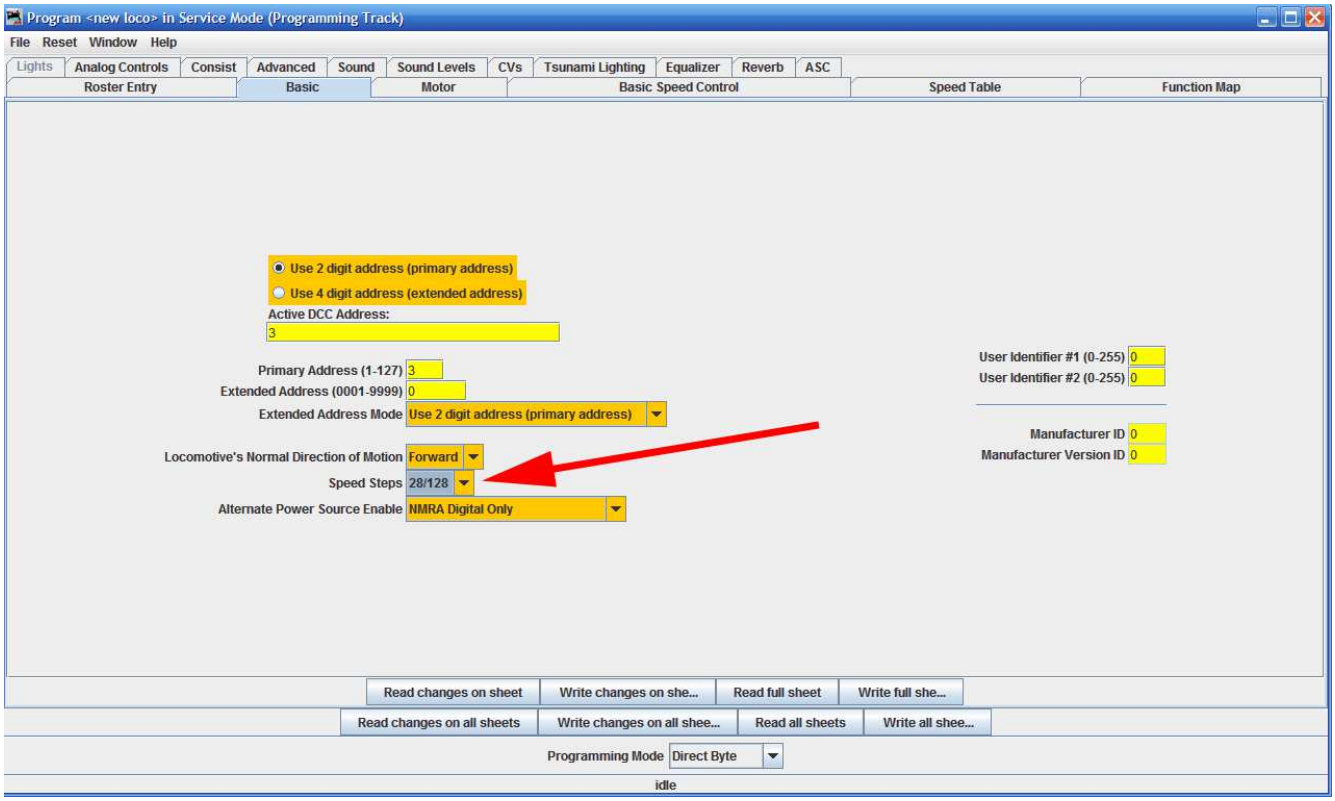
If you don't have your address set to your satisfaction, do so in the BASIC tab.

Before you can adjust any of the speeds, you need to assure that there is no momentum setting in the decoder messing up the results. The easiest way to do this is to set momentum (CVs 3 and 4, for those of you not using DecoderPro) to zero, see figure 5.



5: DecoderPro screen: Mometum (CV 3 and CV4) set to zero in MOTOR tab

Set the decoder to 28/128 speed steps, see figure 6.



6: DecoderPro screen: Select 28 or 28/128 speed steps in BASIC tab

WRITE ALL CHANGES to the decoder and SAVE the file you have created onto your computer.

SET START SPEED FIRST

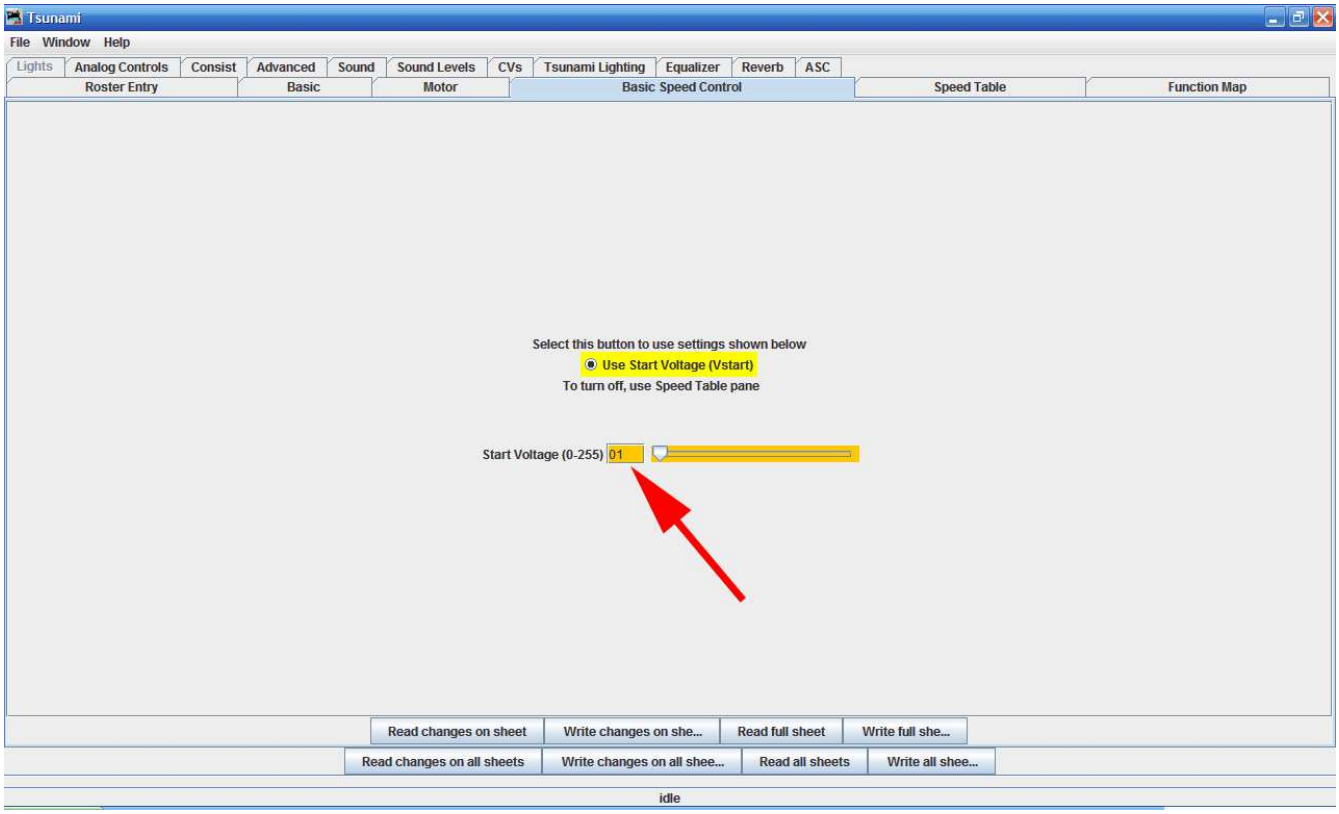
The old saying is, "You gotta walk before you can run." Well, you loco's gotta creep first, too. Most decoders use pretty much the same set up process. I'll note some specific differences along the way.

Open the DecoderPro file for your loco on the computer in the PROGRAMMING ON MAIN mode then you can run the loco with a throttle and customize the loco with the computer. For best results, use throttle capable of exactly reading speed steps, like a DT4xx series from Digitrax or the Pro series from NCE or a LH100 from Lenz.

CV 2 is called Start Voltage in the NMRA standards. The sharp-eyed folks in the crowd will have already noticed that this is a misnomer. The motor voltage is constant; the power applied to the motor to control the speed is varied by changing the length of time that the voltage is applied to the motor as in figure 2. So, CV 2 really should be called Start Speed or Start Power.

The quickest way to set up a crawl is to set your system to 128 speed steps (totally compatible with the decoder being set to 28 speed steps - see ***Mr. DCC's Workbench*** at the end of this column) and adjust CV 2 (7) until the loco just starts to move at speed step

one on the throttle. Because of stiction, the best way to accomplish this is to set CV 2 to 0 and then run your throttle up until the loco runs and back down to speed step 1. If it continues to run at your desired minimum speed, all is well. If not, add one to the value in CV 2 and try it again. If you overshoot, subtract one from the value in CV 2 and try again.



7: DecoderPro screen: Setting start voltage in BASIC SPEED CONTROL tab Note: this is a Tsunami file which doesn't support mid or top voltage (CVs 5 or 6)

Note: if you are planning on using speed tables, make sure CV 2 is zero and adjust CV 67 instead. See figure 9.

Now check for stiction. Set your throttle to zero. Move it to speed step 1, without overshooting. Does the loco move? In my experience, BEMF decoders will overcome stiction given time to sense that the loco isn't moving. Non-BEMF decoders and excessively sticky locos may need kick-start or dither adjustments here. See the manual for your specific decoder. Also, see figure 10.

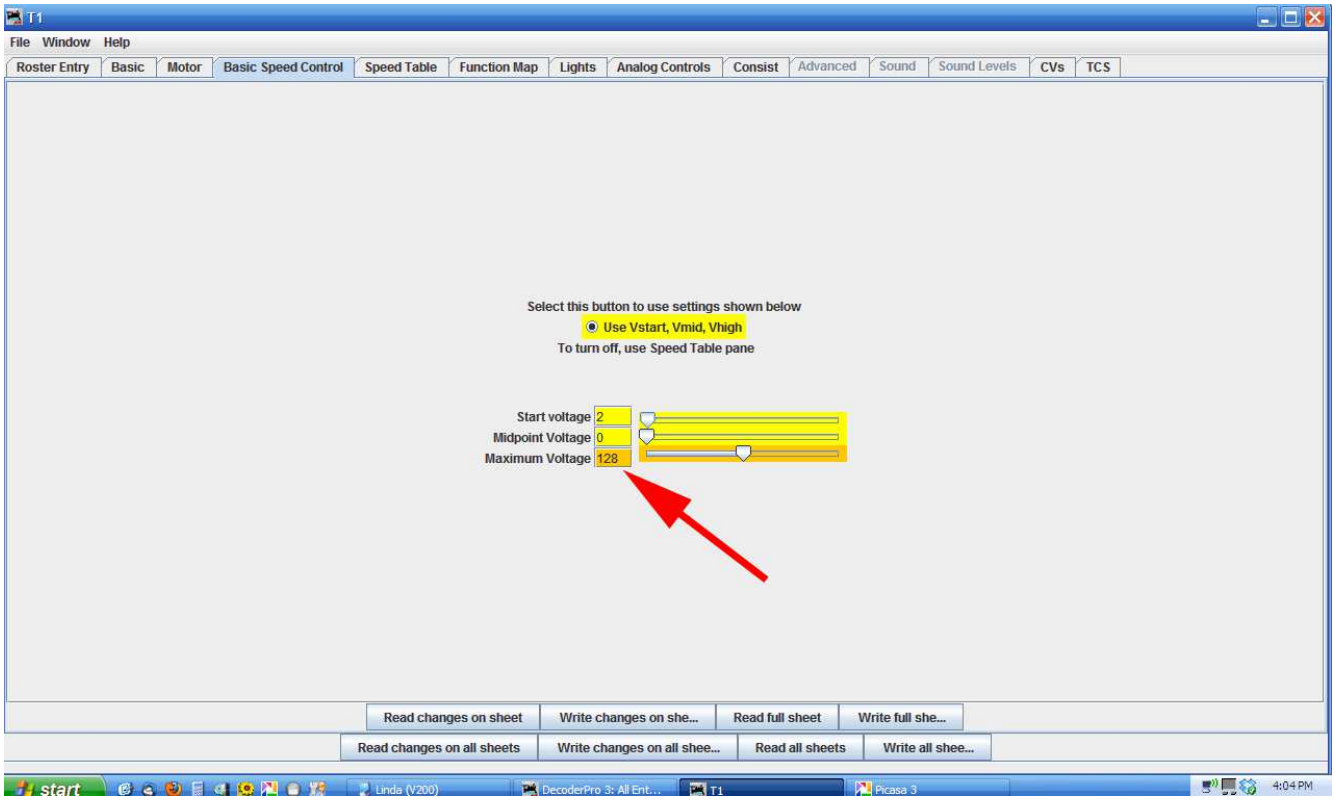
Tsunami users note: If BEMF is going to be used in your Tsunami decoder, CV 2 should ALWAYS BE ZERO. Frequently, locos will run too fast with a Tsunami on speed step one. The Tsunami BEMF is doing too good a job overcoming stiction in these cases. There is a way to fix this, but it is beyond this column. Check it out on my web site in the

middle of the Tsunami page (mrhmag.com/url/dcc-soundtraxx-tsunami) for instructions and a video.

QSI users note: sometimes the loco will continue to run after you bring the throttle to zero, especially with the Q2 series decoders. There is a fix for that available on my web site. (http://mrhmag.com/url/qsi). With the Q3 software, a lot of issues have been fixed and the tendency to run-on is reduced.

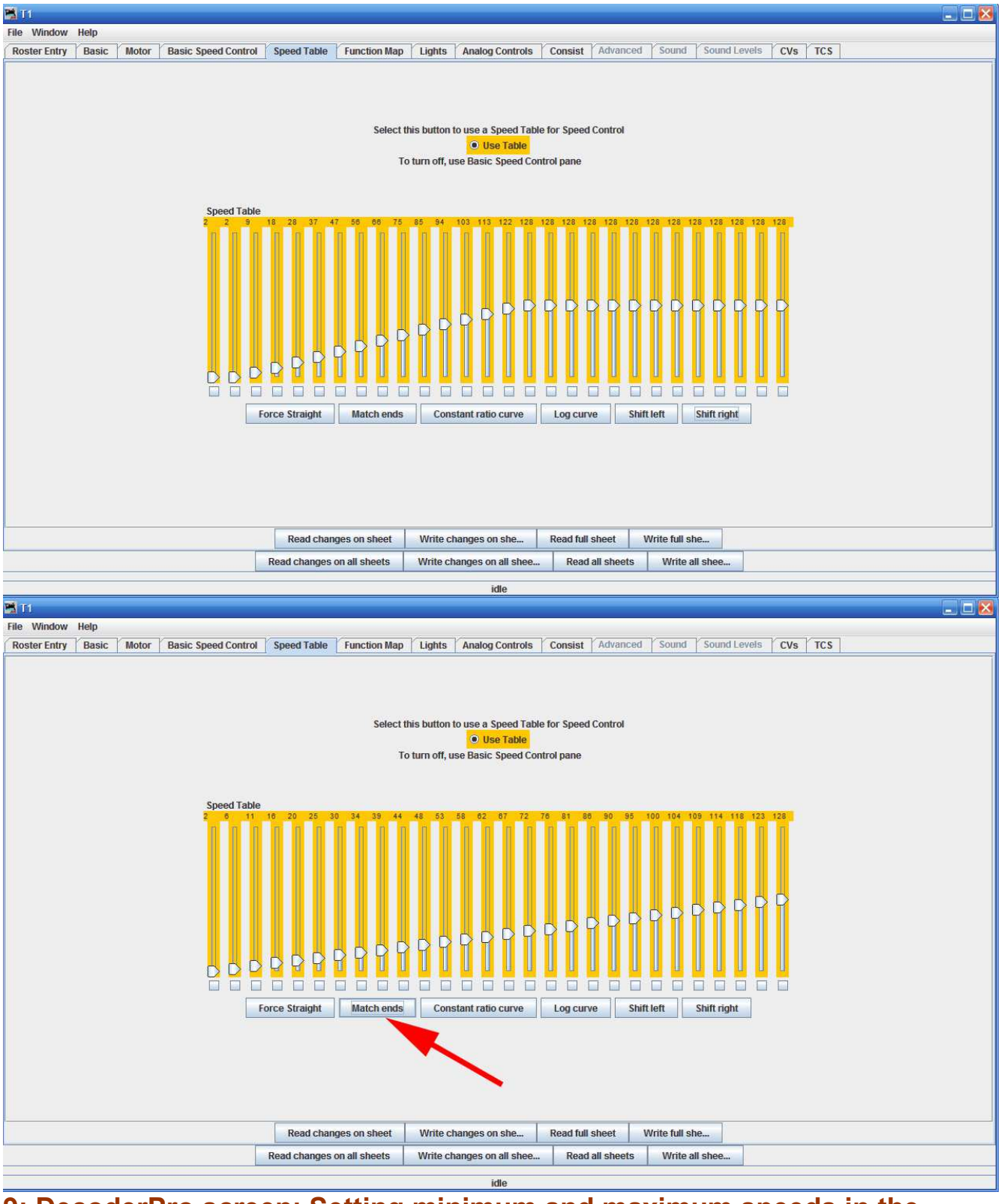
LIMIT TOP SPEED

Many folks stop at this point when adjusting their decoders. I press on and limit the top speed.



8: DecoderPro screen: Setting maximum voltage in BASIC SPEED CONTROL tab with a decoder that supports CVs 5 and 6

Sixty MPH is 88 feet per second, or roughly the length of a road switcher per second. So, if your loco moves past a fixed point in one second, it is doing about 60 SMPH. If it takes two seconds, it is going 30 SMPH. All but the largest layouts with long mainline runs would benefit from speed limiting in the 30 to 40 MPH range, in my opinion. This means that the loco will take about 1-1/2 to 2 seconds to pass a fixed point with the throttle wide open.



9: DecoderPro screen: Setting minimum and maximum speeds in the SPEED TABLE tab instead of the BASIC SPEED CONTROL tab – before and after using the MATCH ENDS button

The side benefit of limiting top speed is that the entire throttle range controls the loco from creeping to maximum. It is so much easier to switch or make realistic movements with the full throttle range available, not just a quarter of it. So, let's set the top speed.

In decoders that support CV 5 (another misnomer: Maximum Voltage), the easiest way is to set CV 5 to 128, see figure 8. Then run the loco wide open and time past a fixed point. If it takes less than 1 second to pass a point, reduce CV 5. If it takes longer than 1-1/2 seconds, increase CV 5. Quickly you have a loco tamed down.

If you are using a speed table, set CV 94 in the same way as I described for CV 5, above. Here's where DecoderPro does you a favor. It has a button you can press to MATCH ENDS. That will make a linear speed table between the crawl speed you set in CV 67 and the top speed you set in CV 94. See figure 9.

Note that Tsunamis don't support CV 5. You need to do some sort of speed table work with them. Learn more about this on my web site (mrhmag.com/url/dcc-soundtraxx-tsunami).

SET MOMENTUM

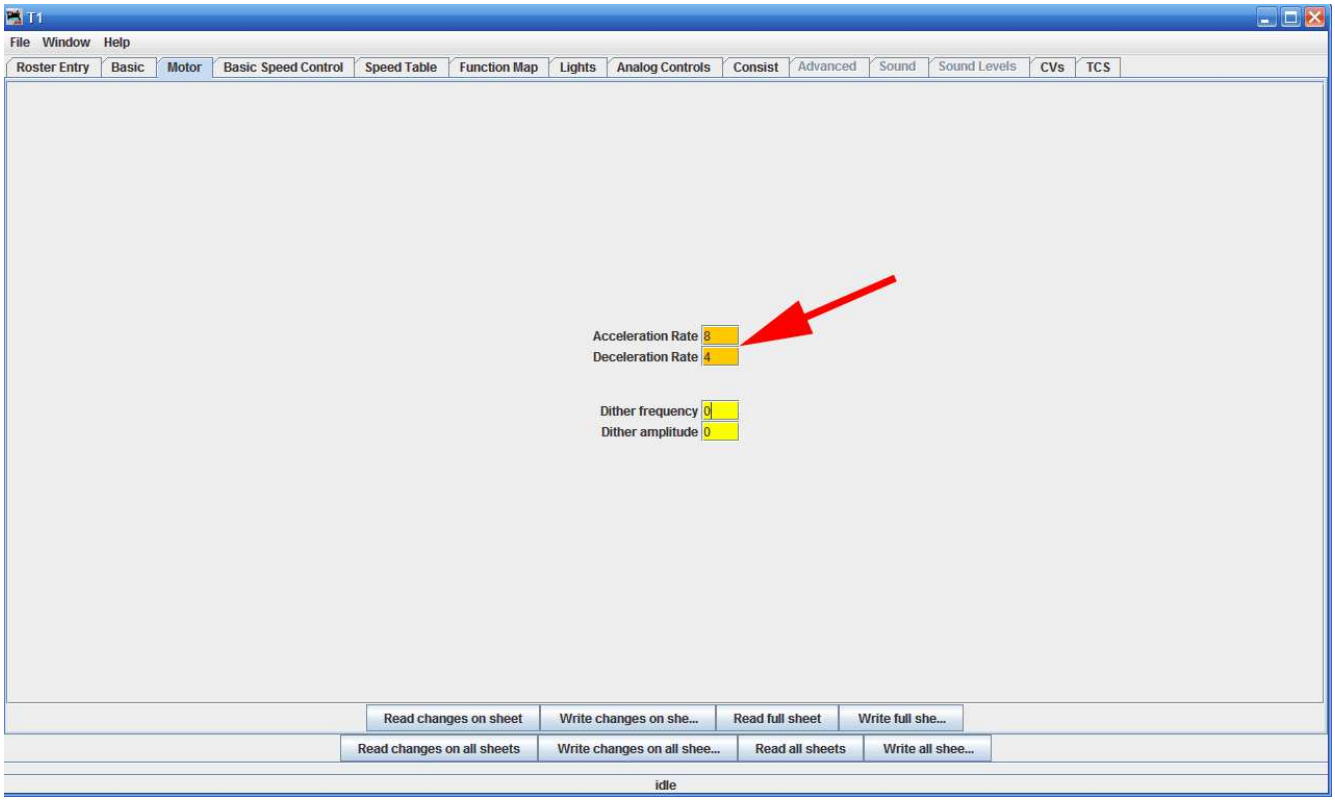
Wanna get a real brouha going? Get a group of DCC operators together and ask, “How much momentum is enough?” You will probably start an argument that ranges from “ANY!” to “Such that it takes 30+ seconds for the loco to come up to speed.” We all have our different ways of operating and momentum setting plays into the crux of that.

Why have any momentum at all? Well, with DCC it is really easy to just hit the DIRECTION button when you want to change direction. Even easier with throttles like the Digitrax UT4, where direction control is a toggle switch! Absent some decoder momentum, you will stress your decoder with the track voltage being applied by the decoder being added to the BEMF being generated by the motion of the train. This can, when you are running high track voltages and high train speeds, cause the voltage on the motor leads to exceed the NMRA standards for DCC voltage. This may damage your decoder.

Okay, so some momentum is good.

If you are using a sound decoder, you may want more momentum set than with a non-sound decoder. Why? The motor in a prototype loco won’t respond immediately to throttle input. It takes some time for spooling up or down. The sound decoder manufacturers generally create this transition sound time. If you have no momentum set in the decoder and you turn the knob from 20 to 40 miles an hour, the loco (and train) may respond instantaneously, while the motor is still making “20 MPH” sounds.

Okay, so, with sound, more momentum is better.



10: DecoderPro screen: Setting momentum in the MOTOR tab – This is for a TCS T1. You can see the Dither settings in this tab, too.

Here are my rules of thumb:

I set the deceleration momentum (CV 4) to half of what I set the acceleration momentum (CV 3). Model train operators don't always think very far ahead. My observation is: if the train slows at the same rate that it speeds up, more crashes occur.

Non-Sound decoders, I use a minimum of 2 in the acceleration momentum (CV 3) and half that in deceleration (CV 4). I find that a maximum of 8 works well, see figure 10.

Sound decoders, I use 10 to 40 for acceleration (CV 3) and half that in deceleration (CV 4).

I recommend you find a throttle response that works for you and make all your locos run the same way. If all your locos respond similarly, guests can learn how you set your locos and work with it. If every loco is different, be ready for some corn field meets. Note that this will probably NOT be the same numbers being set in various manufacturer's products, as different folks' decoders have different sensitivities to the numbers in CVs 3 and 4.

BEMF Settings

Some decoders (TCS, for example) have simple BEMF settings: on or off. Others (SoundTraxx or Digitrax, for example) have some very complicated adjustments to fine-tune the BEMF settings. These decoders will work if you just enable the BEMF, but the tweaking makes a big difference in your operation. I will refer you to your decoder's instructions. To get Tsunamis to creep requires the BEMF settings to be adjusted. There is a way to fix this, but it is beyond this column. Check it out on my web site in the middle of the Tsunami page (mrhmag.com/url/dcc-soundtraxx-tsunami) for instructions and a video.

BEMF Cut-Off

Some BEMF decoders allow BEMF cutoff. This is a way of having your cake (low speed BEMF control) and eating it too (no BEMF at running speeds, to interfere with consisting or create a "cruise control"). In its simplest form, the decoder uses a setting in a CV to tell it above what speed the BEMF control is disabled, or "cut-off". The exact settings vary by decoder, but I would start with the cutoff at 25% of maximum speed and adjust from there to taste.

BEMF & Consists

There are two points of view for using BEMF with locos that are going to be consisted: "Yes." and "No."! I fall in the "Yes" category.

I find that with some tweaking, locos can run in consists with BEMF activated. I believe that folks who say outright, "No." haven't successfully tweaked their locos.

BEMF Cut-Off is an help, too. It allows BEMF control for getting started and no BEMF for locos to fight in the consist at speeds.

I hope you feel a bit less imtimidated by the terms and concepts behind motor control in your DCC decoder.

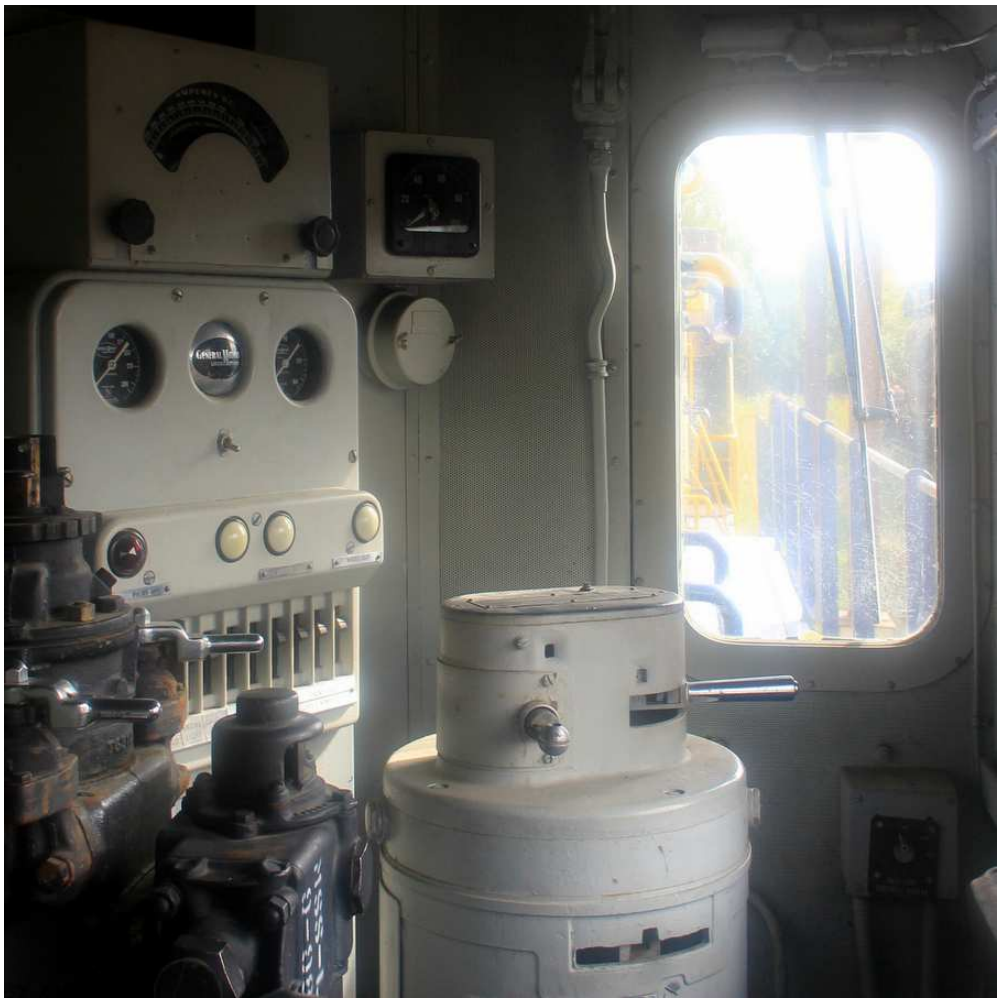
For more information on these topics, you may consult my web site at the URLs imbedded in this column. There is also data on the DCC Wiki site (mrhmag.com/url/dcc-wiki). When looking at the DCC Wiki site, please understand that it is a compilation from lots of folks, so it would be normal for it to be self-contradictory. Also, the CVs for these adjustments are not standardized, so any CVs mentioned on the Wiki should be checked against the documentation for your specific decoder and not just used blindly - you might end up fiddling with something you don't intend.

If you liked this column, please click on the Reader Feedback link here and rate it **awesome**. Please join in the conversation that invaribly develops there about the topics presented in the column. Share your experiences. Thanks.

MR DCC'S WORKBENCH

SPEED STEPS IN PERSPECTIVE

What is a speed step? That is the way that the command station tells the locomotive where you have set the throttle controlling a particular loco.



11 Diesel control stand on an EMD MRS-1

To make things easy, consider how it would work if there were 10 speed steps. As soon as you move the throttle off zero, the locomotive would be told to run at 10% of top speed. As you advanced the throttle, nothing would happen until you reached about 15% of the total throttle range. Then the loco would be told to run at 20%, until you turned the throttle up past about 25% of the range. So, the loco would immediately try to jump from 10% to 20% of top speed, its acceleration limited only by the momentum setting in the decoder, the loco's flywheel and the load of whatever cars it is pulling. Not very realistic.

Folks have said, "Well, locos have 8 notches, so why to I need more than 8 speed steps?" It is true that the diesel motor may only run at 8 different speeds, but there is a throttle that controls how much of the power being generated is directed to the drive motors.

When you are running a prototype diesel, the throttle determines speed with infinite variability. The motor (and its associated sound) does, indeed, have 8 distinct steps. By the way, steam locomotives are infinitely variable, too. So, the more speed steps you have, the more accurately you can reproduce the nuances of loco speed.

Way back in time, when DCC was new, there were several designs of speed steps. Quickly, 14 speed steps became the norm. Then came 28 and 128. Folks pretty much decided that the less than 1% difference available from 128 speed steps was enough, so the standard stopped there. DCC command stations must be able to speak all three versions (14, 28 and 128) to accommodate decoders of all vintages.

Inside modern decoders there are two options: 14 and 28 speed steps, adjusted by setting CV 29. What happened to 128? Well, decoders are kind of bilingual. If they are set to 28, they can understand the command station if it speaks 28 or 128.

"So, with all these choices, what should I do?" is the question on your lips. That's your decision, but here's what I do. Firstly, forget 14 speed steps. There are all sorts of issues that are tied into the speed control with that language. So, ALWAYS, set your decoder to 28 (some call it 28/128, for reasons that you now understand). Then you can go between 28 and 128 by only changing your command station. I always use 128 speed steps when setting up a decoder, that way, you know you are getting the most accurate speed control your system and decoder can provide. If you choose, you can tell your command station to talk to this decoder in 28-step language. I leave the system talking 128 steps, but I'm a control freak, just ask my wife.

By the way, some decoders use more than 128 speed steps internally for speed calculations. The SoundTraxx Tsunami comes to mind. It looks at the speed called for by the command station using up to 128 speed steps. It then calculates the PWM that should be sent to the motor at this moment in time, based on the BEMF and momentum settings and the prior response by the motor to speed changes, in 1028 increments.