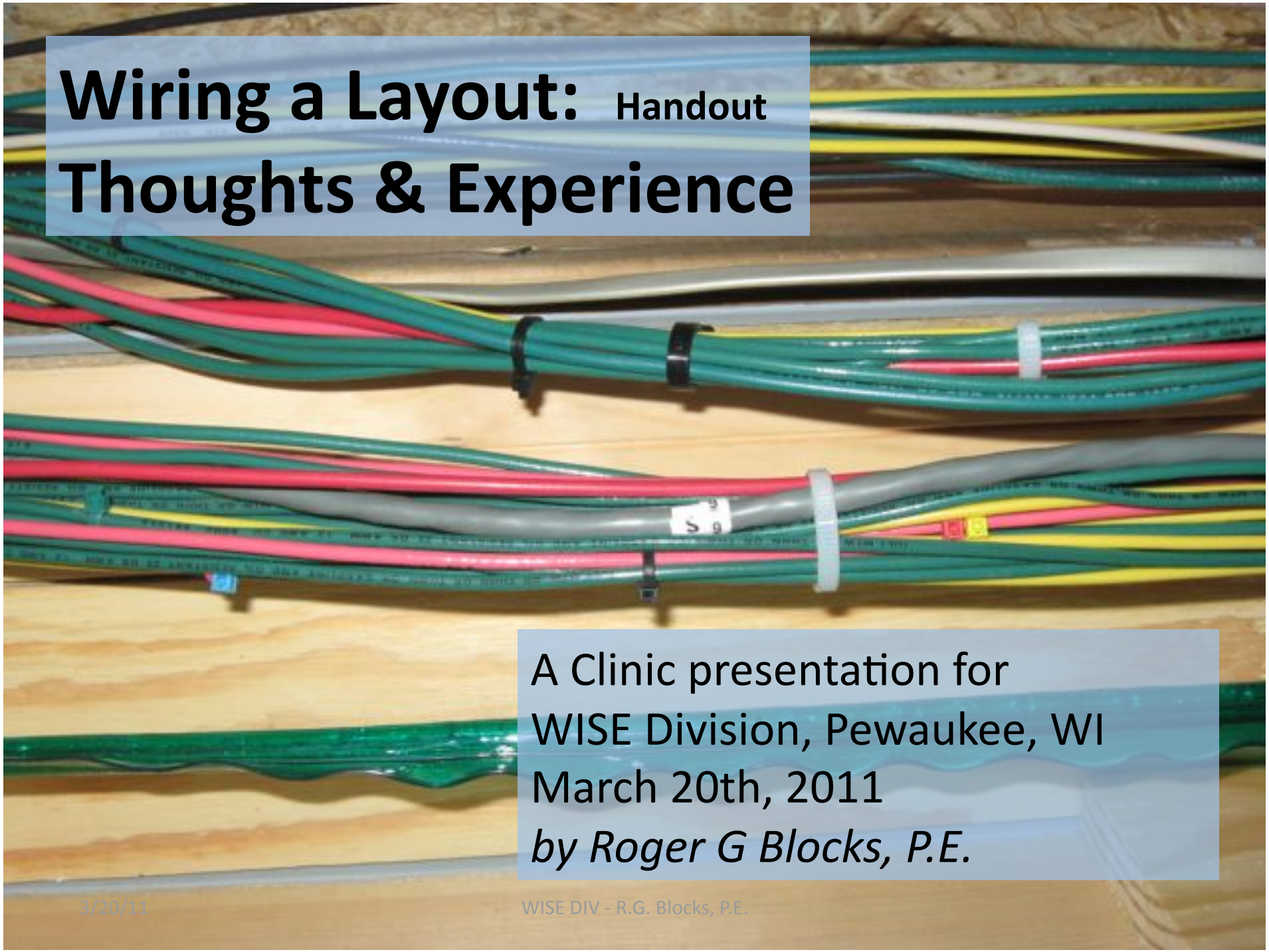


Wiring a Layout: Handout Thoughts & Experience

A Clinic presentation for
WISE Division, Pewaukee, WI
March 20th, 2011
by Roger G Blocks, P.E.

Refresher Info

Basic Ground-rules

- NEC – National Electrical Code specifies wire
- We'll simply cover some rules of thumb
- Ours will be an overview: see NEC for details
- I'm not telling you what to do or use (disclaimer)
- Be smart: do it right the first time (costs less)
- Read, plan, consult, design, review, build

Wire Capacity

- Wire choice: Al vs Cu vx Clad
- It is all about heat
- You don’t want to overheat insulation
- You don’t want to melt the wire
- You don’t want to start a fire
- Cu is the most affordable & it’s easy to solder

Copper is it.. For now

- Copper is the only choice for your wire
- Insulation of used wire is unknown…use new
- 75 degree C (167 F as one max limit)
- 75 degree C will produce 3rd Degree skin burn
- Obviously way too hot…
- If you feel heat in your wire.. Go up a gauge
- Better: use a reliable meter and a little math
- Stranded vs. Solid.. Stranded is superior (more surface area and much more flexible…)

Electrical Computations

- $V = I \times R$: volts = amps times resistance
- $R = V / I$: resistance = volts divided by amps
- $I = V / R$: amps = volts divided by resistance

- $P = V \times I$: watts = volts times amps
- $P = V^2 \times R$: watts = volts squared x resistance

see next slide for all of the combinations..

NEC for Homes

- 14 AWG = 15 Amp max
- 12 AWG = 20 Amp max
- 10 AWG = 30 Amp max
- Note these are the max that you should expect out of wire…
- Many homes (14 Gauge) use switching power supplies in TV's, Microwaves, Amplifiers in Sound systems… and the neutral is warm !

Wire is a resistor

	Max Amps in Air Unconfined Wire	Max Amps for Confined Wire
• 24 Ga.	3.5 Amps	• 2.1 Amps
• 22	7.0	• 5.0
• 20	11.0	• 7.5
• 18	16.0	• 10.0
• 16	22.0	• 13.0
• 14	32.0	• 17.0
• 12	41.0	• 23.0
• 10	55.0	• 33.0

Rules of thumb & de-rated wire

- Wire diameter doubles every 6 AWG gauges you go up (true for solid and close for stranded)
- Change of 3 AWG gauges will halve or double amp capacity (10 AWG=30 Amp, 13 AWG=15 Amp)
- Two strands of any AWG is the same as one strand of wire 3 AWG gauges lower (2 of 20 ga. = 1 of 17 ga.)
- Resistance goes up with temperature
- Use the 60 C or 140 F tables rather than cold wire tables at 20 C or 68F for safety.
- Be conservative as in the following table

Ohms / Foot : Long Runs

- 24 AWG = 3.12 Ohm / 100 ft
- 22 = 1.96
- 20 = 1.23
- 18 = 0.776
- 16 = 0.488
- 14 = 0.307
- 12 = 0.193

Voltage Drop.. Thicker wire

- An HO engine draws about 1 amp give or take
- Lets' start with track being 50 feet from the transformer and figure the drop with 12 ga.
- Two wires x 50 ft = 100 ft… as in the table
- V = I x R = 1.0 Amp x 0.193 Ohm = 0.193 Vdc
- If we apply 6 volts.. Then 6 - .193 = 5.807 vdc
- Or a voltage drop that is about 3.5 % ..

Voltage Drop.. Thin wire

- An HO engine draws about 1 amp give or take
- Lets' start with track being 50 feet from the transformer and figure the drop with 24 ga
- Two wires x 50 ft = 100 ft… like in the table
- V = I x R = 1.0 Amp x Ohm 3.12= 3.12 Vdc
- If we apply 6 volts.. Then 6 – 3.12 = 2.88 vdc
- Or a voltage drop that is about 52 % .. Wow

Consider Wire Routing

- If & where to put hardwire turnout controls
- If & where to put classic block controls
- Centralized or decentralized (by Division)
- Control the expense of your controls
- Work so later modifications are possible
- Reduce probable snagging hazards
- Power vs. Signal wiring separation… etc.

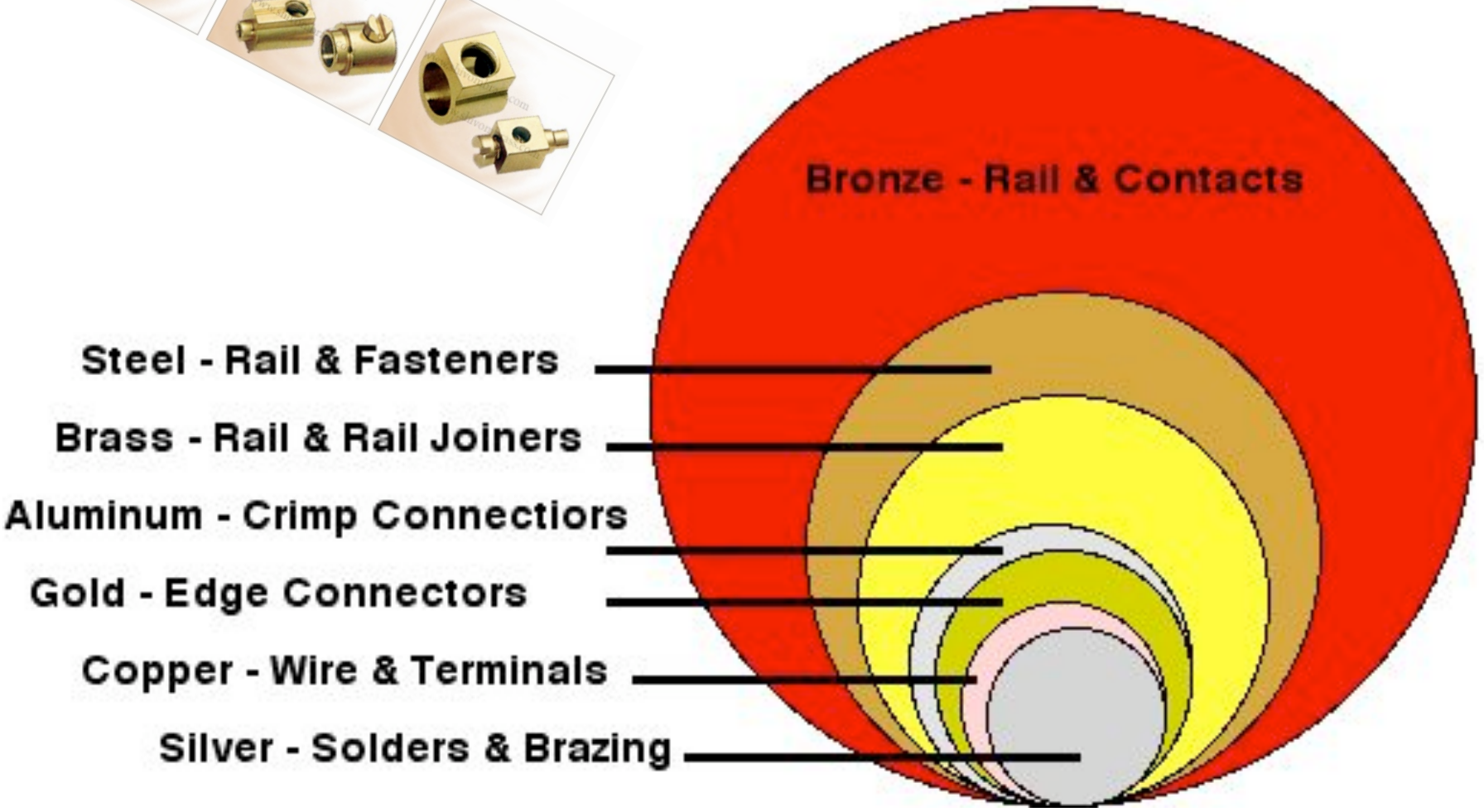
Wire Support

- Train table design influences wiring
- Use simple pass thru where possible
- Use coat hangar (cheap) suspenders
- Glue or Tape (and screw) wire tie supports
- Can be added without disturbing scenery
- Use 12 gauge stranded wire for typical blocks
- Install track feeder (18-22 ga) about every 10 ft

Various Conductors

- Stan Kenton, Paul Whiteman, Dizzy Gillespie
- Silver – Nickel alloy (85% Ag – 15% Ni) super
- Copper (best conductor for the price) good
- Aluminum (darn good, 61% of CU) good
- Brass: (60+% Cu, 30+% Zn, 1% Sn) modest
- Steel – Iron (and a little C + minors) lousy
- Bronze: (88%Cu, 12%Sn) typical bad

Nominal Material Cross Section for about the same Conductivity



Generally Avoid

- Various staples, staple guns for supports
- Various household wire nailer devices
- Two good reasons for avoiding:
  - Too easy to penetrate the wires
  - Shock disrupts the scenery
  - You can get away with it sometimes..

Terminal Barrier Strips

- Larger Terminal Blocks for Power Wiring
- Smaller Terminal Blocks for turnouts
- Mark your wires with numbers / letters to
- Match your layout drawings
- Use crimp connectors (& solder small wires)

Double Pole, Double Throw

- Good for buck: get good contact ratings
- Can do two things simultaneously
- Need to be able to visualize ..
- Source (American Scientific in Milwaukee) or say Chester's (Kenosha)

AC Transformers

- Vary from the simple to complex
- Marx, Lionel and MTH show evolution
- Range typical 6 to 18 VAC
- Characteristics include:
  - Polarity plugs today
  - Circuit Breakers today
  - Need fast CB or Fuse for DCS

Simple DC Power Supplies

- Similar to AC with a rectifier
- Range perhaps 2 – 12 VDC
- May need to fix range if DCC
- Older units may require external Circuit Breaker
- DCC (and DCS) both require quick response to a short circuit.. See manufacturer's instructions
- Will be updated/discussed in first DCC class !

Block Control

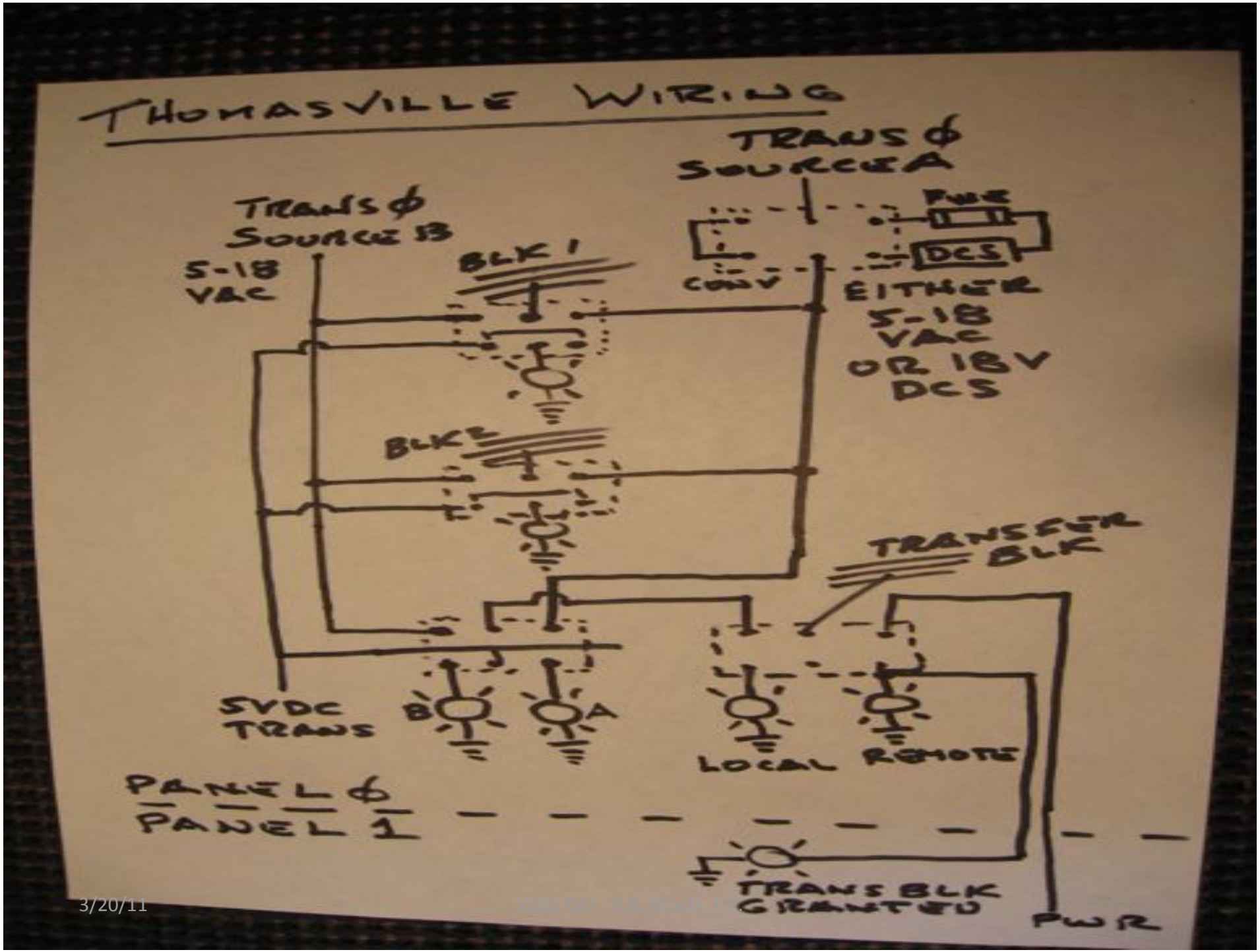
- A block is an electrical control zone
- Classically: more blocks = more trains
- Today's DDC, DCS & DCC: still need some
- Generally Favor: isolate both tracks
- AC three rail: signaling & accessory operation

Reversing Engines

- Classic Lionel reversed direction in Engine
- Classic DC reversed polarity at power supply
- DCS from MTH reversed direction in Engine (AC)
- DCC now reverses direction in Engine (DC)
- Digital reversing is done via a signal on or in the power signal (a digital message)
- Want to be able to run classic DC? Keep DPDT.

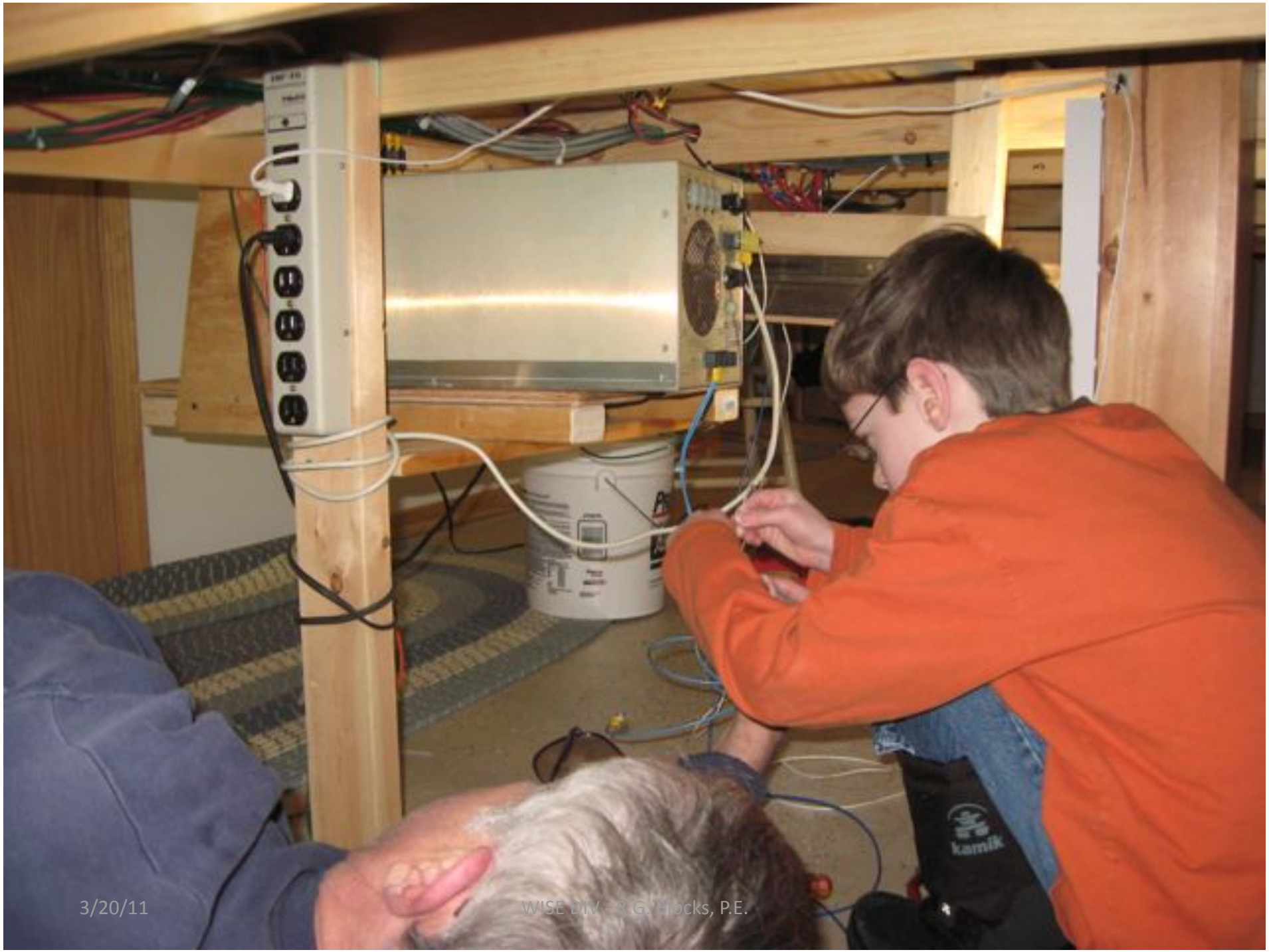
Reverse Loops in DC

- Follow the rails, without blocks = short circuit
- Easy solution: insert a block to prevent short
- Then, add a DPDT switch to reverse polarity
- Y's, Turntables & crossovers have same challenge
- DCC for DC systems solves polarity problems at loops and crossovers with automated devices
- AC systems do not have this problem.


THOMASVILLE WIRING
TRANS Φ SOURCE A
TRANS Φ SOURCE B
5-18 VAC
BLK 1
CONV
PWR
DCS
EITHER 5-18 VAC OR 18V DCS
BLK 2
TRANSFER BLK
SVDC TRANS
B
A
LOCAL
REMOTE
PANEL Φ
PANEL 1
TRANS BLK GRANTED
PWR

Summary

- Covered Design: Distributed vs. Centralized
- Blocks and their use
- DPDT contacts: value for reversing or two voltages
- DPST contacts: value for isolation or two voltages
- Logical design for AC and DC classic operations
- Ability to run AC / DDC / and DCS modes
- Background for Auto-Routing and DCC !


kamik

Currently wiring these details