

Digital Command Control (DCC) Troubleshooting

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**How to find and correct problems encountered during
layout operations**

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Digital Command Control Troubleshooting

Purpose

Railroad operations successful, continuous, reliable

Table of Contents

Basic Troubleshooting Techniques

Tools & Test Equipment Required

Troubleshooting the Layout

Wireless Throttles & Interference

Layout Management



Basic Troubleshooting Techniques

First step — determine the reason for the problem. Two basic questions to ask:

- **What happened?**
- **What changed just before the problem struck?**

For many problems layout details are needed — includes track plan, locations of Boosters and all other DCC-related devices (active or passive), how LocoNet is wired, plus programming information for devices such as BDL, DS64, SE, etc.



Basic Troubleshooting Techniques, Cont'd

In addition to the two basic questions, ask the following as appropriate:

What happened?

Who found the problem?

When did it happen?

Who worked on it last?

Where did it happen?

What were you doing?

When was the last change made?

Intent is not to find fault and ascribe blame. Intent is to find the cause of the problem so it can be resolved quickly. However —

Who told you to do that?

Why didn't you ask first?



Keeping it Running

Tools & Test Equipment Required

Tool/Test Equipment	Use
Quarter	Used for the “quarter test”.
LED Tester	Used to check track power, polarity and Booster phase
Digitrax LT-1 Tester	Used to check LocoNet cables and RJ plugs
Network Tester	Used to test newly made LocoNet cables
Digitrax DT4/5/6xx throttle	Used to check LocoNet voltage, turn track power on/off
RRampMeter	Indispensible for measuring DCC track voltage and current
VOM Multimeter	Indispensible for measuring voltage and resistance
Product Manuals	When all else fails, RTFM
Small hand tools	Same tools used for setting up the layout



Test Equipment – 1

“Quarter”

Used for the “Quarter Test”



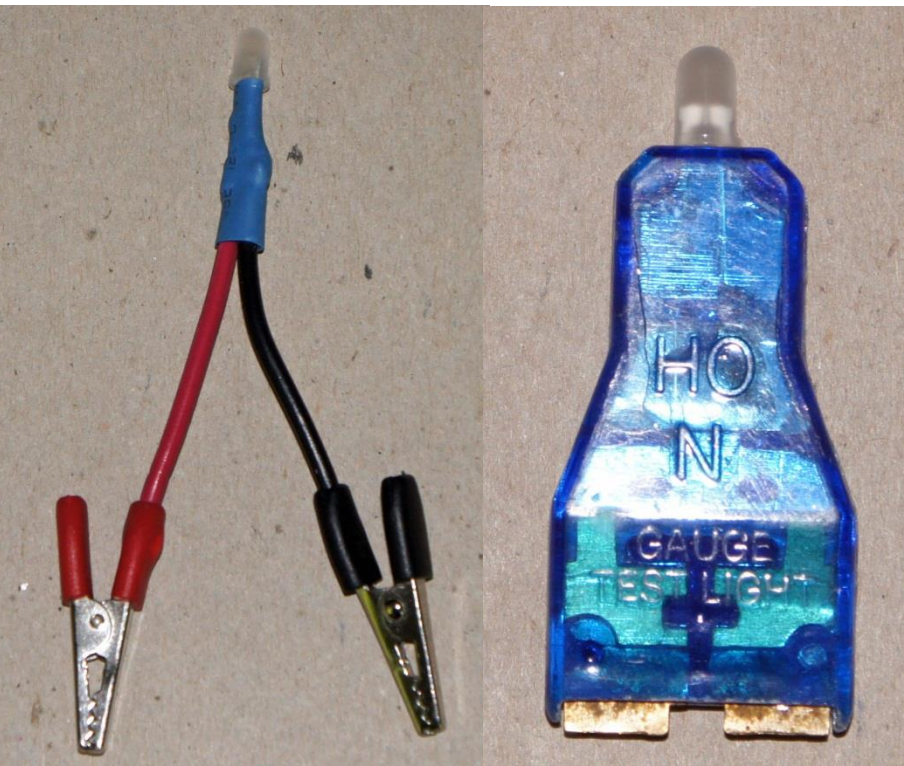
- Quick check for adequate module track wiring
- With track power on, place quarter across rails at end of electrical district. If Booster or Power Manager does not shut down within about half-a-second, then resolve problem or augment wiring.
- If no Booster/PM shutdown then visually inspect wiring from boundary back to supplying Booster/PM. Fix any problems.
- If nothing obvious use RRampMeter to troubleshoot as described later.

If a short does not shut down the Booster/PM heat will build up at location of a short, possibly damaging locomotives and/or rolling stock.



Test Equipment – 2 LED Tester

Used to check track power, track polarity and
Booster phase



- 2-wire bi-color LED in series with 1,000 Ω resistor
- Placed across rails indicates if track is powered and whether DCC (orange) or DC red or green depending on polarity. (red/green)
- Placed on same rail across electrical district boundary indicates Booster phase
 - Lit indicates out-of-phase
 - Dark or very dim indicates in-phase



Test Equipment – 3 LT-1 Tester

Used to check LocoNet cables and RJ plugs



Tests the integrity of the installed LocoNet network.

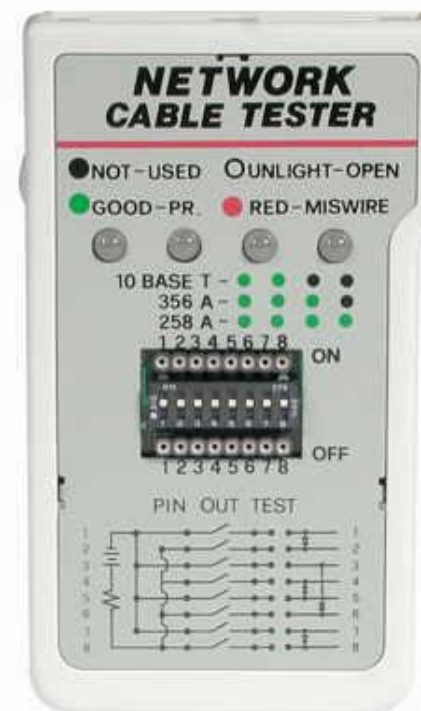
- All four LT-1 LEDs will light if cables and jacks are good to the point tested. (Note: if a throttle is not plugged in only 3 LEDs will light.)
- If any LEDs fail to light, then check cabling back to the point of the last successful test.
 - Two outside LEDs reference Rail Sync lines.
 - Two inside LEDs reference LocoNet data lines.

Note: The LT-1 is not a LocoNet device. During normal layout operations do not leave the LT-1 plugged in longer than necessary to conduct the test. Two LT-1s at the same time will probably bring down LocoNet.



Test Equipment – 4 Network Tester

Used to test newly made LocoNet cables



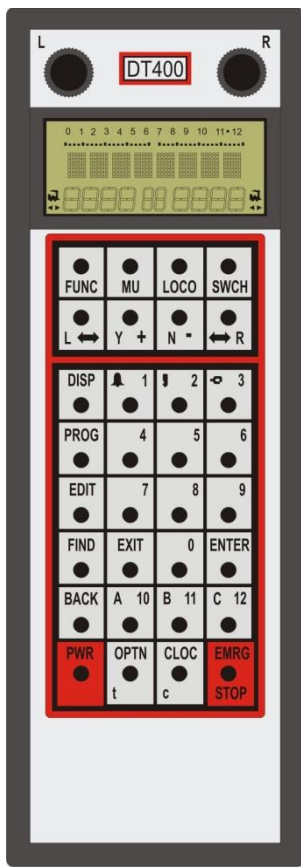
Always test new cables before use. Also use to test/re-test loose cables. Some testers can also work with installed cables.

- Plug cable into tester. Two green LEDs indicate cable is data cable and good. Red LEDs indicate cable is telco cable.
- Single or no LEDs indicate faulty cable.
- While plugged in wiggle cable. Blinking LED indicates potential poor crimp of RJ plug.



Test Equipment – 5 DT4/5/6xx Throttle

Used to check voltages, turn track power on/off



- When battery inserted, briefly shows battery voltage
- When plugged into LocoNet, briefly shows Rail Sync voltage, then briefly shows LocoNet voltage.
- When unplugged from LocoNet briefly shows battery voltage.
- Turn Track Power ON — PWR + Y/+
- Turn Track Power OFF — PWR + N/—



Test Equipment – 6 RRampMeter

Indispensible for measuring DCC track voltage and current, also DC voltage



- True RMS AC voltmeter
- Directly measure track voltage
- In series with track feeder measure track voltage and current.
- With known load (e.g. auto tail lamp) measure voltage drop as you move RRampMeter from power feed to district boundary.



Test Equipment – 7

VOM Multimeter

Used to measure voltage, resistance and continuity



The “universal” meter

- Measure voltage, AC and DC
- Measure current, but not as easy as RRampMeter. Many multimeters cannot handle the high DCC current.
- Measure resistance
- Check continuity
- High impedance does not load circuit being measured



Test Equipment – 8 Product Manuals When all else fails

- **Need definition of OpSw and CV parameters, also meaning of Command Station beeps**
- **Need “how to” instructions**
- **Digitrax — download manuals for all Digitrax products**
- **Others — download decoder manuals, other products as needed**
 - **Lenz, LokSound, NCE, Paragon, SoundTraxx, TCS, etc.**

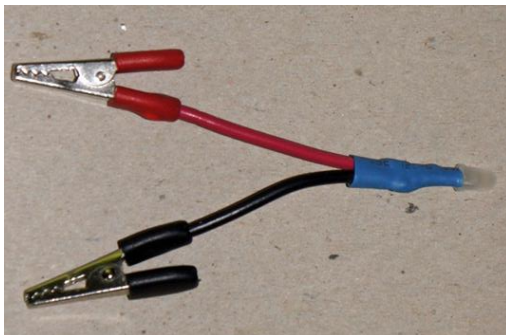
Download to laptop or USB thumb drive. Paper not needed.



Test Equipment “Always Carry” Tools

The DCC person “in Charge” should always carry the following tools with him/her. Then get others as necessary to troubleshoot and solve the problem.

LED Tester



LT-1 Tester



LocoNet Voltmeter





Troubleshooting Design Layout for Ease of Troubleshooting

Electrical Power Districts

- Number dictated by size, shape & complexity of layout
- As well as gaps at electrical district boundaries, put gaps at power feed point

LocoNet

- Split LocoNet into two or more branches
- Consider single LocoNet vs. ThrottleNet + BoosterNet
- LocoNet Repeater(s) very useful in more complex layouts

Grounding

- If layout powered by more than one 120VAC circuit, then run 14ga ground wire between all Boosters and the Command Station
- Connect to electrical ground (through 1 meg Ω resistor) ONLY at the Command Station if needed to prevent static electricity.



Troubleshooting the Layout

First step — determine the affected section of the layout, e.g. electrical district

- **If the layout is equipped with a LocoNet Repeater (LNRP) then a LocoNet problem may be detected by the LNRP diagnostic LEDs.**
- **If not a LocoNet problem, then check for a track short.**
 - **Look for a derailed locomotive/car or loco/car sitting on turnout or gap.**
 - **Check all track and turnouts — ensure gaps are still open.**

As necessary check the various DCC devices in the layout, the track wiring and the LocoNet wiring.

Ensure spares of major components are on hand — Command Station, Boosters, URs, UPs, PMs, LNRPs, LocoNet cables, etc.



Electrical Districts & Track Bus

Gaps at power feed point allow quick determination of which direction a fault lies

- **Unplug one power feeder. If problem goes away, then fault is in the direction of the feeder that was removed. If not, problem in other direction.**

Ensure Power Manager trip current is set to carry the current load required but must be less than the Booster capacity. Use JMRI Configure PM42/72 to read and set.

- **Requires a LocoNet connection to PM42/72 and address set for PM42/72.**
- **Trip current can be reset during operations, as necessary.**

Use RRampMeter to measure current and voltage drop

- **In series with power feed to measure current**
- **With known current load to measure voltage drop**



LocoNet®

- Use only 6-wire flat telephone cable for LocoNet.
- Configure as a data cable, not as a telco cable.



- Do not use Cat 5, Cat 5e, Cat 6, shielded twisted pair, 9 or 25-wire serial cable, etc. These have different impedances than 6-wire flat cable and will affect the LocoNet signals.



LocoNet Problems

- LocoNet voltage measured between wires 3+4 (plus) and 2+5 (minus) with a DC voltmeter.
- LocoNet becomes unstable and/or stops working when voltage is ~7 VDC.
- LocoNet voltage at Command Station with no other LocoNet cables connected should be 14 - 14.5 VDC.
- As devices are plugged into LocoNet the voltage will drop. Anything above 9VDC allows normal operation.
- If low voltage detected begin troubleshooting the entire LocoNet network.
 - If multiple LocoNet branches, disconnect one at a time until voltage returns to normal.
 - Test from the Command Station outwards to the end of the branch, checking each device (cable, Booster, UP, UR, etc.) until faulty device is found. Replace.

Use LocoNet voltage tester & Digitrax LT-1 to determine faulty component.



LocoNet Testing



- ◀ Measure LocoNet voltage
 - Special cable + multimeter
 - Dedicated voltmeter
- ▶ Check LocoNet cable and RJ jacks
 - Digitrax LT-1



LocoNet problems can cause all kinds of bad things to happen.



LocoNet Rail Sync Problems

- **DCC requires Rail Sync signals from the Command Station to provide low-voltage DCC packets to Boosters and accessory decoders.**
- **If a booster is not operating correctly check for the Rail Sync signals using a LT-1 tester.**
 - **The two outer LEDs must be brightly and constantly lit.**
 - **If not, work back towards the Command Station until they are brightly and constantly lit, then identify and replace the offending cable or device.**
 - **For complete and proper operation of the booster all 4 LT-1 LEDs should be lit.**
- **This problem is not the same as a booster “out of phase” condition.**



Locomotive and Decoder Problems

Locomotive(s) is operating normally and then stops:

- **Is track power on to the district in which the locos are located?**
- **Are other locos operating normally in the district?**
- **If yes to above questions, attempt to re-acquire locos on your throttle.**
- **If successful proceed with operating your train.**
- **If not successful replace the loco(s) with known good loco(s).**
- **Take problem loco(s) to the programming track:**
 - **Check that loco is programmed to correct address.**
 - **If not, the decoder could have suffered a check-sum failure and reset itself back to default (address = 03).**
 - **If not the decoder could have become faulty. Replace.**
 - **Check decoder functions other than address.**
 - **Make sure CV19 = 0 unless loco is part of an Advanced consist.**



Throttle Problems

- **Make sure DT4xx/DT5xx/DT6xx throttles have the latest firmware updates installed.**
- **Always suspect the battery first when experiencing throttle problems. Try several.**
 - **Throttles become unstable and stop working around 8 volts.**
 - **A fresh 9-volt alkaline battery is only 8.7 volts.**
 - **Duplex throttle current draw is much higher than simplex throttles.**
 - **Recommend Maha 9.6v Rechargeable Imedion (NiMH) batteries, especially for duplex throttles.**
- **Make sure throttle options are correctly set, e.g. radio vs. IR.**
 - **For DT402D/DT500D/DT602D throttles set display backlight to MIN to reduce current drain.**
- **Earlier outstanding issues with duplex throttles fixed .**

Be sure DT4xx/DT5xx/DT6xx have latest firmware updates installed.



Radios

UR91 Simplex Receiver & UR92/UR93 Duplex Transceivers

Mounting

- As high as possible above the layout
- On poles or “radio towers” for modular layouts, near ceiling for home layouts
- Use multiple UR91/92/93 as required for full coverage of layout
- UR91 and UR92/93 can be co-located in close proximity.

Power

- All UR91 and UR92 *MUST* be powered — use PS14 or equivalent.
- One PS14 or equivalent can power one UR91 and one UR92/93
- Modified UP5 with PS14 can be used to power UR91 + UR92/93 over LocoNet cable

Problems

- Ensure data-style only LocoNet cables between UR and Command Station
- Ensure UR green LED flashes as throttle knob is turned.
- Troubleshoot LocoNet cabling as required; replace UR with spare.



Wireless Throttles in “Noisy” Environments

Duplex and smart phone throttles use 2.4 GHz band. Simplex uses 916 MHz band.

Competing users of the 2.4 MHz band:

- Wi-Fi — IEEE 802.11a/b/g/n specification
- Digitrax Duplex — IEEE 802.15.4 specification
- Microwave ovens — not a problem unless very close (~6’)
- Cordless phones
- Bluetooth (on cell phones)
- Wireless cameras
- Security systems
- Zygbee smart home systems

Smart phones used as throttles follow the 802.11 Wi-Fi spec



Wireless Throttles in “Noisy” Environments

Other “building” source of interference:

- “Noisy” fluorescent or other lighting fixtures
- Older neon signs
- Floor and vacuum cleaners
- Garage door openers
- Welders

These devices inject their “noise” into the power line, which can then get injected into the DCC equipment. Recommend UPS feeding, as a minimum, the Command complex.

- Routers, Wi-Fi Access Points



“Common” Wire Connecting CS with All BS

Keeps all CS/BS at same voltage reference, improves reliable operations.

- 14ga wire (green) connected between the Gnd terminal on the CS to all Boosters**
- No connection between CS or BS to 120VAC electrical ground.**
- However, in low humidity situations a single connection (at CS) in series with a 1 megohm resistor to 120VAC electrical ground is permitted to eliminate potential for static discharge**

Provides protection for both human beings and electronic equipment through the “grounding” of all equipment. In other words our objective is to keep humans from electrocuting themselves and keep the trains running.

Provides smooth transition of locomotives across the double insulated gaps in the track that separate two Boosters, and prevents the possibility of voltage doubling between Boosters which can damage decoders. It also provides more stable operation of the Boosters.



Device Timing

Up to three devices can be involved in device timing:

- **(Command Station) / Booster**
- **Power Manager (PM42/72, PSX)**
- **Auto-Reverser (AR1, BXPA1, PSX-AR)**

Need the auto-reverser to activate before the PM or BS. Adjust detection timings as necessary for proper and reliable operation.

- **(Command Station) / Booster — slowest (1/2 second setting)**
- **Auto-reverser — fastest**
- **Power Manager — in between (slower than auto-reverser, faster than BS)**
 - **PM42/72 detection timing adjustable — in real time via LocoNet connection**
 - **PSX timing not adjustable in real time.**



Keep Firmware Up-to-Date

Several Digitrax devices are user upgradable:

- **DT402, DT402D, DT402R, DT500, DT502D, DT602D, UT6D Throttles**
- **UT4D RF module, not throttle module**
- **Duplex Radio Transceiver (UR92/UR93)**
- **LocoNet Repeater (LNRP)**
- **PR3, PR4**
- **Zephyr Extra/Express (DCS51/52)**
- **DCS210, DCS210+, DCS240, DCS240+ Advanced Command Stations**
- **LocoNet Wi-Fi Interface (LNWI)**
- **Other devices**

Download from Digitrax Web Site “Downloads” page. Instructions on page.

Use either Digitrax software or JMRI to update devices



Command Station

DCS240 is the preferred Command Station for multi-club and/or large layouts.

Be sure CR2032 battery is good in each DCS100 and DCS200 used in the layout, especially those set to be Boosters.

At start of show and each morning, reset Command Station to clear all memory slots.

- **OpSw #39 resets Command Station to default OpSw values**
- **Then reset OpSw parameters to desired values — ½ sec shutdown, 120 slots, purge time, disable analog & aliasing, etc.**

Do a reset whenever everything seems to be going wrong.

JMRI can be used for the reset



DCC Layout Management

Keep the layout operating reliably

Laptop or Raspberry Pi computer running JMRI connected to LocoNet via PR3/PR4 or LocoBuffer-USB. PR3/PR4 required when using Digitrax DigiGroupSetup software for duplex radio transceivers.

- **Set Command Station parameters**
- **Set device parameters — PM42, BDL, PM42, SE8, DS64, LocoNet ID, etc.**
- **Track power on/off**
- **Monitor Command Station slots**
- **Monitor LocoNet messages**
- **Interface with WiThrottle router**



JMRI LocoNet Tools Slot Monitor





Summary

- **Design the layout with reliability of operation and ease of troubleshooting in mind.**
- **Be sure to have the tools and test equipment needed for successful setup, operation of the layout and troubleshooting problems**
- **Monitor layout operations to ensure everything runs smoothly throughout the show.**



Glossary

Command Station: Each system has one command station which receives electrical signals (operator instructions) from throttles. The command station then creates NMRA DCC digital packets in accordance with NMRA specifications to achieve the desired results and transmits these packets to Boosters).

Booster: Booster is the electronic device that combines and amplifies the DCC commands generated by the command station with power from the power supply. The booster sends the DCC commands as electronic signals along with the track power to the decoders to deliver both power and DCC signals to the DCC devices on the layout. A DCC system may have more than one booster.

Throttle: Throttles are input devices that tell the Command Station what you want the decoders to do. You can have many throttles on your system, the number of which is determined by the capabilities of the Command Station.

UR: IR receiver (simplex), radio receiver (simplex) and radio transceiver (duplex) for interconnection with Digitrax wireless throttles.

UP: Universal Panel. A panel mounted on the layout fascia that simplifies the hook-up, maintenance and troubleshooting of the LocoNet layout

PM: Power Manager. A device for limiting the current to one or more electrical district to a safe value, less than the total output current of the Booster, for the equipment being operated.

LNRP: LocoNet Repeater. Isolates segments of your LocoNet layout - Protects segments of LocoNet layouts - Extends large LocoNet installations of more than 20 devices. Acts as a Diagnostic tool if LocoNet network problems occur.

LocoNet: Peer-to-peer local area network (LAN) system architecture used by Digitrax to carry DCC and other commands across Digitrax command control systems.

LocoNet Cable: A 6-wire flat telephone cable used for interconnecting various devices in a Digitrax DCC system. Provides for Rail Sync signals, LocoNet data signals and device power.



References

- North Raleigh Model Railroad Club Web Site — DCC (nrmrc.org)
- Digitrax (www.digitrax.com)
- DCC for NTRAK Layouts – Design and Operational Considerations
(trainweb.org/nrmrc/dcc/ntrakdccdesign.pdf)
- LocoNet & LocoNet Cables (trainweb.org/nrmrc/dcc/loconetandloconetcables.pdf)
- NTRAK Electrical Standards for NTRAK Modules
(trainweb.org/nrmrc/pubs/modwiring.pdf)
- Setup and Train Operations with Digitrax Duplex Throttles and Radio
(trainweb.org/nrmrc/dcc/digitraxduplex.pdf)
- Wiring for DCC (wiringfordcc.com)
- Digitrax and other DCC-related email lists on groups.io