Speed Matching DCC Locomotives

Using DecoderPro

The objective here is to get your locos to run in a consist - and have them all going at the same speed - i.e. to avoid having one or more of them becoming a "rail grinder" because the motors are running faster or slower than the other(s). The following procedure will allow you to speed match them easily – and after you have done one or two of them you will be able to speed match your locomotives - in far less time that it will take you to read this document. So take a few minutes to read all the way thru this one time, then take it with you to the layout and do the first one or two using it as a guide … and then "go for it".

Basic Approach

The basic approach is to get them speed matched first at the low end (slowest speed), then at the top end (fastest), in the middle, and finally with momentum (if you use it). Quite often you will be able to do this on the first pass – once in a while you might need to 'go back and fine tune'. If you are speed matching highly similar locomotives – such as two Stewart FTs with the same decoder in each one – it is usually very easy. If the locomotives or the decoders (or both) are different then it can take more time – but it is still possible and even relatively easy. And the more times you do this the better you will get at doing it. Practice makes perfect!

I am going to assume certain 'givens' in the following … first that you are familiar with and using DecoderPro and second that there aren't any problems in the drives of the locos such as a loco that has a 'bind' in the drive and won't run well. You don't –have- to use DecoderPro to use this procedure … but it does make it a lot easier and faster.

**** Phase 0 - Preparation ****

1) OK - BEFORE - you start this exercise. CLEAN the track -and- CLEAN the locomotive wheels. If you try to speed match locos with poor connectivity between the locos and the track it can quickly become an exercise in futility. Whatever track is used to test your speed matching should be "as immaculate as possible". (After they are properly speed matched you will even be able to use the way they run together as a measure of when you need to clean the track!)

2) Use DecoderPro to read all CVs and create a roster entry for both/all locomotives. If you aren't using DecoderPro then read and record all of the relevant CVs (see below).

3) Turn OFF all momentum – it is the motor sheet in DecoderPro and is aka CVs 3 and 4 – set both to zero in all locomotives you are going to match. You will put the momentum back in later – but it makes observing the relative speeds of the locomotives take longer and will create errors in the process. You also may want to turn off BEMF if the decoders are not TCS or QSI. My experience is that you can leave the BEMF on for both of those brands. You may be able to leave it on for others – only you can judge this … later in the procedure. If you are in doubt – start with BEMF on and then change to it being off if you just can't seem to get them matched.

4) Set your throttle/command station and the decoder to run in 100(Digitrax)/128 speed step mode. You can do speed matching using 28 speed step mode … but it is a lot harder - most of the time. And locos that were speed matched in 28 step mode won't necessarily run well together in 128 step mode. Even if you normally run your layout in 28 step mode I recommend first matching them in 128 and then changing to 28 and "adjusting as necessary". (I'm sorry I can't tell you if this method will work for older 14 step mode decoders … I've never used a decoder that old!)

5) If you change which method of speed control you use – from basic to the speed tables or vice versa - locomotives that were matched one way will usually not be matched if you change them to the other method. However you –can- match them with one using basic and the other using the speed tables. What you can't do is to change a locomotive to a different motor control method after doing the speed matching. Similarly – if you are using a particular speed table method (user, or built in) then if you change the speed table … you have to redo the speed matching. You will find that if you have more than one locomotive using a pre-set speed table that you will have trouble matching them … so I recommend using "User Defined".

6) Set the top speed of both locos to 180 (VMax or CV 5 for basic … or CV 94 if you are using the speed tables). If you are using the speed tables then use DecoderPro to do a "match ends" so that they have a straight line progression from the bottom to the top. I hear you asking "why 180?". The particular number is arbitrary. What is important is that it –not- be 255 … because you will need 'room' to adjust one loco to the other. I have also found that the speed increase above 180 is inconsequential … and that something close to 180 also provides a more realistic top speed. Some guys use a number that is as high as 225 – and I know one guy who uses something down around 150. And one who sets -all- of his locos to a maximum speed of 30 scale mph! I suggest you try first using my 180 and see if you like it.

7) Get both/all locomotives running as good as you can get them to run at speed step one (SS1). This means that they should start moving at SS1 and move "smoothly and steadily". It is not particularly important that you have them running at the slowest possible speed at SS1 … just that they are running at the speed you want them to at SS1 – and that they should be "steady" at SS1. Do this one locomotive at a time. At this point you are not trying to get them to run at the same speed at SS1 – just get them to run smoothly at SS1 and at whatever speed you consider to be 'correct/slow enough'. And check SS1 in both forward and reverse.

8) Use a section of track on your layout that is 10 to 20 feet long – the longer the better … and if it is double track that is even better … whether or not it is on a grade doesn't matter. And pick a section of track that you can see from where your DecoderPro computer is running so that you can use DecoderPro to make changes to the CVs.

9) Consist the locos – but do not couple them to each other – and run them as SS1 to see which one is FASTEST at SS1. If any of them are sound locos this is a good time to also "Mute" them. What I usually do is to add them one at a time to the same consist … and mute them as I go.

10) Personally what I do is to use DecoderPro and before I go on to the following I bring up a DecoderPro entry for each of the locos – in Ops Mode – and use that to make all changes to the decoders. But I use a regular throttle to actually consist and run the locomotives during the speed matching. Using both of these 'at the same time' makes this quick and easy to do. The following becomes a repeated series of running the locos and observing them, making a change to the CVs using Ops Mode (and "Write Changes"), redoing the observing, etc., etc., etc. …until you get them running the way you want them to run in each phase.

**** Phase 1 - Speed Match them at Speed Step 1 ****

1) Match the slower locomotive – at SS1 - to the fastest one. Change the Start Voltage (aka VMin or CV2 … or CV67 if you are using the speed table) by adjusting it so that the -slower- one matches the faster. Use the DecoderPro Ops mode programming tool to do the change. Just keep going back and forth between running and observing the locomotives – and using DP to adjust the slower one to run at the same speed as the faster one by changing the start voltage.

2) Please note – in the prior phase we consisted the locos but didn't couple them … you want to keep them that way in this step and all following steps - until you get to the "Final Verification" at the end.

3) Keep running and adjusting until they match each other "perfectly". Run them for at least 2 or 3 feet each time. Don't pay any attention which one starts first – the goal here is to get them to run at the same speed at SS1 after they have "settled down" to whatever speed they run at when the cab is set to SS1.

4) When you have them running at the same speed – then reverse the direction and check that they run the same in both directions. If they do not run –very- close to each other in both directions you may have to use the "trim" CVs to adjust (CVs 66 and 95).

5) Now run them up thru the first few speed steps – no more than as high as SS10 in 128 step mode and usually only up to about SS5 – and see that they match at all the lower speed steps. You can do this part in steps of 2 or 3 speed steps at a time – just keep observing. The locomotives should match each other in speed all the way to SS10.

6) Repeat for additional locomotives if you are speed matching more than 2 locos. Although I will say that I usually do "one pair at a time" (check the end of this document for my thoughts on "fleet matching").

**** Phase 2 - Speed Match the Fastest Speed Step ****

1) Depending upon your DCC system this will probably be either SS 100 or SS 128. It is OK to use a slower speed than "the top speed on the cab" … such as "80" or even "75". But no lower than that. If you are someone who uses 'scale speed' then this is the time to set the highest scale speed you will want them to run (see below for more on scale speed).

2) Run the locos at the top speed and adjust the Faster one to match the Slower by using the Maximum Voltage (aka VMax or CV5 … or CV94 if you are using the speed tables). I'm saying to reduce the speed of the faster one. Again don't pay attention to which one -gets- to its top speed first – you are trying to get them to run the same at their "steady state".

3) Check that they run at the same maximum speed in both directions and keep adjusting until they do. Again you may have to use the "trims".

4) If you are using the speed tables you can now use DecoderPro to redo the "match ends" so you have a straight line curve on both locos. You do not have to use the speed table on both/all locos … but it is easier if you do.

**** Phase 3 - Speed Match them in the Middle ****

1) Now that you have them running the same at the slowest speed and the top speed you need to match them "some where in the middle". It is not important that you do this at exactly the mid point between SS1 and the top … anywhere close to that middle speed will work in my experience and I often use a point that is around 40 percent of the full speed range for this phase.

2) Still consisted and still not coupled - run both locos at the middle speed and change the faster one to match the slower. It actually doesn't matter which loco you change or even if you change both of them (for this phase). Use the Midpoint Voltage (aka VMid or CV6 … or CV80 if you are using the speed tables) to do this. This adjustment is usually quite small and I frequently find that the locos will be "already matched up" for this one.

3) Check both directions and adjust as necessary using the trims (probably not needed).

4) If you are using the speed tables you can now use DecoderPro to create one straight line curve from the low to the middle and another one from the middle to the top (known as using 'mid points'). Or you can just use the sliders to create a smooth curve. Making sure you leave the mid point where you set it in #3 just above!

**** Phase 4 - Initial Verification/Validation ****

1) Now run them slowly up thru the full speed range to check that they are running the same speed thru out. This may involve first doing 'the bottom half' and then 'the top half' … depending upon how long the track is that you are using. I like to do this by 'stepping' them up thru the speed range quickly and stopping and observing them at 10, 20, 30, … etc. Then when I bring the speed back down I will use 75, 65, 55, … etc. If space is limited you may have to use the cab to change the direction of travel between the higher steps. If you do, make sure that they have stabilized before you observe them.

2) What you are looking for is that they "track with each other" when you change the speed at a rate of about "1 speed 'stop' (10 speed steps or so) every few seconds". The rate you want to use is such that you can see that they have increased/decreased - and settled down - for each change. I've found that I often do this by "stopping every 10 speed steps or so". It doesn't really matter how many speed steps between each stop you use. It doesn't even matter if you go up and down the speed range with exactly the same number of speed steps between each stop. The point is to see if they are matched thru out the speed range.

3) If there are any problems – if one is running faster/slower than the other – then go back thru the matching and adjust the speed ranges that need it. You may need to go all the way back to Phase 1 and repeat everything up to this point – but you will probably not have to do that.

**** Phase 5 – add back in the momentum ***

1) OK, now you get to add back in the momentum (CVs 3 and 4). Start by putting in what you normally use for each decoder brand you are matching.

2) Run the locos at the slowest speed, the middle, and the top. Reverse them at each speed range and see that they coast to a stop and reverse 'at the same time' if you change direction while they are moving. A little bit of difference is usually not a problem. Adjust whichever one seems to have the amount of momentum you don't like – i.e. match the one you don't like to the momentum on to the one you do.

I'll digress here to give you "A few words about momentum".

If you ask 5 guys what they are doing for momentum – you will probably get 7 different answers! The following are my methods. They are based upon the fact that I work with a lot of sound decoders – and most sound decoders compare the current speed with the target speed and adjust the -sound- based upon any difference. Said differently, sound decoders -need- momentum. For instance when I'm setting up a Tsunami I start out with the acceleration set to 30 and the deceleration set to 20 … and then make minor adjustments from those values.

Please note that 3/3rds to 2/3rds ratio. It is a key item (to me). If the accel is set to 15 then I will set the decel to 10 ... or 18 and 12 … or 24 and 16, etc. I might make minor adjustments to that ratio but it is usually very close. But I've found that ratio to produce a locomotive that "runs the way -I- want it to" … but I know lots of guys who have very different ideas about momentum than I have.

I am someone who has come full circle on the topic of momentum. I liked it at first, then I hated it, and now I'm back to liking it and even 'preferring it'. When I first started the journey back to using momentum I was puttting in "just a little" - and not putting any in the switchers. Now I use what most guys consider to be "a lot" … and even put considerable amounts of momentum in switchers. Is it the "Pit" or the "Pendulum"?

**** Phase 6 - Add back in the BEMF ****

1) If you turned off the BEMF - turn it back on now and see what happens. Many guys will tell you "you can't use BEMF in consisted locomotives". My own experience is that this is "only true for a few brands of decoders when matched to specific other decoders". I have successfully matched TCS to TCS, TCS to QSI, QSI to QSI, TCS to Tsunami, QSI to Tsunami, and Tsunami to Tsunami … all with BEMF on! And non-BEMF decoders to those that have BEMF.

2) Some guys will leave the BEMF on in one loco and turn it off in all the others.

3) If you are using BEMF "cut off" you will need to adjust them so that they cut off at the same speed step.

4) This is a "your methods may vary" thing. You may find that you have to leave the BEMF off on all but one - or even all – of the locos in order to have them speed matched and running the way you want them to … personally I've found that I can use BEMF in almost all my locomotives and still have them speed matched – perfectly. Even across brands! However, just like which speed method you are using (basic or table) – if you change a locomotive that you have already speed matched from using/not using BEMF … you will have to redo the speed matching for that locomotive.

**** Phase 7 - Final Verification ****

1) Finally … couple them up (still consisted) and run them together. If any of them are sound put them on mute. Run them through the entire speed range. Run them in both directions.

2) Look for "bucking" in the couplers. A certain amount of continuous/repeated slacking and stretching is OK (the slower/less frequent the better) … what you are looking for is not so much that they are "absolutely perfectly matched" as when they are "fighting each other". Some guys refer to this as "surging" or "cogging".

3) LISTEN to them running (with sound muted). You should not hear any of them behaving like it is a rail grinder (spinning its wheels faster than the other). They should both/all be quiet thru out the speed range. You may be surprised by how much noise is actually in just the drive (without the sound). If they are not properly matched you will not have any problem hearing it! If you want to know what to listen for – take any locomotive you have and put your finger across the rails in front of it so it can't move and turn up the speed until the wheels start to turn – that's the sound you -don't- want in properly matched locomotives. Another way to do the same thing is to listen to them running coupled up – and then uncouple them (but leave them consisted) and listen again (muted!) and see if they are a lot noisier when coupled.

4) Any problems in #2 or #3 means you need to go back and make adjustments. I usually do this "only for those speed ranges that need it". You may find you have to turn off the BEMF - or you may not. You may or may not need to readjust the momentum (usually not). However – if they were properly speed matched when they weren't coupled up … they should be properly matched when they are coupled. (But you still need to test!)

5) Last But Not Least - **save the updated DecoderPro roster entries** with the final settings. Just to be absolutely certain - I often take the time to put them on the programming track and actually do a Read All Sheets before I save a roster entry … that way I know that what I saved is what is in the decoder.

**** Fleeting ****

Many guys just speed match sets of locos that will always be run together – by the individual set – but don't try to match one set to another. Others have started to use a concept called "Fleeting". By fleeting I'm referring to the practice of not only matching given sets of locos that will "always be run together" but also to the idea of wanting to "be able to run any loco with any other" – or any loco in a given speed class (purpose) with any other.

There are two basic approaches to this – choose yours. Some guys want all the locos on their layout to be able to be consisted with any other loco. Other guys will divide their locos into classes and only match "within a class". Examples of some classes that some guys use are Switchers, Road Switchers, Road Power, Steam Switchers, Heavy Steam, Logging Locos, 1st Generation -vs- 2nd Generation, by Make and Model, etc., etc., etc. – there are far too many variations on this theme to list them all but you get the idea. Do you really expect to MU your switchers with your road power? My recommendation is that you do "what makes sense for your layout". Some of the clubs out there have their own methods of dividing up the locos into classes.

If you have divided up your locos into "speed classes" then you will not only have to match them "two at a time" but also "all the locos in the class". This is usually done one locomotive at a time using the process above – but note that when picking the slowest or fastest loco you need to pick the slowest or fastest loco - in a speed class - and match all the others to that one. When you have more than a few locos in a class quite often you will end up using one loco for the standard for the 'slowest' - and a different loco (also from the same class) for the 'fastest'.

A special case of fleeting is when you are doing a group of locos such as an ABBA set of Fs – usually that will always be run together. Many guys choose to use the same DCC address for all locos in a consist of this type – if you are going to do that it is easier if you speed match them first with *separate* addresses … and then set the addresses all the same when the speed matching is complete.   When I do an ABBA set what I often prefer to do is to first get two of them matched, then match the third to those two, and finally match the fourth to the first three. By that I mean that I keep the ones that have already been matched consisted coupled together - and speed match the additional ones to them. If they are going to have the same DCC address I will even change each one to the final address when it is speed matched so that I'm always working towards the final consist and checking it as I go.

**** Scale Speed ****

   Some guys are using 'actual scale speed' to match their locos. They purchase a device such as the one made by TrainSpeed and use that - or use some other method of measuring scale miles per hour and, usually in combination with the speed tables, set up their locos so that if the throttle is set to "30" then the loco runs at 30 scale mph (and the rest of the speeds as well). Some even adjust the top speed of the loco to match the prototype.
   Personally I am not a fan of this approach. First, it takes a lot longer to do than the method I described above. More importantly, I'm just one of those guys who prefers to use the throttle to set the speed I want the train to be running at … by looking at it. I slow the train down some when climbing a grade, let it speed up first and then back off when starting down a grade, make adjustments based upon how long the train is, come to a stop just before coupling and then make the final move to couple, etc., etc., etc.
   Again … this is one of those things you need to make your own decision about.

   I warned you at the beginning that it takes longer to read this document than it does to actually do a speed matching … but I still recommend that you go back and reread it from start to end at least once more ...

- Jim Betz (September 2011)