

# Scale Rails

Electrical/Electronic Wiring and  
Troubleshooting Clinic

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# Topics

1. Basic AC and DC circuits
2. Using a meter - Voltage AC/DC, Current AC/DC, Ohms
3. Test Lights
4. Basic electrical formulas
5. LED basics
6. Reading Resistors
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8. Track wiring – feeders, buses, rail joiners
9. Turnouts – Tortoise, switches, LED's
10. Troubleshooting Track Problems
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# Basic AC and DC Circuits

- AC (Alternating Current) is the power supplied to our homes (Westinghouse).
  - Arrives as 120/240 VAC to our homes and small businesses.
  - Large businesses use three phase power.
  - Requires a transformer or switching power supply to lower to levels we use for our train systems.
- DC (Direct Current) is the power used to operate electronics (Edison).
  - Batteries, inverters, Wall warts, Regulated power supplies are examples.
  - Most devices operate with a negative ground just like our cars.
  - Common voltages are 1.5, 5, 12, (24, 48)

# Using a Meter

- Two types of meters (analog and digital)
- Digital is most common today.
- Most meters are designed to measure
  - AC (0-2000 VAC)
  - DC (0-2000 VDC)
  - Ohms (0-10 Meg Ohms)
  - Ohms (short test) (tone)
  - **Current (0-250 MA and 0-10 Amps) be careful!!!**
    - Never leave meter set to current setting (MA) or leave probes in Current positions. Can result in blown fuse or damage to meter. Always double check.
  - Warning: Working with voltage beyond 12V is dangerous.

# Test Lights

- Purpose: Test for presence of voltage.
- Types:
  - Neon (Use only with AC) (120-240 VAC)
  - Incandescent (each bulb as voltage limits). Most common is 12-18 Volts. Works on AC or DC.
  - LED (Requires LED with resistor in series). A LED with a 2.2K resistor will let you test up to 24 Volts AC or DC. If you only want to test 12-15 Volts then use a 1K resistor.

# Basic Electrical Formulas

- $V=IR$ 
  - **Voltage(V)** equals **Current(I)** \* **Resistance (R)**
  - What value resistor do you use with an LED?
  - $R=V/I$
  - DC Power supply is ~12V. 15ma is good for LED's.
  - $12V-(\sim 1V \text{ for each LED in series})/15\text{ma} = 11/.015 = 700 \text{ ohms.}$
  - 1 K (1000 ohms) is a common value.
- $\text{Watts} = I * V$  or  $I^2 * R$ 
  - How many Amps is a circuit drawing?
    - Take the average hairdryer (1800 watts).
    - $I=W/V=1800/120=15 \text{ amps}$
  - What wattage resistor should I use ( $\frac{1}{4}$  or  $\frac{1}{2}$  watt)?
    - $W=I^2 * R=1000 * .015 * .015 = .22 \text{ watts (suggest } \frac{1}{2} \text{ watt)}$

# LED Basics

- LED's are a constant voltage device. This means you must limit the current they draw to avoid killing them.
- Stated another way. As you raise the voltage across the LED, the voltage will rise until it hits the turn-on threshold of that LED (~1.5 VDC). Once it turns on, it will draw as much current as possible until either the power supply gives up or the LED dies. Usually the LED will die first. LED's like 15ma (.015 amps).
- LED's can never be put in parallel but can be put in series. Standard LED's must always have a current limiting resistor. The series method can be used in lighting buildings and passenger cars. Try a max of four in series. So that's  $4 \times 1 \text{ volts} = 4 \text{ volts}$  drop across the LED's. Then  $12 - 4 = 8 \text{ volts}$  across the resistor. So then the resistor value is  $R = V/I$  or  $8 / .015 = 533 \text{ ohms}$ . 470 is a common value (yellow-violet-brown).
- Common resistors are 10, 22, 33, 47, 68, 100, 150, 220, 270, 330, 470, 560, 680, 760, 1K, 1.2K, 1.5K, 2.2K...

# Reading Resistors

- Resistors have four bands of color.
- Hold the resistor with the silver or gold band to your right.
- Starting from left to right.
  - The first band is a number
  - The second band is a number
  - The third band is the number of zero's
  - The fourth band is tolerance (accuracy). Gold = 5%, Silver=10%
- Band colors to numbers.

•0 = Black	•5 = Green
•1 = Brown	•6 = Blue
•2 = Red	•7 = Violet
•3 = Orange	•8 = Gray
•4 = Yellow	•9 = White
- Example: You want a 1000 ohm resistor (1K) (K=Kilo=1000)(M=Meg=1,000,000)
  - 1=Brown, 0=Black, 2 zeros = Red (Brown-Black-Red)
- Example: You have a Resistor (Red-Red-Red) What value is it?
  - Red=2, Red=2, Red=2 Zeros=2200 ohms or 2.2K



# Building Lighting

- Incandescent
  - Suggest using a 9-12 Volt system.
  - Can use AC or DC with incandescent lamps.
  - Suggest running the incandescent lamps at 75% of rated voltage to extend life.
  - Remember that incandescent lamps draw a lot of current and get hot.
- LED's
  - Suggest using LED warm white lamps. Greatly reduces the power demands on the wall-warts.
  - Cheapest way to buy LED's is Christmas lights (<\$.20/each).
  - You can put LED's in series but never in parallel.
  - You can usually put four in series with 12VDC, remember to add a resistor.
  - Some of the LED's have resistors built in already. LED's run best drawing between 10-15 ma. I bought a set at Target and put four in series without a resistor. They drew 8 ma at 12-13 VDC.

# Track Wiring

- Never rely on rail joiners to conduct power! Will break down over time.
- Soldering rail joiners will conduct power but can cause trouble when the track expands or contracts with temperature changes.
- **Always** install power drops/feeders on each section of **track** and all **turnouts**. 22 gauge stranded wire is a good choice. Keep the two colors consistent at all times.
- Use 12 gauge wire for buses. Stranded is easier to work with but solid will work.
- Make the feeders and the buses the same color if possible.
- Good idea to put a short tester across the two rails while connecting track. This will show a problem quickly.
- **Avoid using power routing turnouts. I feel they should be burned and then be careful where you put the ashes. Never use them on any part of a reversing loop.**
- DCC Insulated frog turnouts can be used. Suggest using Electro-frog turnouts for best results. Power the Frog off the tortoise switch contacts.
- Suggest powering each major track section from a separate electronic circuit breaker. Makes finding track shorts easier.
- Currently find DCC Specialties (Tony's) the easiest to work with.
- Block switches can be added to power off tracks but not necessary in DCC.

# Wiring turnouts

- Suggest using Electro-Frog turnouts.
- Electro-Frog turnouts (DCC) friendly require no additional gaps to prevent shorts unlike the power routing turnouts.
- Always connect two feeder wires to the turnout outside rails to prevent future power problems.
- Suggest adding jumper wires on the output rails A to A and B to B. Some manufactures put in tack welded jumpers but they seem to fail.
- Suggest using a Tortoise switch machine to operate the turnout.
- Parts needed to operate the turnout.
  - 12 VDC supply, wall-wart (\$5). Can operate many.
  - Tortoise switch machine (\$15-18)
  - DPDT toggle switch, no center off (\$1.50-2.00).
  - Two bi-color R/G LED's (\$.40)
- See handout for wiring diagram.
- Use Tortoise switch contacts to power frog.

# Troubleshooting Track Problems

- Problem: Loco stops on turnout or open track.
  - While loco is stopped. Don't touch. Get your meter and set to AC volts for DCC and DC volts for DC power.
  - First measure the track power on each side of the loco.
  - If one side is zero:
    - Next measure across the rail joiners. You should find voltage across one of the rail joiners. This is the problem area.
    - Fix for problem two ways.
      - Add feeders to fix the problem. Preferred. Both rails.
      - Or Solder a wire across the rail joiner. Do the other rail joiner too, it will fail soon.
  - If not zero:
    - Then check for dirty track. Check the frog power if so equipped.
    - If frog power is zero, then check for bad tortoise contacts. Rare.
  - If problem still exists, check to see if loco has dual power pickups. One set may be not working.

# Locomotives

- Most new locomotives come with DCC (motion and/or sound).
- All are set to address 03. Usually want to set to the cab number (1-9999).
- Address can be changed with throttle or computer.
- Newer MRC decoders support read back capability. Required to set by computer. Older ones do not.
- BLI (Blueline) series is also difficult to work with. Other BLI OK.
- MTH are difficult to program. Avoid.
- Most manufactures support the 8 pin plug if decoder is not already installed. Easy.
- If not DCC ready then you have some work to do. You may need help.
  - Check the running and stall current of the motor.
    - Set the DC track voltage to 12VDC.
    - Set the meter to high/10 amp range. Connect meter in series with DC track power and the loco.
    - Connect power to the motor. See how much current the loco draws running. Hopefully 250-300 ma.
    - Then stall the loco to measure the peak current. If it stays around 500 ma then you are ok. If it goes over 1 amp then you must repower the loco or buy a high current decoder. Digitrax is the only company making a 2 amp decoder. 2 amps running 4 amps peak. It is large and would require a steam tender. Would not fit in a diesel frame.
    - Can type motors usually draw less current when stalled. Open frame (5 pole) motors will cause trouble.
  - Check if the motor is isolated from the frame.
    - Find the two motor wire leads. Disconnect them. Use the ohms setting on the meter to make sure that the motor wires are not in contact with the rail pickups (track power).
    - Many old motors use the frame of the motor for one of the power connections.
    - If so, you must isolate the motor or you will burn out the decoder.

# DCC System Basics

- Many systems available today.
  - Layout size and total number of operating locomotives are key parameters.
  - Don't suggest mixing DC and DCC.
- Most DCC systems require the following:
  - AC power pack (converts 120VAC to 16-18VAC)
  - Command station (Develops DCC track voltage and digital controls).
  - Throttle (allows user to operate one or two locomotives).
  - Decoder (installed in locomotive, receives DCC signal from throttle via track to operate DC motor in locomotive (also lights and sound if installed)).
- Digitrax products
  - DCS51 – good for up to 4 basic locomotives. 22 slots. Keep in mind that complex sound takes more start up power. (\$150-225)
  - DCS100 – good for 8-10 locomotives. Complex sound OK. 22-120 slots. (\$400)
  - DT402D – dual throttle (\$200)
  - UT4/UT4D – single throttle (\$70, \$119)
  - UR90 - IR receiver (\$40)
  - UR92 – IR and Radio receiver (\$120)