# North Raleigh Model Railroad Club

## Application Note

## DCC Locomotive Speed Matching

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North Raleigh Model Railroad Club
Issue 2.1

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## Introduction

Prototype railroads operate long trains by adding more diesel locomotives to provide the power needed to move the train at the desired speed over the track profile of the route to be followed. This locomotive lash up is called a consist; several locomotives are being run together as a single locomotive. Prototype locomotives have equipment to synchronize the members of the consist for efficient aggregated tractive effort. While steam locomotives each require a crew the end effect is the same as for diesel locomotives.

It is well known that our N Scale model locomotives from different manufacturers and different locomotive models from the same manufacturer do not run at the same speed for the same throttle setting. Thus we cannot consist (MU) locomotives of different types/manufacturers as freely as prototype railroads can. Essentially, without speed matching, we are limited to consisting locomotives which just happen to run at the same speed. This is so because even the same models from a manufacturer, e.g. 2 x Atlas GP9, do not offer much chance of being reasonably speed matched. Most are not.

The answer is to speed match the various locomotives. This can be done utilizing the capabilities of DCC decoders in two ways:

- Use the Vstart, Vmidpoint and Vmaximum settings in the decoder Configuration Variables (CV). This is a quick and easy way to get close, especially with two locomotives of the same type and manufacture. Close is often not good enough.

- Use the 28-step speed table built into most DCC decoders.

Using a special Speed Matching Script with JMRI software and a specially constructed layout allows for a relative easy method of setting the 28-step speed table to speed match our N Scale locomotives so we have the same freedom as the prototype in consisting locomotives.

The individual operator can choose the speeds in which to match his/her locomotives. One suggestion for matching different locomotives is provided in the table below for diesel locomotives:

| Diesel Locomotives | |
| --- | --- |
| Type of Locomotive | Speed |
| Freight | 70 |
| Passenger | 100 |
| Switcher | 50 |

Note: Check the maximum speeds of locomotives in your roster to ensure the selected speed for matching is within the capability of the locomotives in the class. For example, do not choose 80 mph as the maximum speed for your freight locomotives if some of them cannot go that fast.

Choosing a speed for matching steam locomotives is not as easy, as maximum speeds for steam locomotives are almost totally dependent on their wheel diameter, steaming capabilities and vintage. You may have to check prototype information to determine the maximum prototype speed for the particular locomotive.

## Speed Matching Layouts

Members of the North Raleigh Model Railroad Club have access to two layouts that can be used for DCC Locomotive Speed Matching. Both are designed to operate solely with Digitrax DCC systems as Digitrax DCC is the club's Standard. The layouts are:

- A foldable portable layout constructed by Jim Kalenowski and Joe Peacock, and configured with eight detection sections, as shown below. Overall dimensions of the layout are 42″ wide x 42″ deep. When folded for transport the dimensions are 42″ wide x 21″ deep.
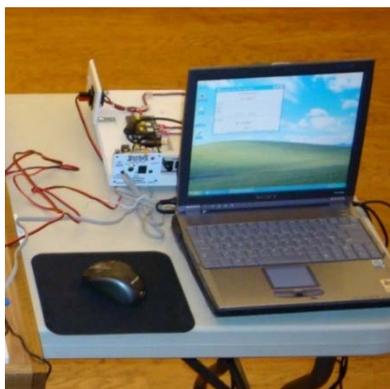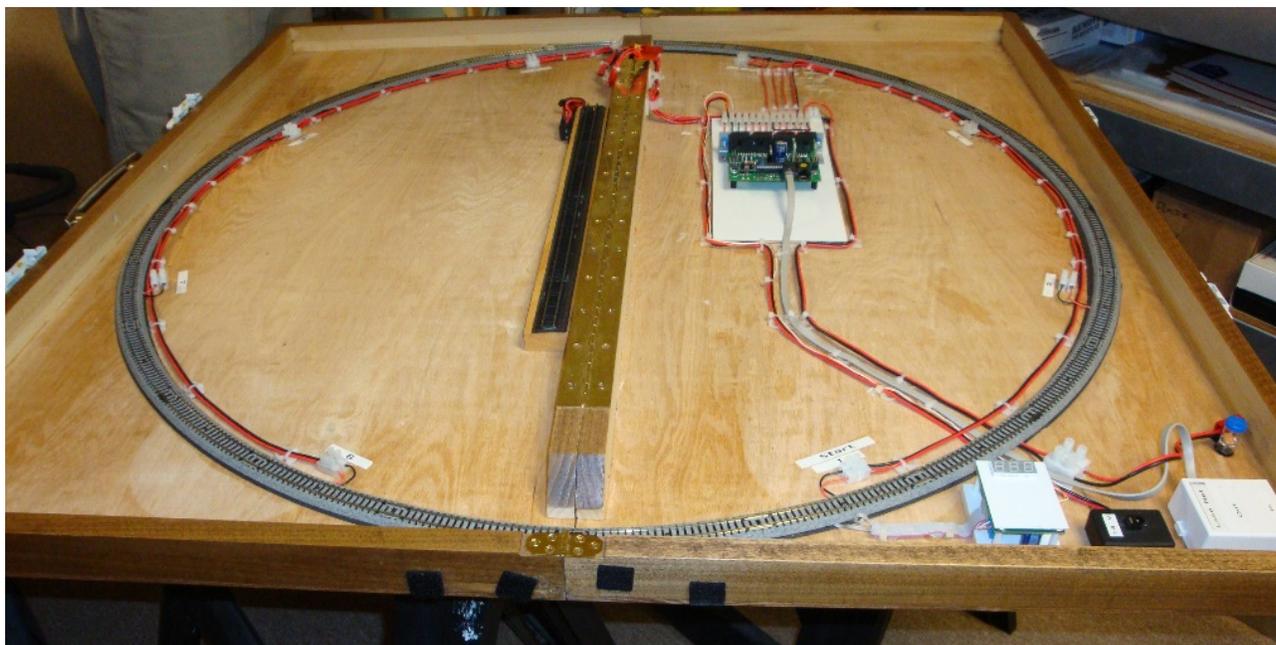
- A non-foldable layout constructed by John Wallis, and configured with twelve detection sections, as shown below. Overall dimensions of the layout are 40.5″ wide x 40.5″ deep, fixed.
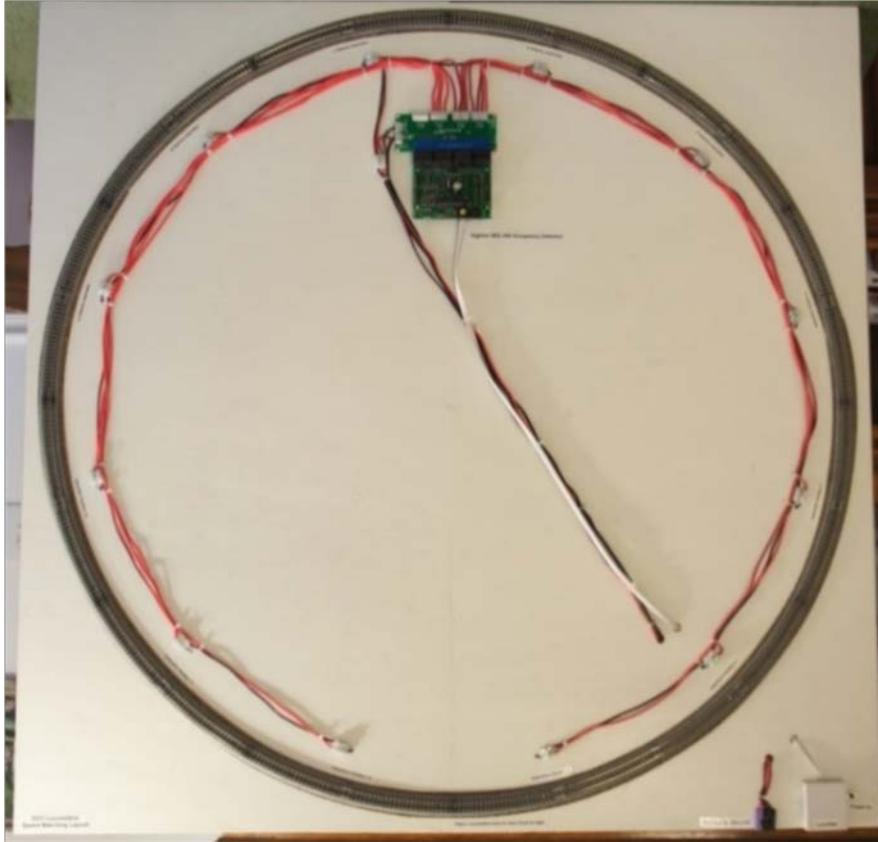


Overall Layout View



Connections to Command Station + LocoNet + BDL168 Power
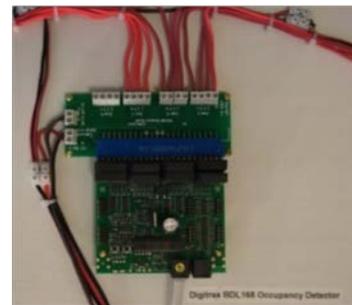


Digitrax BDL168 Detector

Both layouts consist of a circle of 19″/481mm radius Kato Unitrack (Cat. No. 20-160) divided into 8 or 12 electrical sections as stated above. The electrical sections are connected to a Digitrax BDL168 for detection of the locomotive as it travels the layout. Note that speed matching will be faster with 12 electrical sections than with eight sections.

Wire the BDL168 44-pin connector per the diagram in the Digitrax Instruction Sheet for direct home wiring. An alternative to wiring the connector is the BDL168 Breakout Board available from Acculites at http://www.traintekllc.com/prodinfo.asp?number=ACL-168SZ&variation=&gclid=CML28-ec-cQCFYQkgQodpzMAOA. The correct OpSw settings for the BDL168 are the default settings that come with a new BDL-168.

In normal operation the green LED on the BDL168 should wink once every couple of seconds. The red LED will flash to reflect LocoNet commands to/from the Command Station.

Use of Optional Model Railroad Technologies Accutrack Speedometer or TCS Trainspeed 1 to Verify Loco Speed

The Model Railroad Technologies Accutrack Speedometer or the TCS Trainspeed 1 Speedometer can optionally be used to verify speeds detected by the script. The Trainspeed 1 provides a result more consistent with the script speeds.

### Layout Connections
The BDL168 and track on the speed matching layouts are connected to a Digitrax Command Station (see note under "DCC System" on page 7) with three connections:

- LocoNet
- Track Power (Rail A and B)
- Common wire between BDL168 Ground and Command Station Ground terminal.

In addition power (PS14 or equivalent) must be supplied to the BDL168. Note that this power supply should power only the BDL-168, and not be shared with any other device.

The Digitrax Command Station is then connected to a Windows computer running JMRI through a LocoBuffer or a PR3. A Mac or Linux computer could also be used in place of the Windows computer.

# How the JMRI Script Works

## Speed Matching Script
The speed matching script requires JMRI version 3.0 or higher.

The speed matching script will automatically build a speed table for a decoder using OPS mode programming, and create a text file on the computer desktop for future use. The following is a summary of how the script works:

- The user enters information about the locomotive into the "Speed Matching Table Input Panel." (shown below)
    - Locomotive road number
    - Decoder DCC address
    - Type of Locomotive (steam, diesel, etc.)
    - Scale (defaults to "N")
    - Brand of Decoder (defaults to "Digitrax")
    - Acceleration (CV3) and deceleration (CV4) desired (disabled while script is running)
    - Direction to be tested (defaults to "Forward")
    - Top speed desired.

- A throttle is created in JMRI to run the locomotive.

- The locomotive is warmed up for a few laps around the layout (in both directions if diesel; in forward direction only if steam).

- The top speed of the locomotive is measured (in both directions for diesels)

- Using the block detectors to measure time, the script adjusts the throttle until the appropriate speed is found for the speed step.

- Seven speed steps are measured, and the rest interpolated. The measured speed steps are 4, 8, 12, 16, 20, 24 and 28.

- The values determined for the speed steps are written to the decoder, and a text file is created on the computer containing the speed step values and other appropriate information for the decoder.

- The locomotive is released from the JMRI throttle, and the throttle is discarded.

During the speed matching process you can watch events using the Script Output viewer; click on "Panels" then "Script Output". When the script completes and the speed table values are written to the decoder the script output viewer will show those values, as well as indicate the total time used in running the script. See below.



```
[Block 1]
Measured Speed MPH = 148.7  Measurement # 5
[Block 1]
Measured Speed MPH = 148.6  Measurement # 6
[Block 1]
Measured Speed MPH = 148.6  Measurement # 7
[Block 1]

Reverse Max Speed =  149.0 MPH

Measured Speed MPH = 145.5  Measurement # 1
[Block 1]
Measured Speed MPH = 143.1  Measurement # 2
[Block 1]
Measured Speed MPH = 150.9  Measurement # 3
[Block 1]
Measured Speed MPH = 148.3  Measurement # 4
[Block 1]
Measured Speed MPH = 147.7  Measurement # 5
[Block 1]
Measured Speed MPH = 148.0  Measurement # 6
[Block 1]
Measured Speed MPH = 151.2  Measurement # 7
[Block 1]

Forward Max Speed =  148.0 MPH

Decoder Brand Installed is  Digitrax


TARGET SPEED BEING MEASURED IS:  11.0  MPH



Throttle Setting  40
Measured Speed MPH = 53.3  Measurement # 1
[Block 4]
Measured Speed MPH = 50.5  Measurement # 2
[Block 5]
Measured Speed MPH = 53.7  Measurement # 3
[Block 6]
Measured Speed MPH = 48.0  Measurement # 4
[Block 7]
Measured Speed MPH = 53.3  Measurement # 5
[Block 8]
Measured Speed MPH = 48.3  Measurement # 6
[Block 9]
Measured Speed MPH = 50.5  Measurement # 7
[Block 10]
Difference =  39.5 MPH at throttle setting  40


Throttle Setting  35
```

Script Output Viewer

```
Difference =  1.1 MPH at throttle setting  57

Closest throttle setting is  57    On to next speed step

Measured Values
[0, 0, 0, 0, 42, 0, 0, 0, 58, 0, 0, 0, 70, 0, 0, 0, 80, 0, 0, 0, 90, 0, 0, 0, 102, 0, 0, 0, 114]

Turn on acceleration and deceleration
Writing value to CV3:  0
Writing value to CV4:  0

All Speed Table CV Values
[26, 30.0, 34.0, 38.0, 42, 46.0, 50.0, 54.0, 58, 61.0, 64.0, 67.0, 70, 74.0, 76.0, 78.0, 80, 84.0, 86.0, 88.

Writing Speed Table CV Values to Locomotive
CV 67  =   30
CV 68  =   34
CV 69  =   38
CV 70  =   42
CV 71  =   46
CV 72  =   50
CV 73  =   54
CV 74  =   58
CV 75  =   61
CV 76  =   64
CV 77  =   67
CV 78  =   70
CV 79  =   74
CV 80  =   76
CV 81  =   78
CV 82  =   80
CV 83  =   84
CV 84  =   86
CV 85  =   88
CV 86  =   90
CV 87  =   93
CV 88  =   96
CV 89  =   99
CV 90  =   102
CV 91  =   105
CV 92  =   108
CV 93  =   111
CV 94  =   114

Turn on speed table


Transferring Data to a Text File on PC Desktop for future use:  C:/script/Loco 9532_DCC# 9532_Digitrax.txt


Test Time =  25L  min.
Ready for next locomotive
```

Speed Table Values

## System Startup — Windows Computer

Connect the computer to the Command Station using a LocoBuffer or PR3 with the appropriate cables and then turn it on. Allow the computer to boot to its desktop.

From the desktop create a "Scripts" folder in the root of the C:/ drive, as follows:

- Click on "Start" then "My Computer" ("This PC" for Windows 8), and then click on the "C" drive."

- Right click on a blank spot in the window and then in the dialog box click on "New Folder" and then type in "Scripts" (without the brackets), then click OK.

- If you would like a Desktop shortcut to the Scripts folder then right click the folder, and hold down the button as you drag the Scripts folder to the Desktop. When you release the mouse button you will be asked if you wish to Copy, Move the folder, or Create a Shortcut to the Folder. Select "Create Shortcut."

- The steps above may be slightly different depending on your version of Windows.

Start JMRI by double-clicking on the DecoderPro or PanelPro icon.

Before using the above configuration for speed matching it is important to do an OpSw #39 reset of the Command Station, especially if the Command Station has been used for running trains on an NTRAK, T-TRAK or home layout.

Once the OpSw #39 reset is complete be sure that OpSw #5="c". Other settings are not important for speed matching.

## Preparing for Speed Matching

Both the locomotive and speed matching layout must be in top shape to ensure the best possible speed match results. This requires some preliminary effort as follows:

### Layout

After ensuring all necessary electrical connections are made and secure the prime task is to ensure the rails are completely clean. Use a track cleaning car, a Bright Boy hard rubber cleaner or an old sock soaked in isopropyl alcohol, or equivalent. Remember also that wheels pick up power from the inside top of the rails, so ensure both the top and inside top of the rails are totally clean.

### Locomotive

There are several tasks to ensure a locomotive is in top shape for speed matching, as follows:

- Clean and lubricate the locomotive
  - Make sure that dirt and extraneous material (dust, hair, etc.) are removed from the mechanism
  - Clean out any dried lubricant.
  - Apply gear lubricant to the gears in the locomotive, both at the motor shaft and the trucks.
  - Apply one drop of light oil (e.g. LaBelle 108) to the motor and gear bearings, and to the axles.
  - If the axle ends are the point of contact for electrical pick-up for the locomotive (e.g. Atlas, Kato) apply one drop of Conducta-Lube to the axle ends.
  - Also apply a drop of Conducta-Lube to the contact points between the truck wipers and the copper strips.
  - Clean the wheels.

- Place the locomotive on the programming track.

- Create (or update) a Roster Entry for the locomotive in DecoderPro
  - If the locomotive and decoder are new simply create an entry and set the desired address in the Basic pane.
  - Create a Roster entry and then do a "Read All Sheets." This will preserve all previous CV settings, and enables a locomotive to be restored to its prior state should an error occur during speed matching.
    - Alternatively (preferred) the locomotive can be reset to its default CVs, and started fresh by manually doing a decoder reset (normally CV8 = 8) using a throttle rather than DecoderPro.
    - After doing a reset create a (or modify its) Roster entry and set the desired address in the Basic Pane.
  - Turn the BEMF setting off in the Motor pane, as some locomotives do not MU well with BEMF turned on.

- The locomotive is now ready for speed matching.

## DCC System

For consistent results between locomotives, especially if you are speed matching a larger number of locomotives, you should always use the same Booster to power the speed matching layout as you will then always have the same track voltage. Ideally you should calibrate your Booster output voltage (DCS100/200 or DB100/150/200) to be 12 volts at the track (assuming the "N" setting on the Booster). Instructions on how to calibrate the Booster track voltage are provided in the Digitrax manuals. Note the Zephyr/Zephyr Extra track voltage is fixed at 14V; unless your locomotives will always and only be run from a DCS50/51 it is recommended not to use these for speed matching.

# Running the JMRI Speed Matching Script

## Initial Steps

The following steps must be completed before the JMRI scripts can be run:

- Be sure the connections between the computer and the Command Station, and between the Command Station and the BDL168 are in place. Make sure there is a PS14 (or equivalent) powering the BDL168.

- Power up the Command Station and the BDL168. Turn on track power using a throttle connected to the Command Station.

- Turn on the computer and allow it to boot to the desktop.

- Start the JMRI software by double-clicking on the DecoderPro icon, or by clicking "Start" then "All Programs" then "JMRI" then "DecoderPro". The initial DecoderPro window will open, as shown below.



If the "Preferences" window opens instead be sure to enter the correct information for the Command Station in use, the interface device in use (LocoBuffer or PR3) and the correct COM port for the device.

- As you open the various windows involved in running the scripts be sure to move them into suitable spots on the desktop so all can be seen.

## Speed Matching a Locomotive

Speed matching a Locomotive makes use of the NRMRCSpeedMatch_v1.7.py script. Do the following:

- From the DecoderPro start window click "Panel" then "Run Script." From the "Run Script" selection menu find and double-click the "NRMRCSpeedMatch_v1.7.py" script.
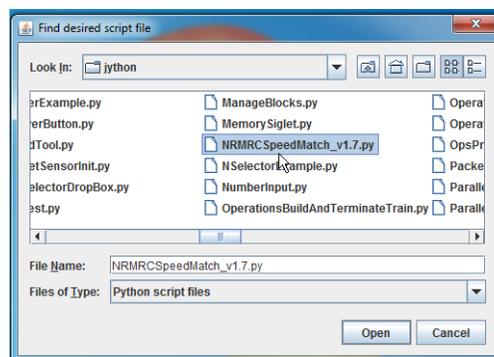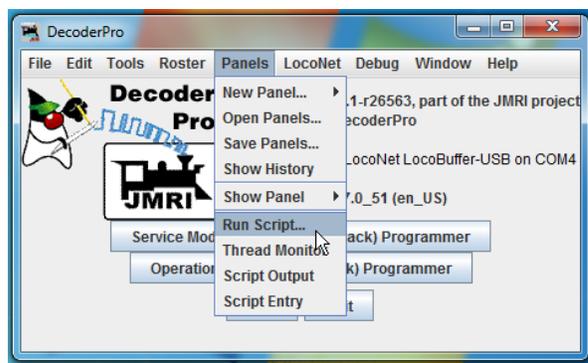
- The Speed Match Input window will open. Do the following:

  - Enter the locomotive number
  - Enter the DCC address of the locomotive
  - Select the scale — N or HO (default is N)
  - Select the type of locomotive — diesel or steam (default is diesel)
  - Select the decoder manufacturer (default is "Digitrax")
  - Select the desired acceleration (CV3) and deceleration (CV4) — CV3 and CV4 settings are disabled during the run.
  - Select the desired direction (default is "Forward")
  - Enter the Maximum Speed
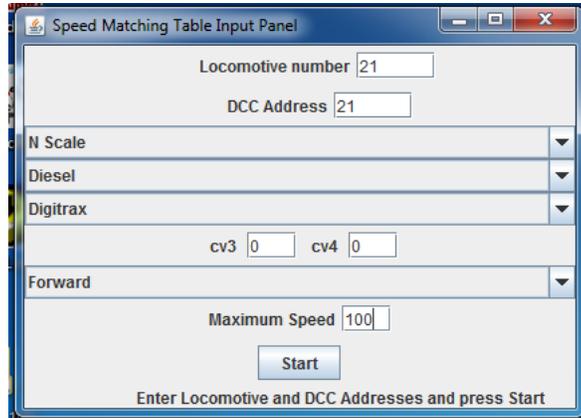


- From the DecoderPro start window click "Panel" then "Script Output." This will display what is happening as the script is running, and provide the maximum speed results when the script finishes.
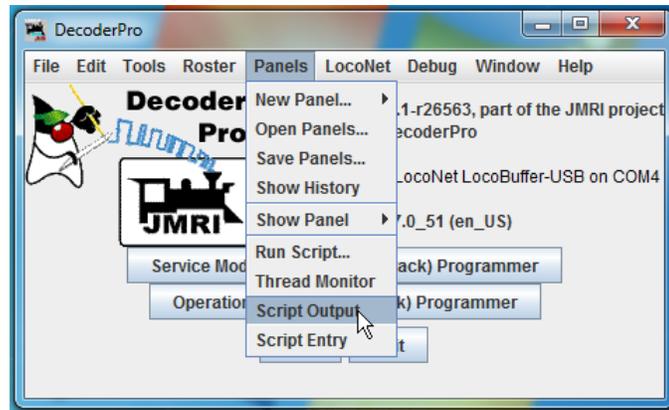


- Place the locomotive on the track in Detection Section 1 and facing counter-clockwise. The press "Start" on the "Speed Match" input menu.
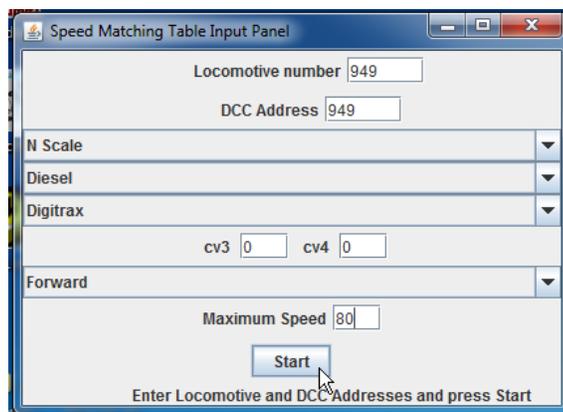
- The script will run. The locomotive will make ten loops in forward and reverse directions (steam in forward only) to warm up the locomotive. Then the locomotive will make measured runs for seven loops in each direction (steam in forward only) and the maximum forward and reverse speed will be shown on the Script Output screen; you may want to record these speeds for future reference. Then the script continues the speed matching process running the locomotive at seven different throttle sessions and measuring the speed.

  Note:  After the warm-up laps and maximum speed measuring laps the script first determines the correct throttle setting to achieve a speed that is approximately 14% of the maximum speed requested. It begins with throttle setting 40 and reduces the setting until it finds the setting that results most closely to achieving that 14% speed. It is possible that the 14% speed cannot be achieved even at throttle step 1. This is most likely to happen with locomotives with a very high maximum speed (such as Kato locomotives) and BEMF is not turned off. This is one of the main reasons for turning off BEMF in the locomotive before running the speed matching script.

  For example, 14% of 100mph is 14mph; 14& of 80mph is 11.2mph, rounded to 11mph; 14% of 70mph is 9.8mph, rounded to 10mph.

  It the script cannot get the locomotive to run at the 14% speed with any throttle setting speed matching cannot occur and the script will provide an error message in the script output. In this case the script will not be able to write the speed table to the decoder, although the script will continue to run. If this error message is seen the script should be aborted as described below in "If Something Goes Wrong" below. Put the locomotive on the programming track and be sure BEMF is turned off in the decoder, then try again.

- Finally the locomotive stops running and the following occur:
  o   The speed table CV values determined by the script are written to the locomotive using OPS mode.
  o   The values of CV3 and CV4 as specified in the input window are written to the decoder.
  o   A text file is created containing the values written to the decoder and saved to the folder created earlier.
  o   The locomotive is released from the throttle.
  o   The throttle is discarded.
  o   The time taken to fully run the script is posted on the screen.

  Note: If the screen does not show the elapsed time for the script it is possible the script did not create the text file. However, if the individual speed steps are shown on the screen this means they have been successfully written to the decoder. Remember to update the decoder CV settings in the Roster.

- The script can now be used for another locomotive

## Matching Speeds in Both Directions
The script speed matches the locomotive in one direction only. To speed match in the reverse direction you can adjust the settings of the Trim CVs, CV66 (Forward) and CV95 (Reverse), if the decoder supports these CVs. The default values are 128/128; a higher value is faster and a lower value is slower. The Accutrack or Trainspeed 1 Speedometer is used to match the speeds. In a JMRI OPS mode programming window for the locomotive address do the following:
- Open a JMRI Throttle by clicking on "Actions" then "New Throttle."
- Click on the "CVs" tab.
- Scroll to CV66 and adjust the value as desired, then CV95 and adjust as desired until you get the forward and backward speeds the same on the Accutrack or Trainspeed 1 Speedometer
- Be sure to save CV66 and CV95 then close then close the programming window.
- You can now operate your locomotive.

## If something goes wrong.
If something goes wrong and you need to end the script or start over, "Steal" the locomotive using another throttle and stop the locomotive. Then do the following:
- Close the Input panel.
- Under the "Panels" tab, select "Thread Monitor" and "Kill" the script, or simply close JMRI and reopen JMRI software.

**If the Script Does Not Write the Speed Table to the Decoder**

Sometimes the Script is not able to write the Speed Table to the locomotive's decoder. This is caused by decoder contacts (motor brushes, power) that are not tight enough for a solid 100% connection all of the time. Sometimes a blob of solder on the contacts will solve this problem.

In some instances you may need to write the speed table values manually using the values saved to the text file on your computer.

In some instances the BEMF setting in the decoder may not permit the script to reduce the speed of the locomotive low enough to measure the first step at 11mph, even at throttle setting 1. In such cases the Script Output window will show a statement saying the Speed Table cannot be written, and this will appear as soon as the 11mph test fails. The need to disable BEMF appears more important with TCS decoders and locomotives with higher top speed.

# Update the Locomotive's Roster Entry

Once all the above steps have been completed and you are satisfied the locomotive has been properly speed matched, place the locomotive on the programming track and update its entry in the Roster to ensure the new CV settings are recorded. Open the "CV" tab and do a "Read Entire Sheet." This will enable you to reset your locomotive should anything happen to the settings in the decoder.

You are now finished.

# Note:

To request a copy of the speed matching script email Jim Kalenowski at jamesk3142@aol.com or John Wallis at wallisjm@att.net.

Once you have obtained the script it should be saved in a place where JMRI can find it. There are two options:

1. The **preferred** location is the jython folder. The specific location of the jython folder on your computer can be found by opening JMRI, then clicking on "Help" and then "Locations". (For example: c:\Program Files (x86)\JMRI\jython)

2. The alternate **non-preferred** location is anywhere on your computer, and then tell JMRI where to find it. Open JMRI then click on "Edit" then "Preferences", and then "File Locations". In the resulting dialog box find the "Jython Script Location" and enter the full path to your script file in the entry area, then click on "Set". Be aware that doing this will stop access to the regular Jython folder; alternative 1 is strongly preferred.

# Reference

The Speed Matching script could not have been created without the previous work of Phil Klein, Thomas Stevens and Eric Bradford.