The Art

of

Trouble shooting

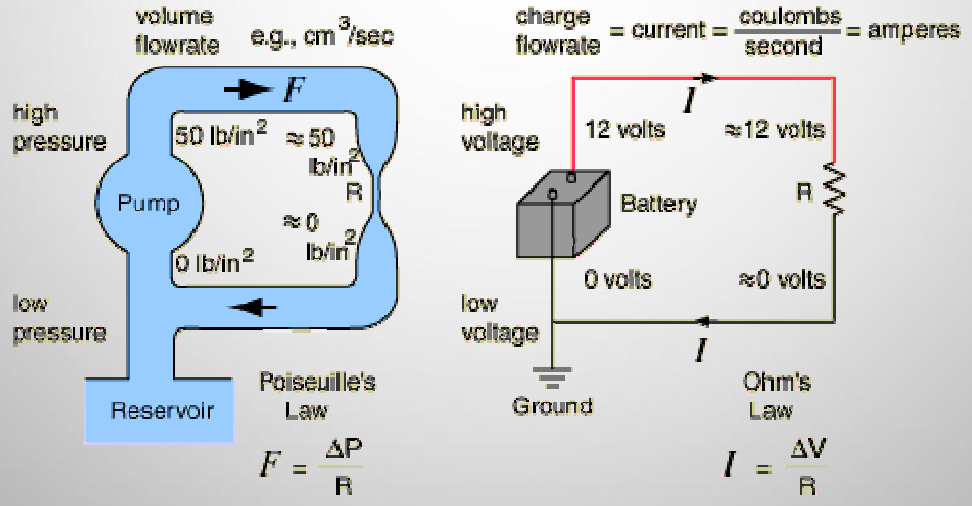
Two wire

How 2-Wire Works

- There are only two wires (the 2-wire!) going from the controller to all the decoders
- There is always a voltage on the 2-wire
- The current flowing depends on the number of decoders installed

Electricity

- Electricity is similar to water flow:
  - Volts (V) is like water pressure
  - Amps (I) is like water flowing
  - Resistance (R) is like friction loss



Electricity

The relationship of Volts, Amps, and Resistance is called Ohm's Law.

Mathematically:

I = E / R Current (I) equals voltage (E) divided by resistance (R)

- As the voltage goes **up** (higher pressure), the current (flow) goes **up**
- As the resistance goes **up** (corrosion on splices, smaller wire), the current goes **down**
- As the resistance goes **down** (2-wire shorted, more decoders added), the current goes **up**

2-Wire Electricity

- Voltage always on
- Current depends on resistance (higher R = lower I)
- Resistance depends on
  - The number of decoders (more decoders = less resistance)
  - Length of 2-wire (longer = greater resistance at end of wire = lower voltage at end)
  - Size of 2-wire (smaller = greater resistance at any given place)
  - Problems on 2-wire (wire, splices, decoders)

2-Wire Problems

2-wire problems include:

- Nicks in wire (copper exposed, leaving one or both wires touching the earth)
- Dead shorts (wires touching each other)
- Bad splices
  - Corrosion (high resistance in wire)
  - Water in splices (shorted to earth, like nicks)
- Decoders
  - Bad (lightning damage)
  - Connected incorrectly (blue always goes to 2-wire)

What should the current on your 2-wire be?

- **It depends on the resistance**
  Basically, this means the number and type of decoders
- **Establish Your Benchmark**

How? Find out how many decoders there are on your site.

- Each LD-050, LD-100 and LD-200 takes ½ (0.5) milliamp.
- Each LD-400 or LD-600 takes 1 milliamp.
- Each Sensor Decoder (SD-100) takes 7 milliamps.
- RKLD-050 takes 0.5 ma

Here's an example of a site:

Size Decoder	Quantity		Total Milliamps
LD-050	15 x .5	=	7.5 ma
LD-100	15 x .5	=	7.5 ma
LD-200	20 x .5	=	10 ma
LD-400	10 x 1	=	10 ma
LD-600	5 x 1	=	5 ma
SD-100	1 x 6	=	7 ma

Benchmark: 47 ma

Or Guesstimate

- If you are having problems and you don't know the Benchmark for your system, use this simple procedure:
- Determine how many decoder *addresses* are in the system and multiply by 0.5 ma. (Addresses in the decoder setup, e.g., under Setup (Main Menu) > Installation > Decoders. RKD you just have to know.)
- Worst-case scenario: your benchmark will be at the highest possible current draw.
- I.e.: 200 addresses x 0.5 ma = 100 ma (if all LD-050)

  but if actual system were using all LD 400, that would be 50 decoders, @ 1.0 ma / dec = 50 ma
- *50 ma extra is not a show-stopper when it comes to extra current on the two wire path.*

Universal Troubleshooting Procedure

If you can move the Problem,

you can solve it!

Three Facts

It is only Two wires!

The longest piece of wire in the system is the greatest distance between two valves!

Chase the High Number!

Troubleshooting 2-Wire

A practical approach can be divided into answering two (2) relatively simple questions.

Is the fault in the:

1. **Controller**

   or

2. **Field** Installation (two wire path).

The Controller

- If there's too much current on the 2-wire, the controller will display the message "short circuit."
- If this happens, power down the controller.
- Then disconnect the two-wire path from the controller.
- If you can move the problem, you can solve it!

The Controller

- Turn the controller back on.
- If the message remains on the controller, the controller is at fault. Call your local distributor or Tucor for an RGA. (Return Goods Authorization.)
- Depending on the situation, a loaner maybe available.

The Controller

- If the controller comes on without the short message, the problem exists **in the field** and not in the controller.
- To continue troubleshooting, turn the controller off again and reconnect the 2-wire path.

DC vs. AC

- DC – Direct Current – is like a battery.
  - Voltage never changes polarity. One wire is always positive, the other negative.
  - Current only flows in one direction, positive to negative.

DC vs. AC

- AC – Alternating Current.
  - Voltage changes polarity. First wire “A” is positive and “B” negative, then they switch to A=negative and B=positive, back and forth.
  - Speed of change is called frequency, measured in cycles per second or Hertz (Hz).
  - Since voltage is changing, current also flows in both directions, back and forth, at the same frequency.
  - Your house’s electricity is 60 Hz, 120 VAC. Tucor’s is 1 Hz, 24 VAC.

Two-Wire Path Voltage and Current Measurements

Remember:

You're only troubleshooting a piece of wire!

The longest piece of wire in a two wire system is

The greatest distance between two valves

or

The distance from the controller to the first valve or splice.

Tools

Standard Digital Multimeter

- Needed for voltage measurements
- Must read AC and DC levels
- Must measure and display voltage and current down to .00X (millivolt = 1/1000 of a volt, or milliamp = 1/1000 of an ampere)
- Must measure and display resistance down to 1 ohm.

Amprobe AC50A Clampmeter

- Invaluable for troubleshooting two-wire path faults
- Must measure *milliamps* AC (to 0.5 ma)
- No need to disconnect wire path
- Does not measure resistance

Know your equipment!

Have it with you!

Know ***how*** to use it before you *need* to use it!

Know that it works ***properly*** when you need to use it!

The Two Wire Path

What am I looking at?

In the normal operational mode, the two wire path works on a 1 Hertz (Hz) signal

(1 cycle per second – AC)

Your house electricity operates on a 60 Hz signal

(60 cycles per second)

What you will measure

- You can measure an AC *voltage* (with a voltmeter) only if there's *not* a short on the 2-wire. If you have a short the voltage = 0!
- There will be an AC *current* (measured with a clamp-on ammeter) only if there is a completed circuit on the 2-wire. A short will cause a high current (> 250 ma). But if there's an open circuit, ma = 0! A different problem!
- Chase the HIGH NUMBER!

Troubleshooting

The two-wire path is easy to troubleshoot and repair. Finding Leaks to ground and bad decoders is straight-forward. Here are some common symptoms of a damaged two-wire path or bad decoders:

- Controller displays “short circuit” (leak to ground)
- A series of valves do not work (open 2 wire)
- A single valve fails to operate (bad wire connection)
- Some valves work erratically (leak to ground)
- Older valves do not work (solenoid issues)

- Solenoids are not easily identified when they have ground faults.
- Decoders have electrical switches inside that are only connected to the solenoid when the decoder is told to turn on by the controller.
- When you turn on a valve, there is a high inrush current to pull in the solenoid. It quickly drops to a much lower holding current. The Holding voltage is typically measured at about *2 VDC, not 24 VAC.*

- At this point you want to turn the controller back on and place it in *Short Finding Mode*.
- Go into the **Test Menu** and enable the *Short Finding Mode.*
- When the controller is in Short Finding Mode, it sends out 37-40 VAC in the 50Hz mode so that your clamp meter and voltmeter will pick it up.

Scenario – excessive leak to ground

Chase the High Number

Understanding your benchmark (for example, 46 ma), your system is reading (with clampmeter) 330 ma.

Chase the High Number

Find a three-way splice halfway out.

(Do not go to the nearest valve, splice)

Chase the High Number

If you read 330 ma in, with 330 ma and 0 ma out, then

Chase the High Number

You will only read what is coming back through the clampmeter.

Chase the High Number

It’s the Law*

The electrical current entering a junction must equal the current leaving the junction.

If 150 ma comes from the controller into a valve box, the sum of the currents leaving must be 150 ma.

* Kirchhoff’s Current Law

- Continue to Chase the High Number
- Always “break the system in half” each time you move.
- If you get to a three-way splice and read only zeros, the problem is behind you (back towards the controller).

Measurements

Two Types of Measurements: "Normal Mode" and "Short Circuit Mode"

- Normal voltage = Two-wire path voltage when controller is powered on & no valves (decoders) are active

- Good line voltage: Multimeter will swing from +35 to -35 volts about once a second, not a good way to troubleshoot, very difficult to determine the accurate voltage.

- Note: some meters have a "peak hold" option. This can be used to measure the highest voltage (+35) when in Normal.

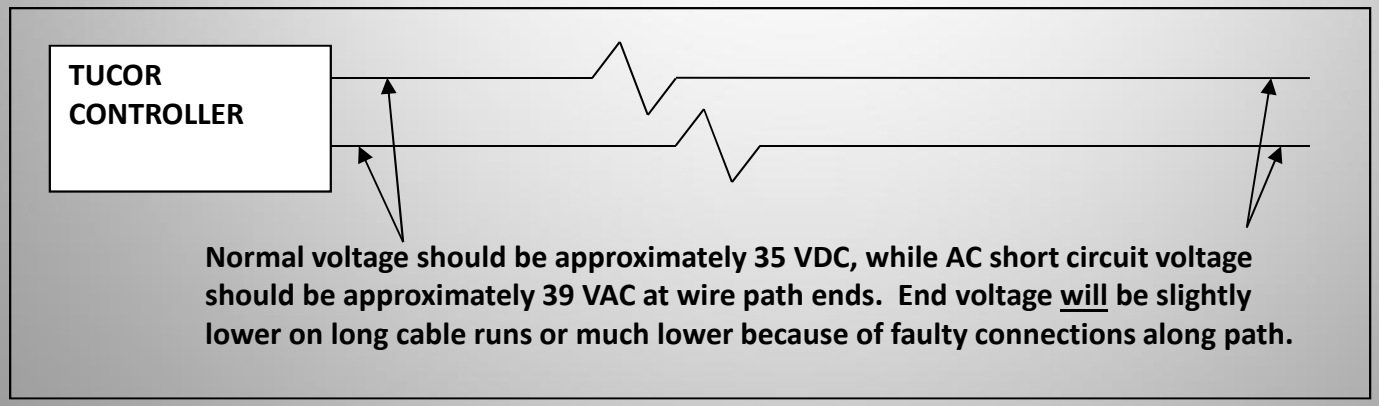
Obtaining Normal Voltage Set

1. Set multimeter scale to V-DC (sometimes represented by [V-])
2. Set multimeter range to read a maximum of 40 volts

   Typical meter voltage ranges are 2, 20, 200; or 1, 10, 100; or 5, 50, 500; so set the range accordingly.

   Ex. If the multimeter has ranges of 2, 20, 200 – set the range to 200.

3. DC normal mode should read +/- 35 volts.
4. Voltage should not be lower than +/- 30 VDC



Obtaining AC Short Circuit Voltage Set

- Set multimeter scale to V-AC (sometimes represented by [V~]).
- Set multimeter range to read a maximum of 40 volts.
- AC short circuit mode should read 35-37 volts.
- Voltage should not be lower than 30 VAC; this indicates probable leakage to ground (system will work, but erratically).

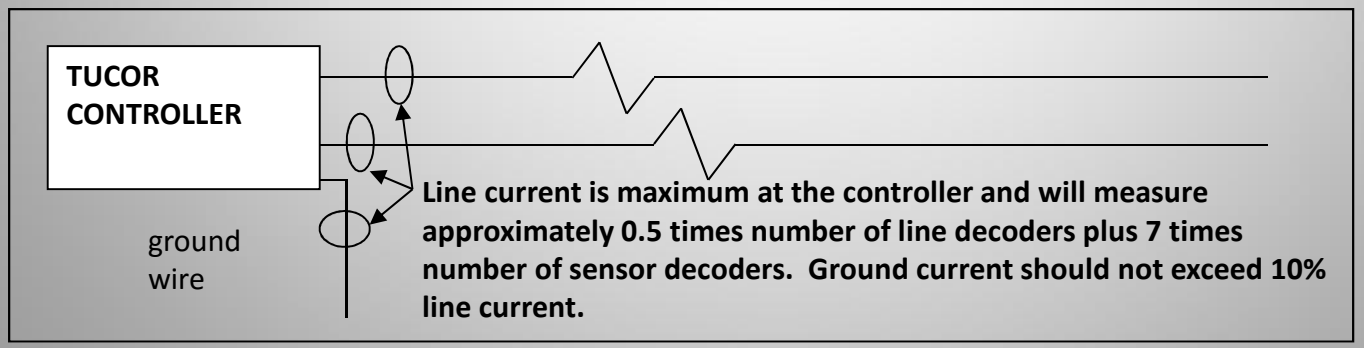
Obtaining Current Measurements

1. Place the controller into “Short Circuit Mode”
   a) Places a 50 cycle, 38 volt AC signal on the two-wire path
   b) Limits line current to a safe maximum so as not to damage the controller’s electronics from a line short
2. Set clampmeter to lowest range (if benchmark is higher than lowest range, use next setting)
3. Clamp meter around **a single wire** at a time
4. Measure current individually in both wires of the two-wire cable and in the ground wire

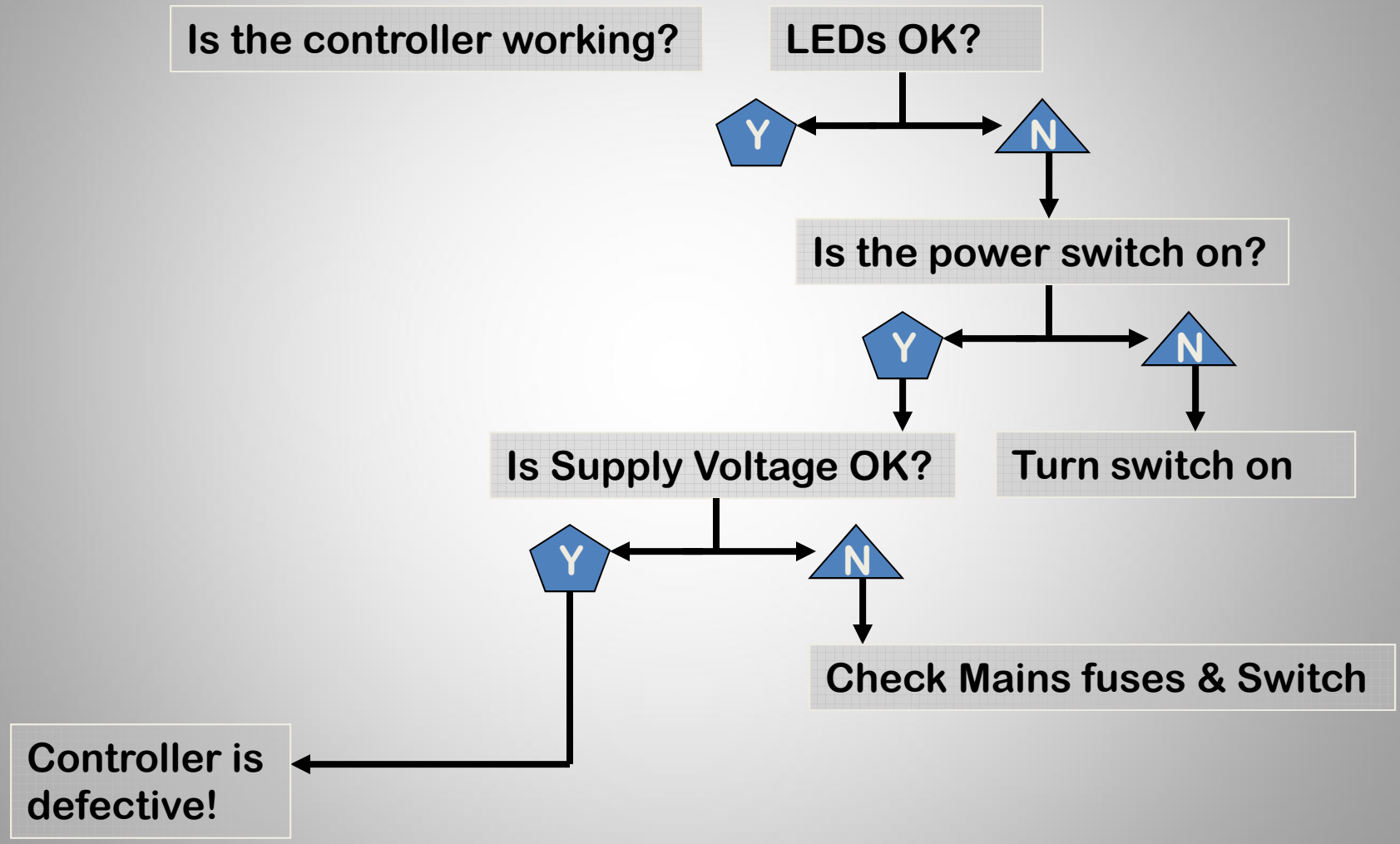
At the controller end, maximum current in short circuit mode will be approx.
0.5 ma x # of decoders + 7 ma x # of sensor decoders

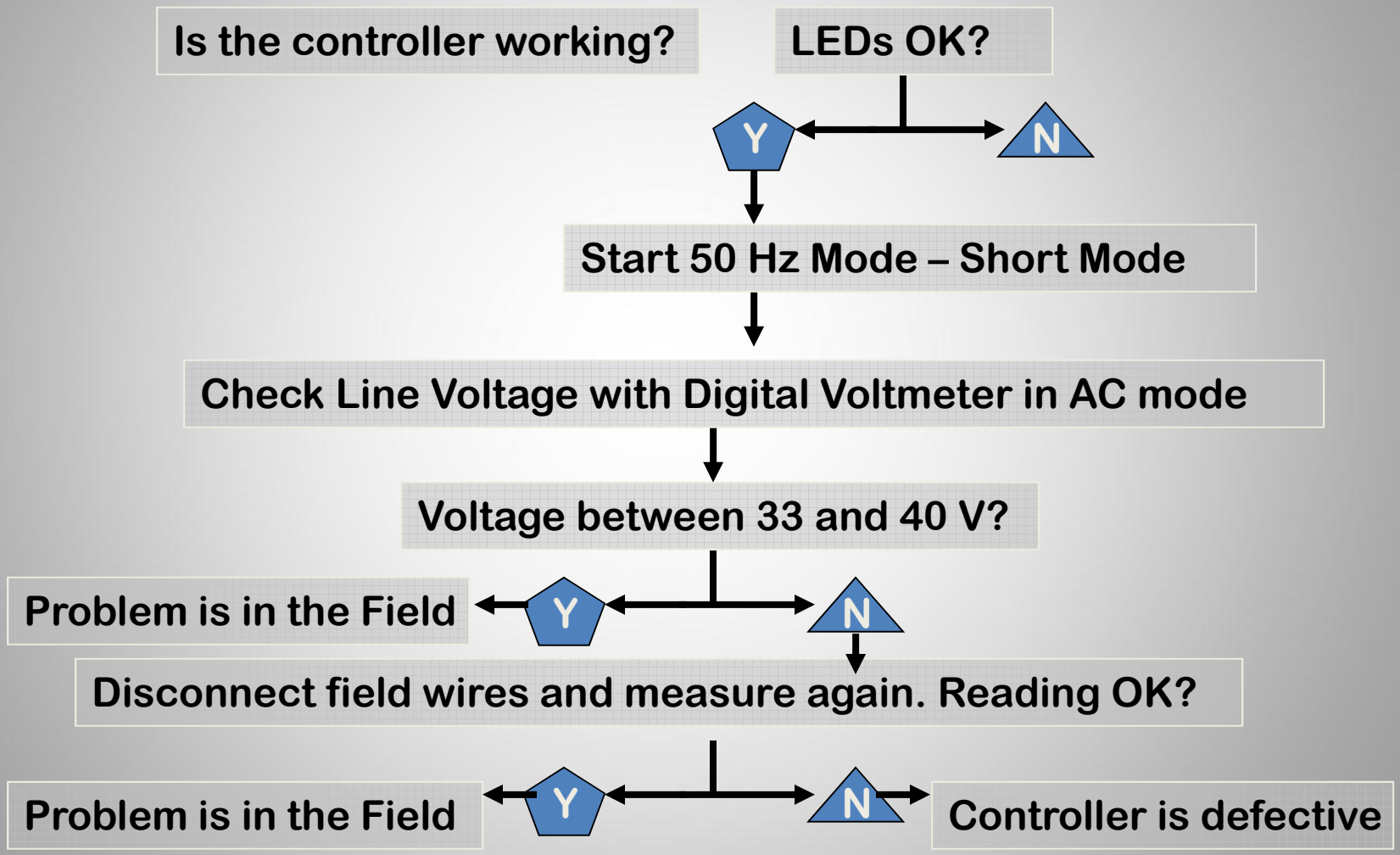
Ex. 38 decoders & 1 sensor decoder = .5 x 38 + 7 = 26 ma

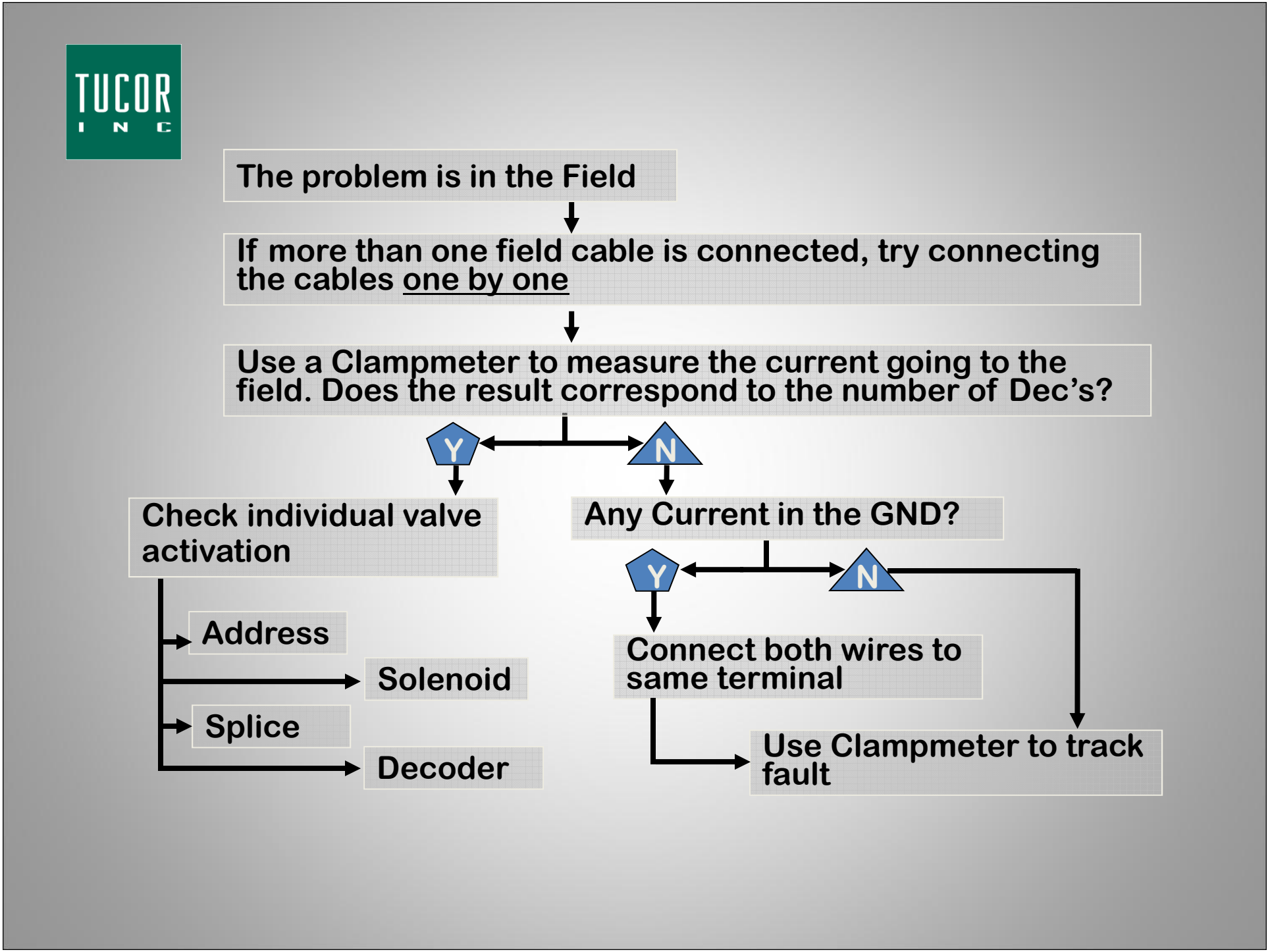
Ground current should not exceed 10% of line current (arbitrary)



Trouble Shooting flow chart Process


Is the controller working?
LEDs OK?
Y
N
Is the power switch on?
Y
N
Is Supply Voltage OK?
Turn switch on
Y
N
Check Mains fuses & Switch
Controller is defective!


Is the controller working?
LEDs OK?
Y
N
Start 50 Hz Mode – Short Mode
Check Line Voltage with Digital Voltmeter in AC mode
Voltage between 33 and 40 V?
Problem is in the Field
Y
N
Disconnect field wires and measure again. Reading OK?
Problem is in the Field
Y
N
Controller is defective


The problem is in the Field
If more than one field cable is connected, try connecting the cables one by one
Use a Clampmeter to measure the current going to the field. Does the result correspond to the number of Dec's?
Y
N
Check individual valve activation
Address
Solenoid
Splice
Decoder
Any Current in the GND?
Y
N
Connect both wires to same terminal
Use Clampmeter to track fault

- At this point you are ready to trace where the problem is. First check the voltage at the controller's line terminals Controller in *Short Mode*. It should be between 35-40 VAC. If the voltage is lower, there might be a problem with the controller (If you can move the problem you can solve it). Now it's time to use your clamp meter. Turn the switch to "2A". Open your clamp meter and place it around the black wire only and then the red wire. There should be some reading (What is your Benchmark). This reinforces that there is a short on the two-wire path.

- This example would have a 200 station controller. If a clamp meter were connected to a controller with this set of decoders, you would expect to see a number very close to 46mA. If the numbers were much higher, that would mean there is a short in the field.
- After you have calculated your Benchmark number in milliamps for your site, gather a set of plans or as-builds to find out where the two-wire path goes.
- If the two-wire path is looped, disconnect it at a junction point (halfway out).

- With the controller still in Short Finding Mode, find a valve box about mid point and put the clamp meter first around the red, then the black wire. If the number is still high then the problem is still ahead of you. If the number is low or not present, then you have passed the problem.
- By going to the mid point, you know what direction to head. Now move half way back towards the controller OR forward from where you are and check the reading again. You should be able to isolate the problem between two points.
- One valve box will have a high number and the other one will be low (or the wire is damaged between).

- At the valve box with the high number, check the blue wires on the decoder, if higher 1 ma, disconnect. Go back to the controller to make sure that the problem went away. The number should represent the number of decoders left connected to the controller.
- If you are positive that you have found the problem, use your multi-meter to verify 35-40 VAC at the controller. This is the line from the controller.

- **QUESTION:** How can I find the bad wire if there are three or more wires at a junction point?

- **ANSWER:** Take a reading on each one of the wires coming into the valve box. Make sure that you are checking all blacks or all reds.
  - The line with the highest number is the one coming from the controller.
  - Find the one with the next highest number and that is your problem line (Chase the High Number).
  - Go to the next valve box and if the number is high, (Chase the High Number) continue on.
  - If the number is low, go back to the junction box and find out where the other wire goes.

Problem

A single valve fails to operate

- ACTION: If the system works normally with the exception of a single valve, the problem either lies in the decoder or valve solenoid. The failure rate of a decoder is less that 1% of 1%. So the probability of a line decoder being the problem is very low.
- If a single valve is not coming on, first check wire connections.
- Verify that the decoder's address is correct inside the controller.

- Scroll through the list to find the valve and verify that the address matches with the one in the field.
  - If it doesn't match, change the address and verify the operation by turning that valve on manually from the controller.
  - If the address matches, use the **Line Survey** feature on controller, activate the decoder from the controller manually, you will see your benchmark plus 15 - 30 ma. This verifies your decoder is working.
  - Check your solenoid.

Some valves work erratically

- ACTION: If you experience problems with valves that have worked in the past, the problem probably lies in the two-wire path. This may happen after a rainstorm or after heavy irrigation. Then the problem disappears after some time. This can be frustrating and confusing.

- There are a number of two-wire path problems that can cause temporary failures.
  - One example is if a line was not terminated properly at the end of a two-wire path and is buried in the earth. If the ground is wet and the end of the wire is exposed, the current is going to ground.

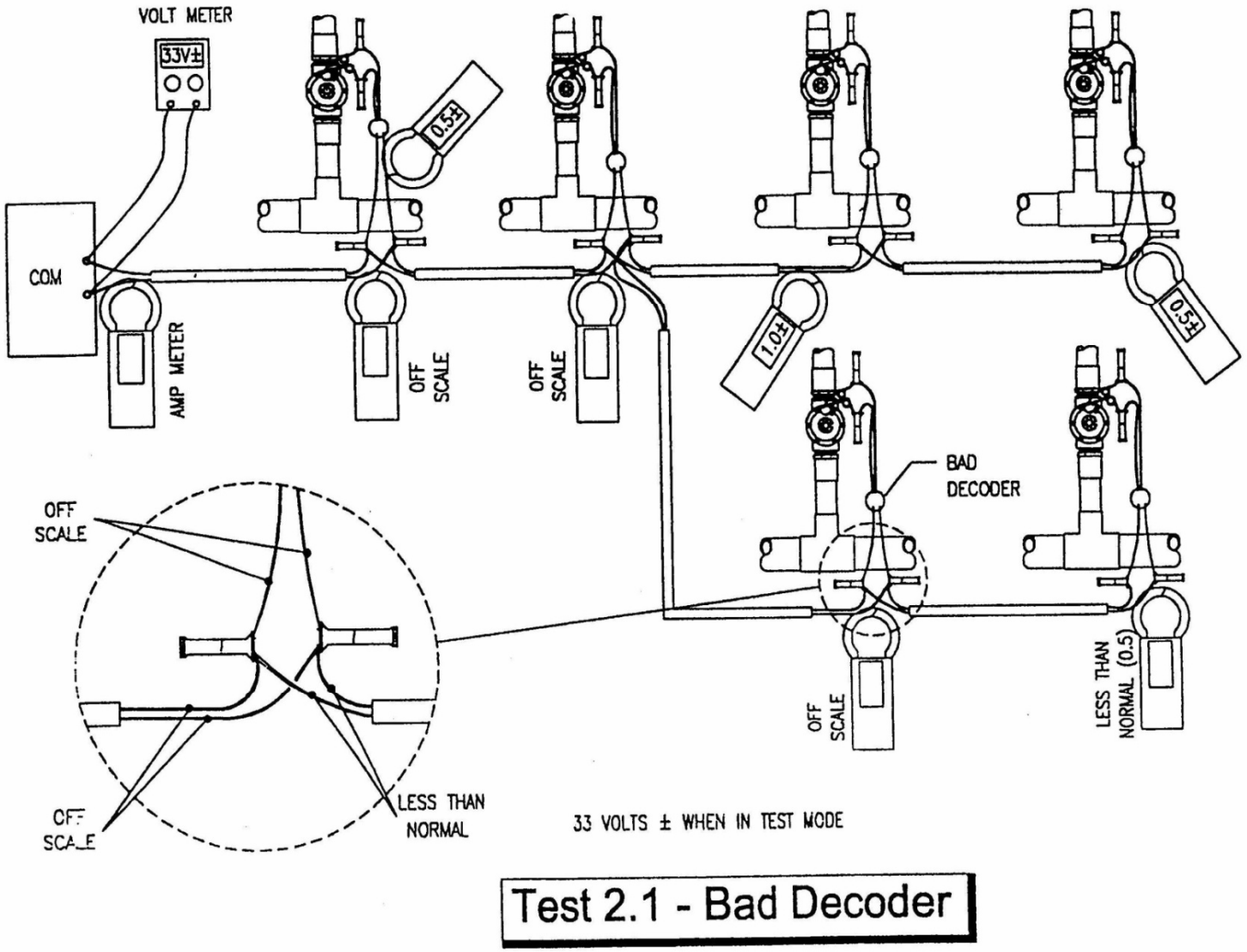
- Or maybe a wire splice was not sealed properly and water contaminated the connection.
- It is possible that another contractor nicked one or more of the wires during the installation process.

Each one of these examples causes interference with the communication. These examples may not be big enough to cause a “short circuit” but still large enough to cause some problems. At some point, the two-wire path is exposed and current is going to ground. To correct this problem, put the controller into short finding mode and trace the problem down. For the procedure, read, ***“the controller displays short circuit.”***

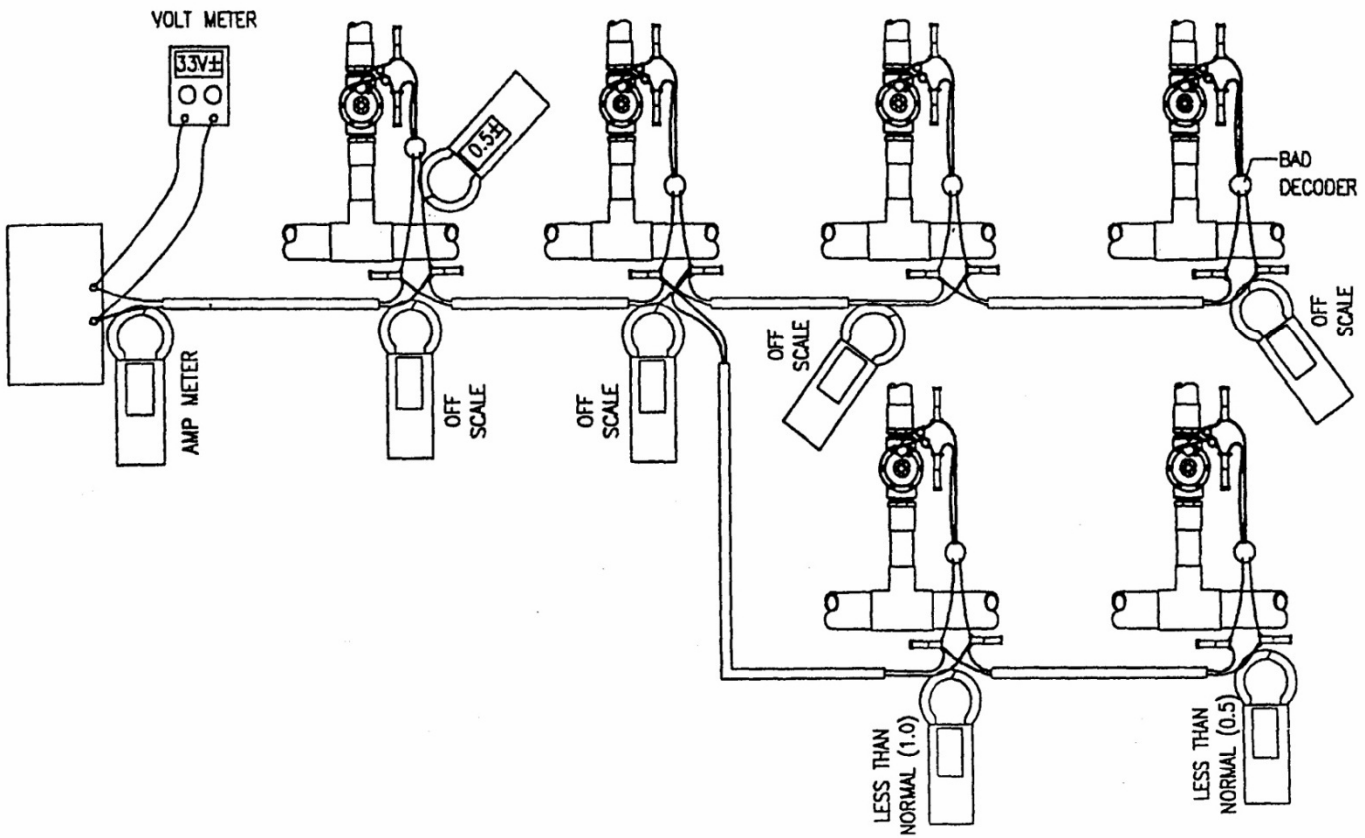
Older Valves Do Not Work

- ACTION: If you find that everything works except for the older or existing valves, the solenoid may require more pull-in time or holding voltage. Changing some parameters inside the controller can change this. The Tucor System is based on a Rain Bird solenoid and therefore it is rare to have to change this.

Troubleshooting Examples

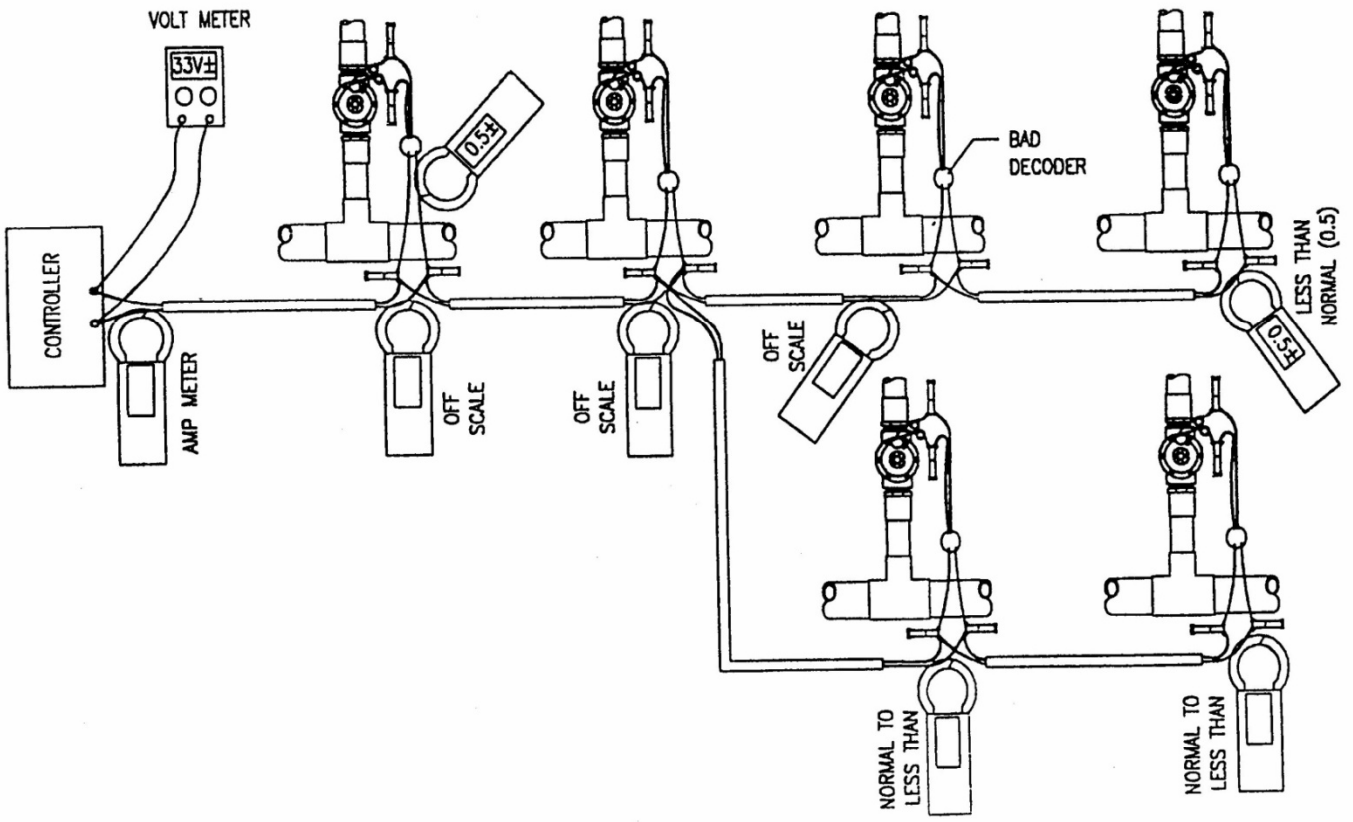


Test 2.1 - Bad Decoder



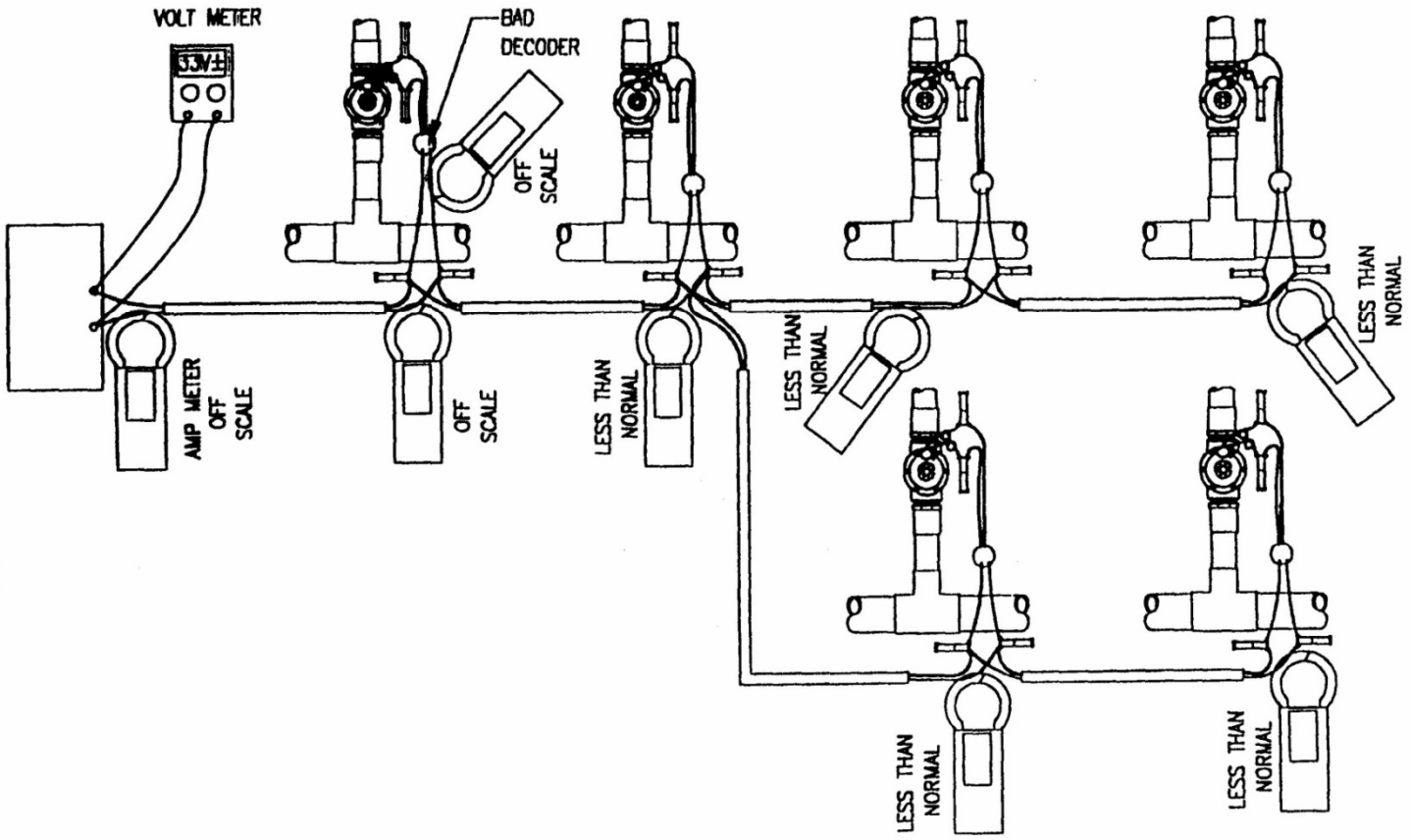
33 VOLTS ± WHEN IN TEST MODE

Test 2.2 - Bad Decoder



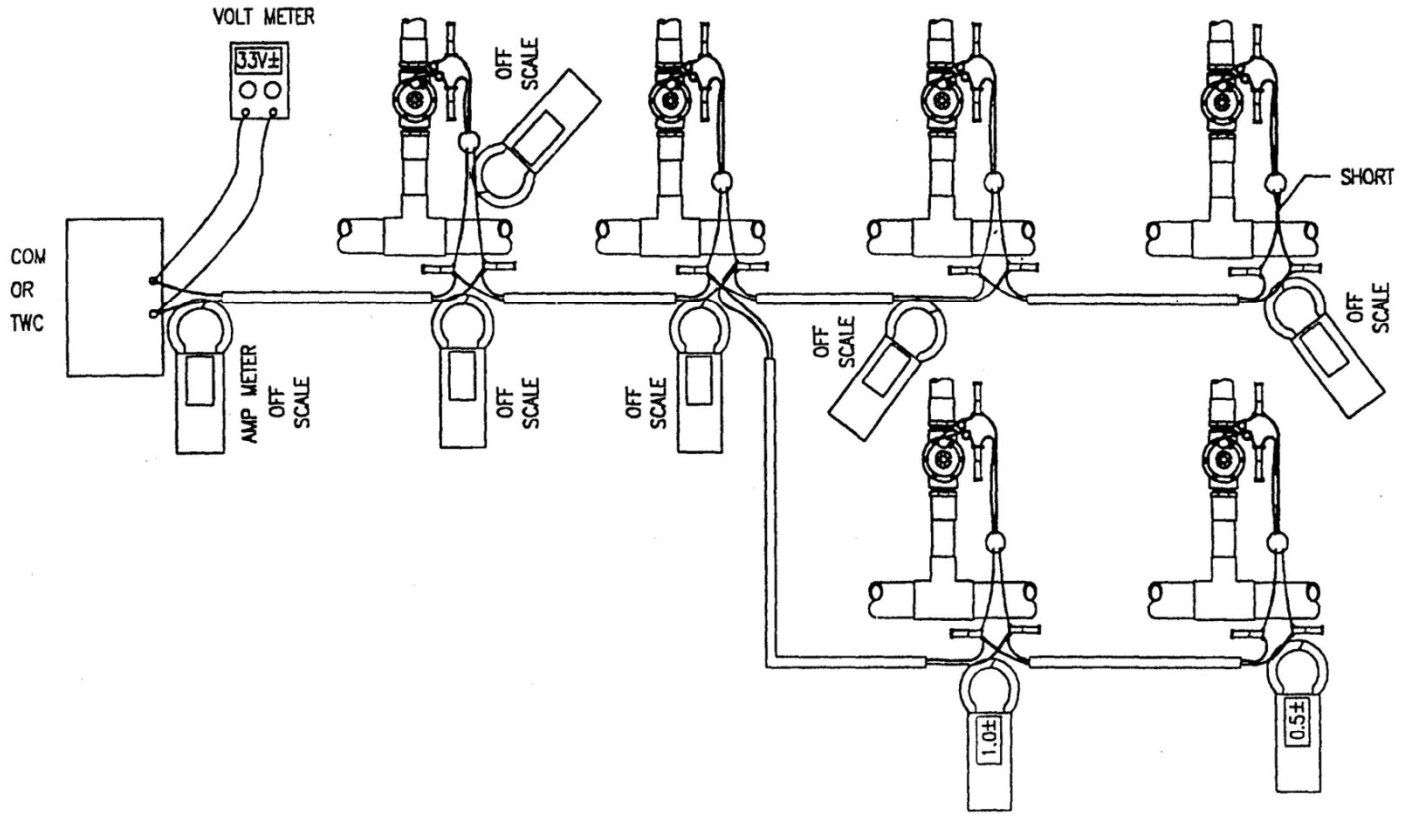
33 VOLTS ± WHEN IN TEST MODE

Test 2.3 - Bad Decoder



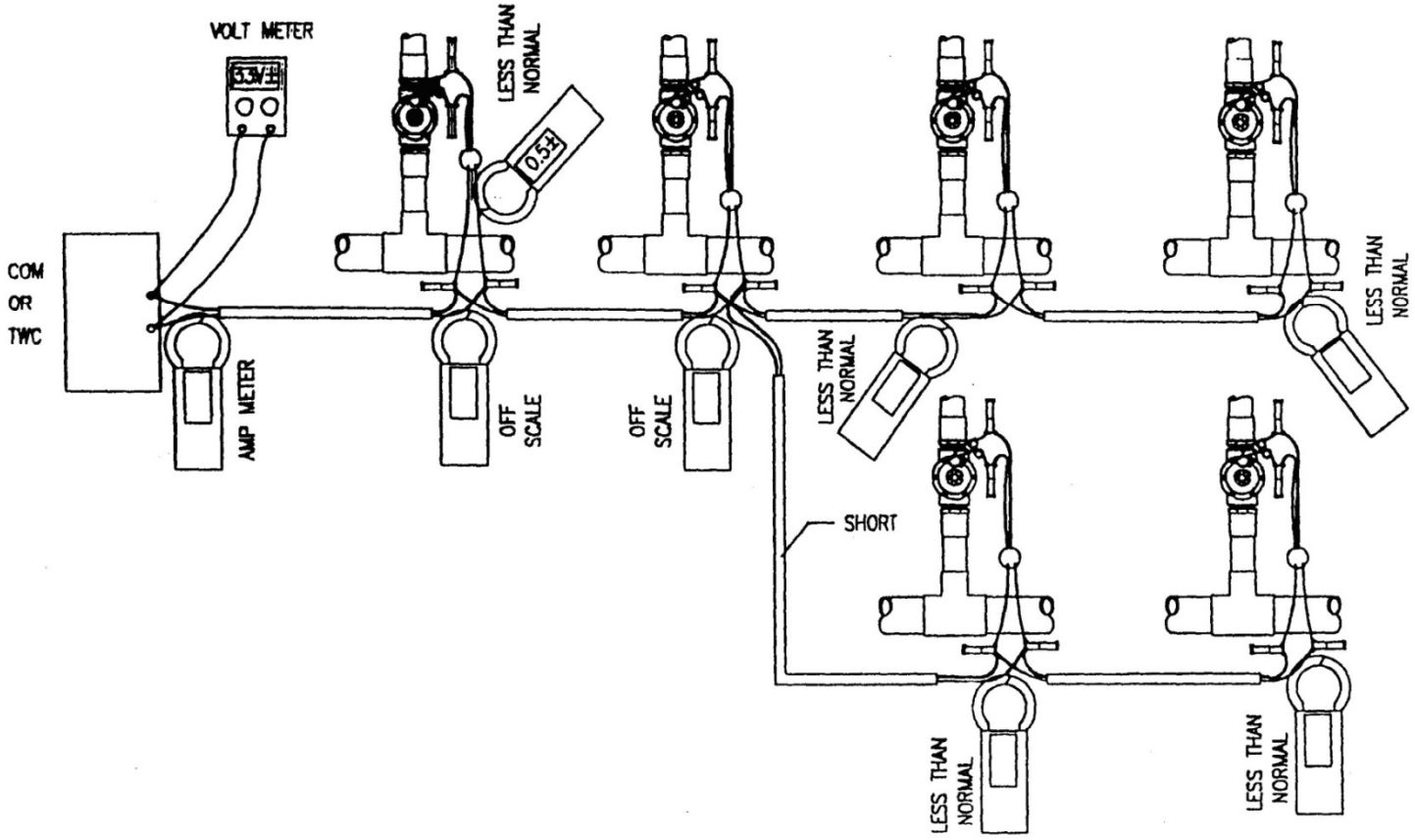
33 VOLTS ± WHEN IN TEST MODE

Test 2.5 - Bad Decoder



33 VOLTS ± WHEN IN TEST MODE

Test 3 - Line Short

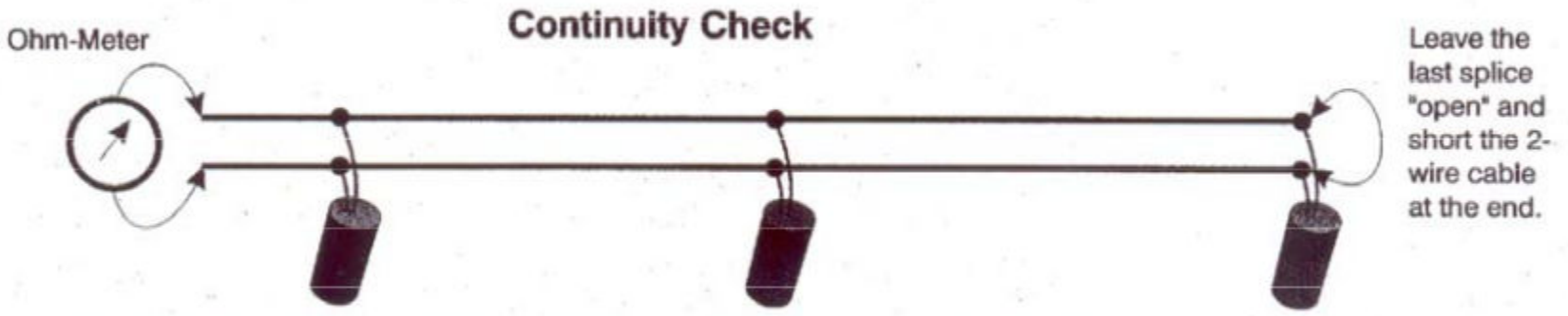


33 VOLTS ± WHEN IN TEST MODE

Test 4 - Short System

Testing of the existing installation

Testing a New 2-Wire Installation to Determine Quality of Installation



You can calculate the loop resistance on basis on the length of your cable. Usually Ohmmeters are not very precise at such low resistances. Values will normally be less than 10 Ohms. Look for readings considerably larger which would indicate a bad splice or damaged cable.

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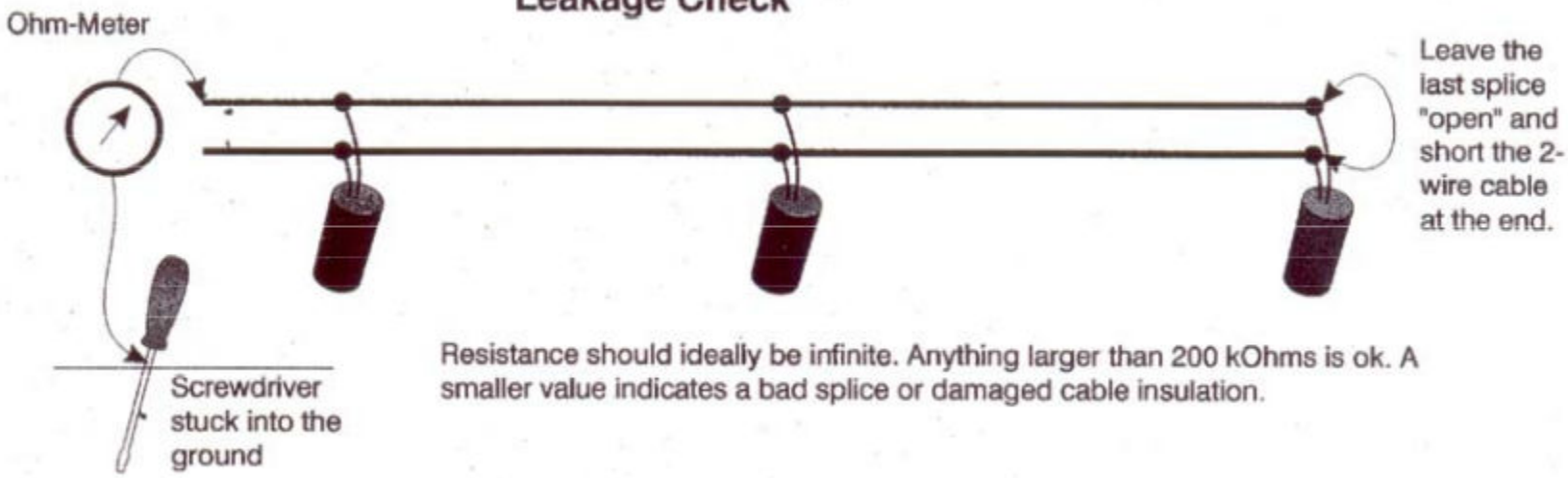
Leakage Check



Resistance should ideally be infinite. Anything larger than 200 kOhms is ok. A smaller value indicates a bad splice or damaged cable insulation.

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Shorting Check

Resistance should be infinite. Any measurable value indicates a damaged acble, a wiring mistake or a defective decoder.