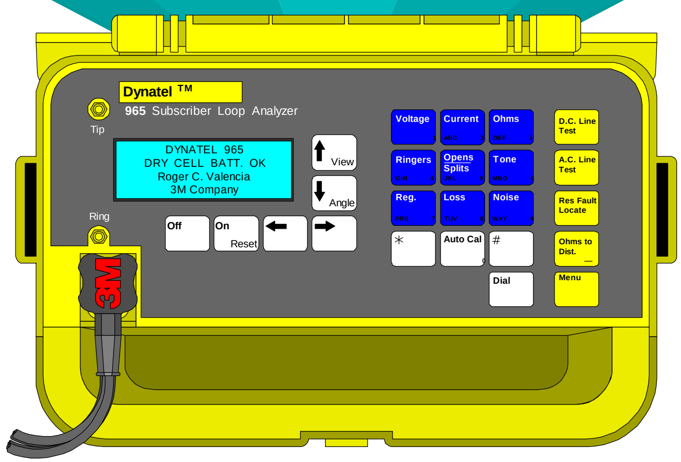
3M

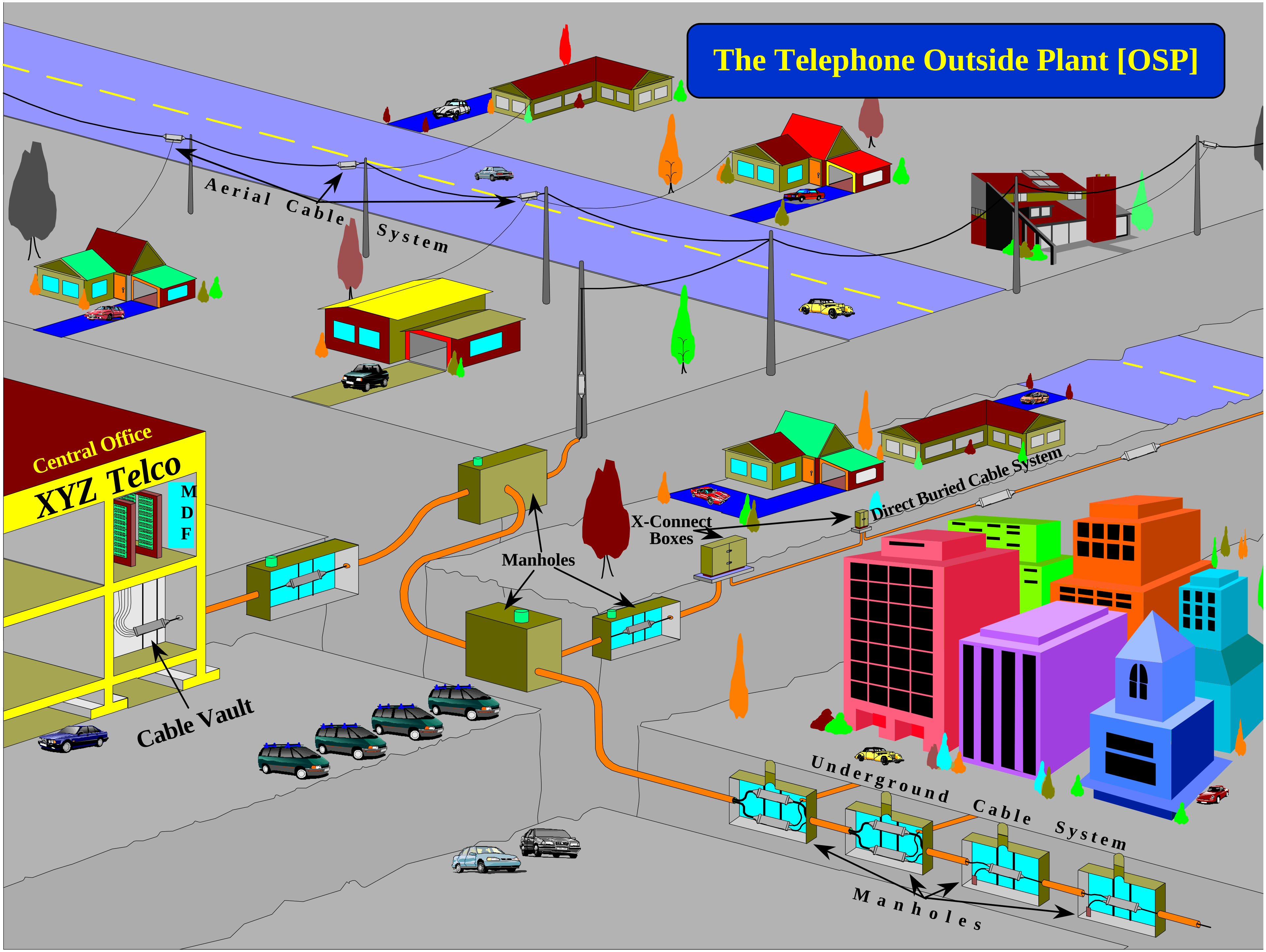
Dynatel™ Systems



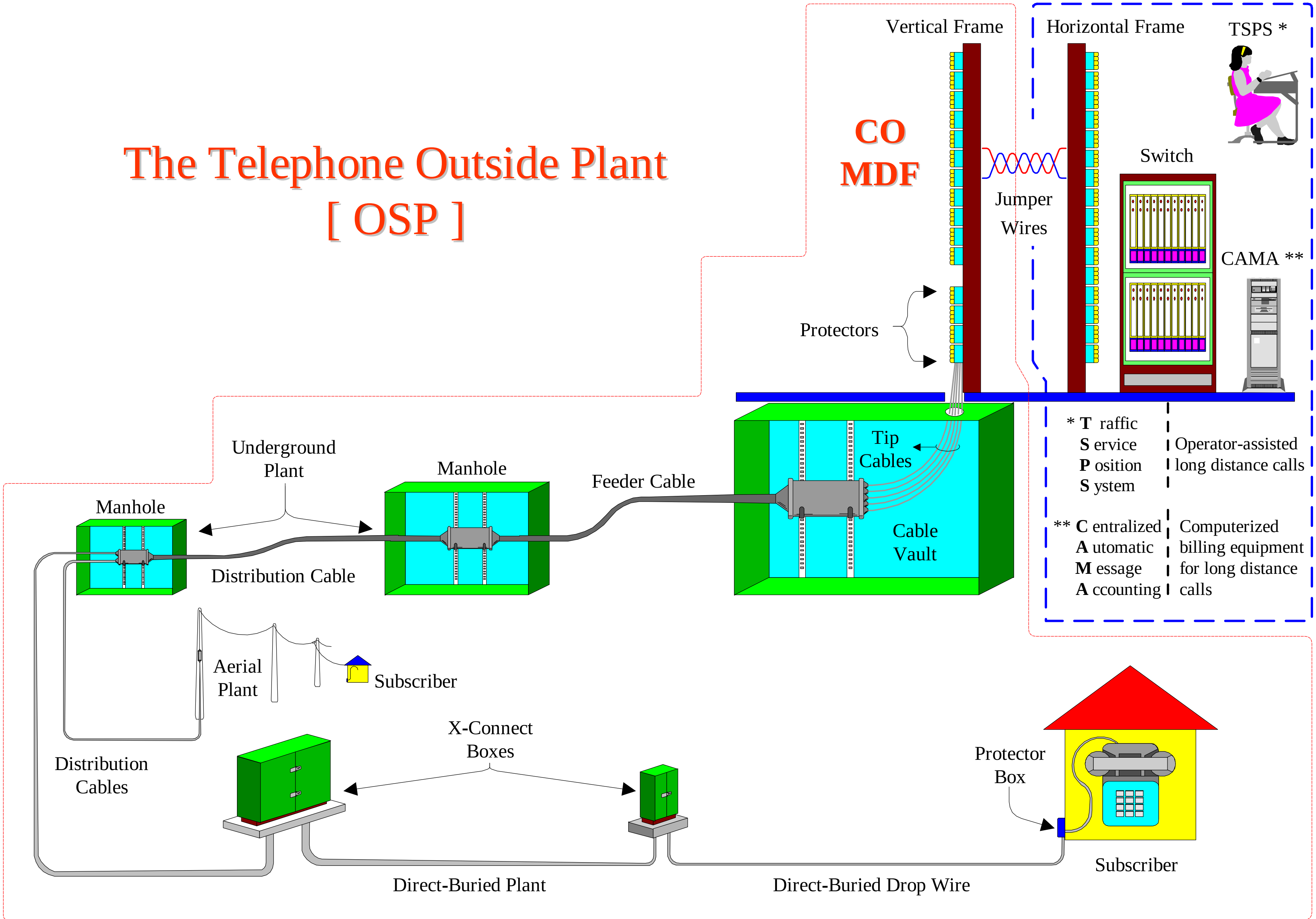
Outside Plant

Telephone Cable Testing & Fault Locating

Prepared By:
Roger C. Valencia
Global Technical Service
3M Test & Measurement Systems
3M Austin Center
Austin, TX, USA - January 1999


The Telephone Outside Plant [OSP]
Aerial Cable System
Central Office
XYZ Telco
MDF
Cable Vault
Manholes
X-Connect Boxes
Direct Buried Cable System
Underground Cable System
Manholes

The Telephone Outside Plant
[OSP]



The

Telephone Cable

[Definition]

It is one of several other types of communication facilities or media which is generally made up of paired, insulated copper conductors called TIP [A] and RING [B].

A cable can consist a few pairs, hundreds of pairs or thousands of pairs and the conductors can be of different sizes or gauges depending upon system requirements.

Other types of Communication Facilities

OPEN WIRE SYSTEMS [Telegraph]

COAXIAL SYSTEMS [CATV]

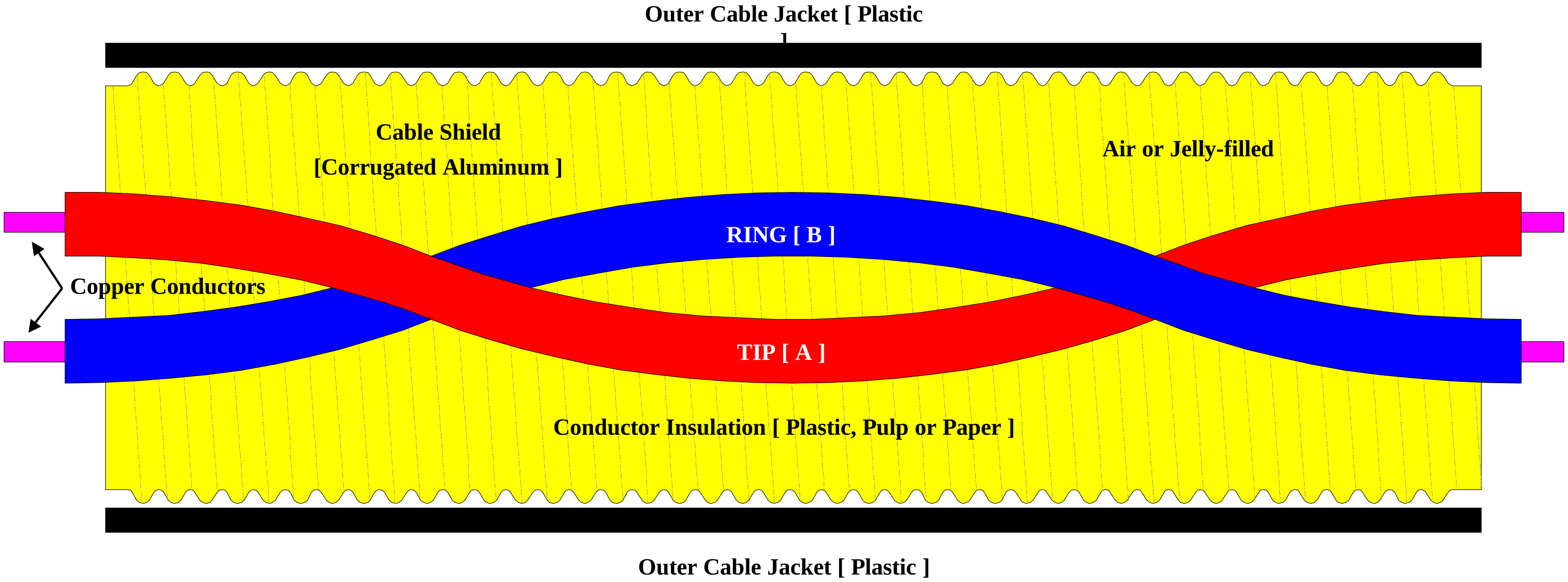
RADIO SYSTEMS [Microwave, Cellular

COMMUNICATION SATELLITES [Disk]

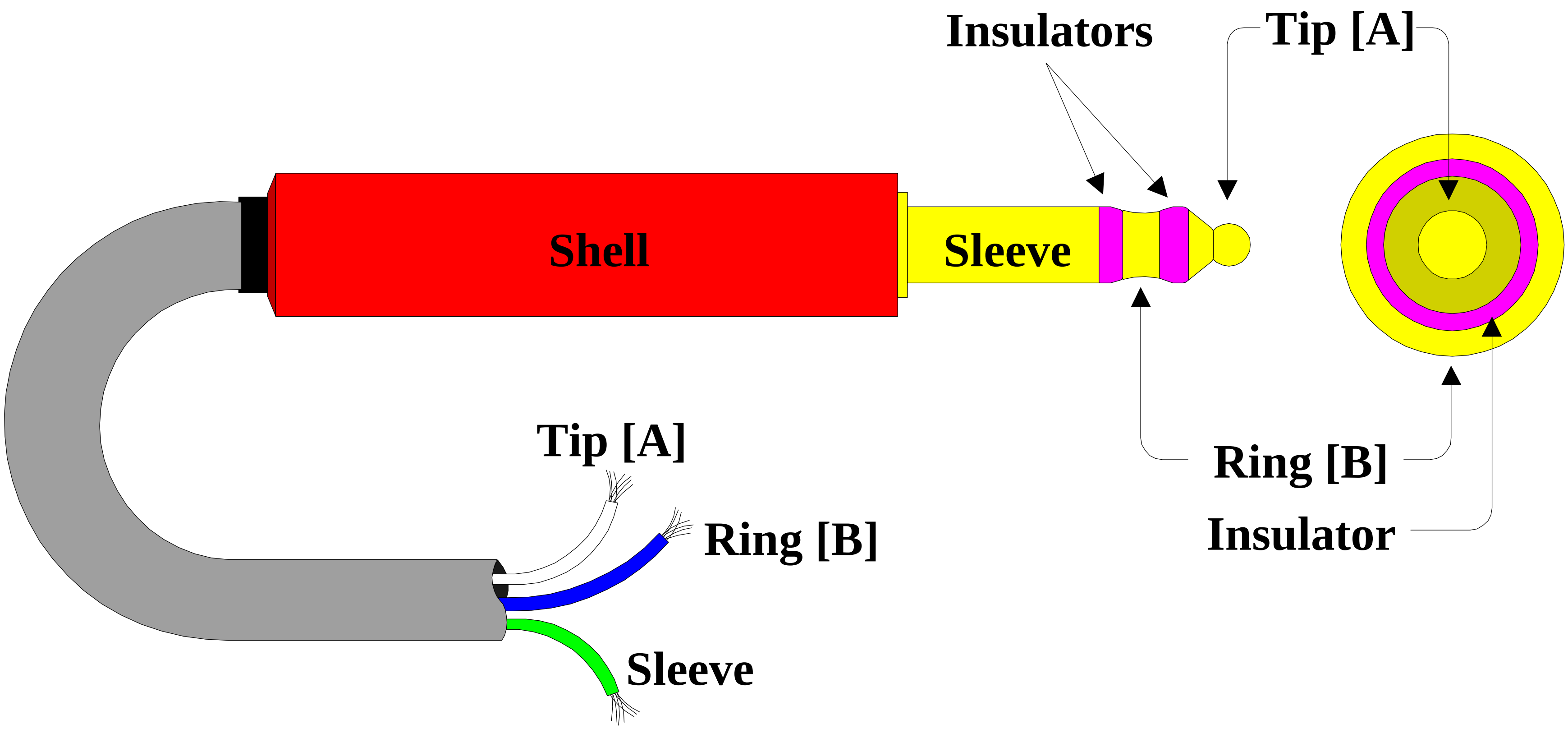
FIBER OPTIC SYSTEMS

The Telephone Cable

[Basic Construction]



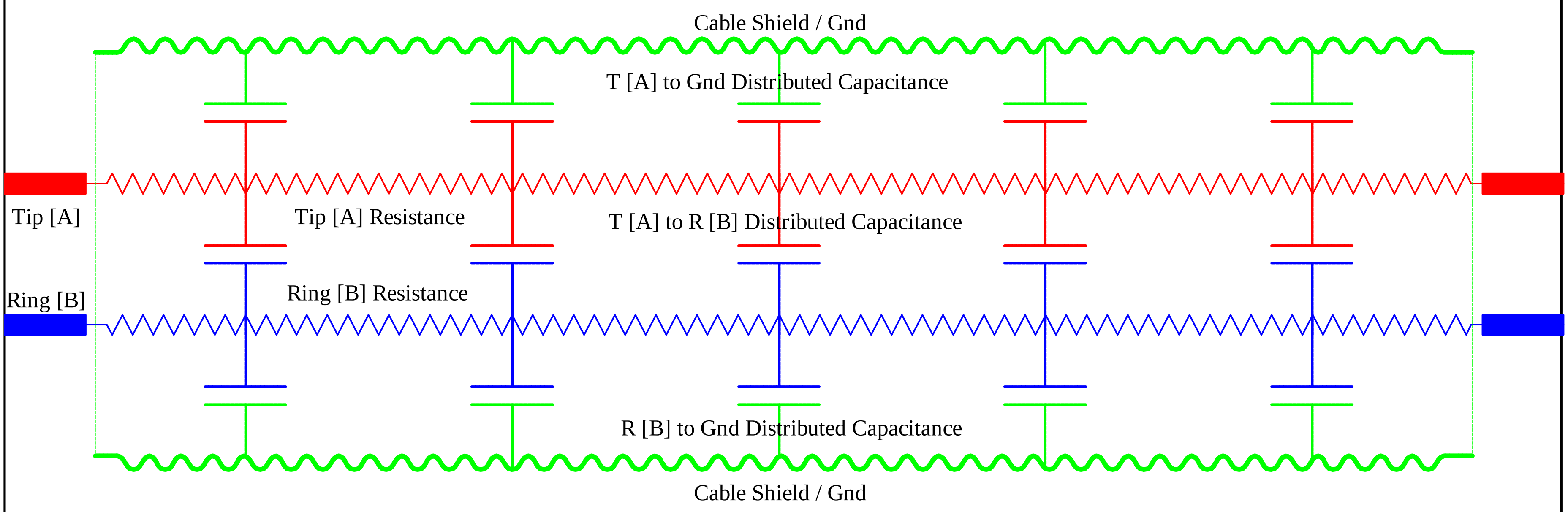
The origin of the name Tip [A] and Ring [B]



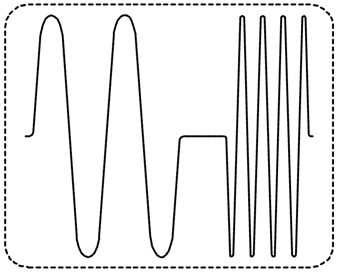
The

Telephone Cable

[Electrical Representation]

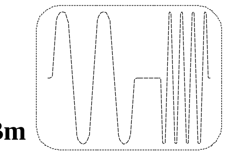


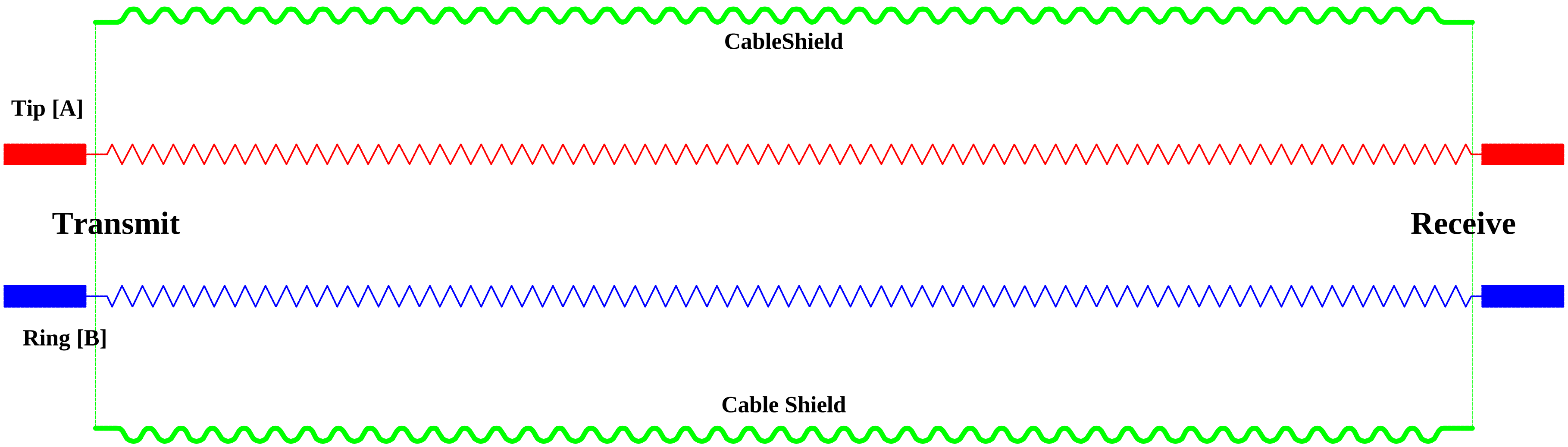
Effect of Cable Resistance to Signal Transmission



Note:

In a pure resistive circuit, the transmitted signal is only attenuated but its original shape is maintained. In other words, the signal is not distorted.

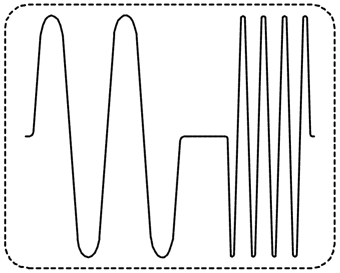




Effect of Cable Resistance and Capacitance to Signal Transmission

0 dBm

[1 mw]

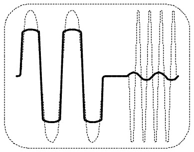


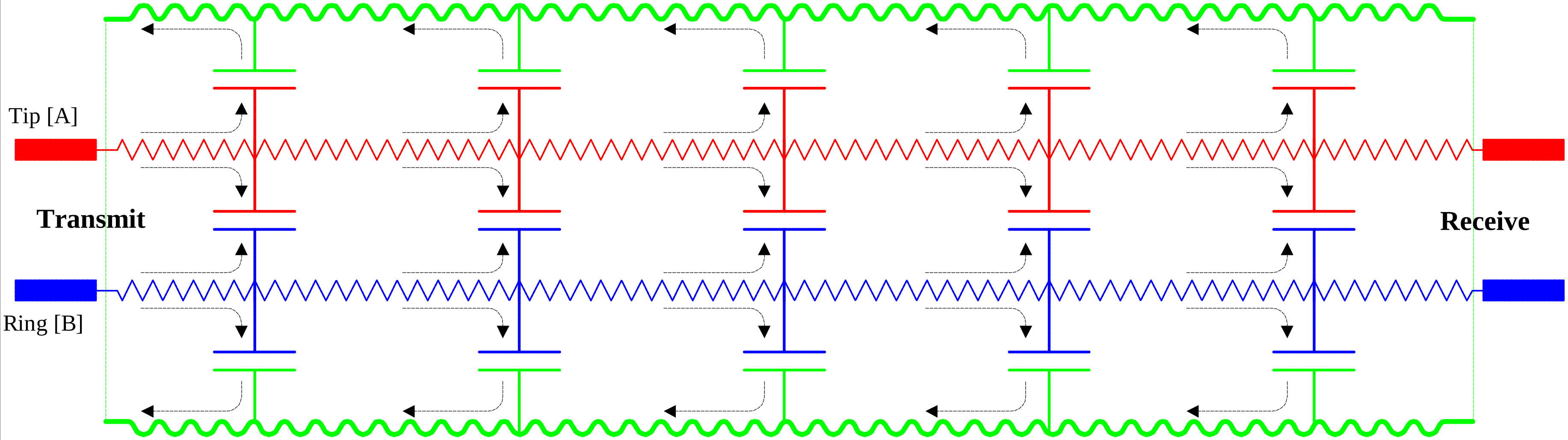
Note:

In a circuit where both resistance and capacitance exist, the transmitted tones were attenuated and at the same time, their original shape were also altered or changed. In other words, the signal became distorted.

Higher frequencies normally suffers most because of the combined filter effect of cable resistance and capacitance. In the illustration, the high frequency tone was almost totally absorbed by the distributed capacitance of the cable.

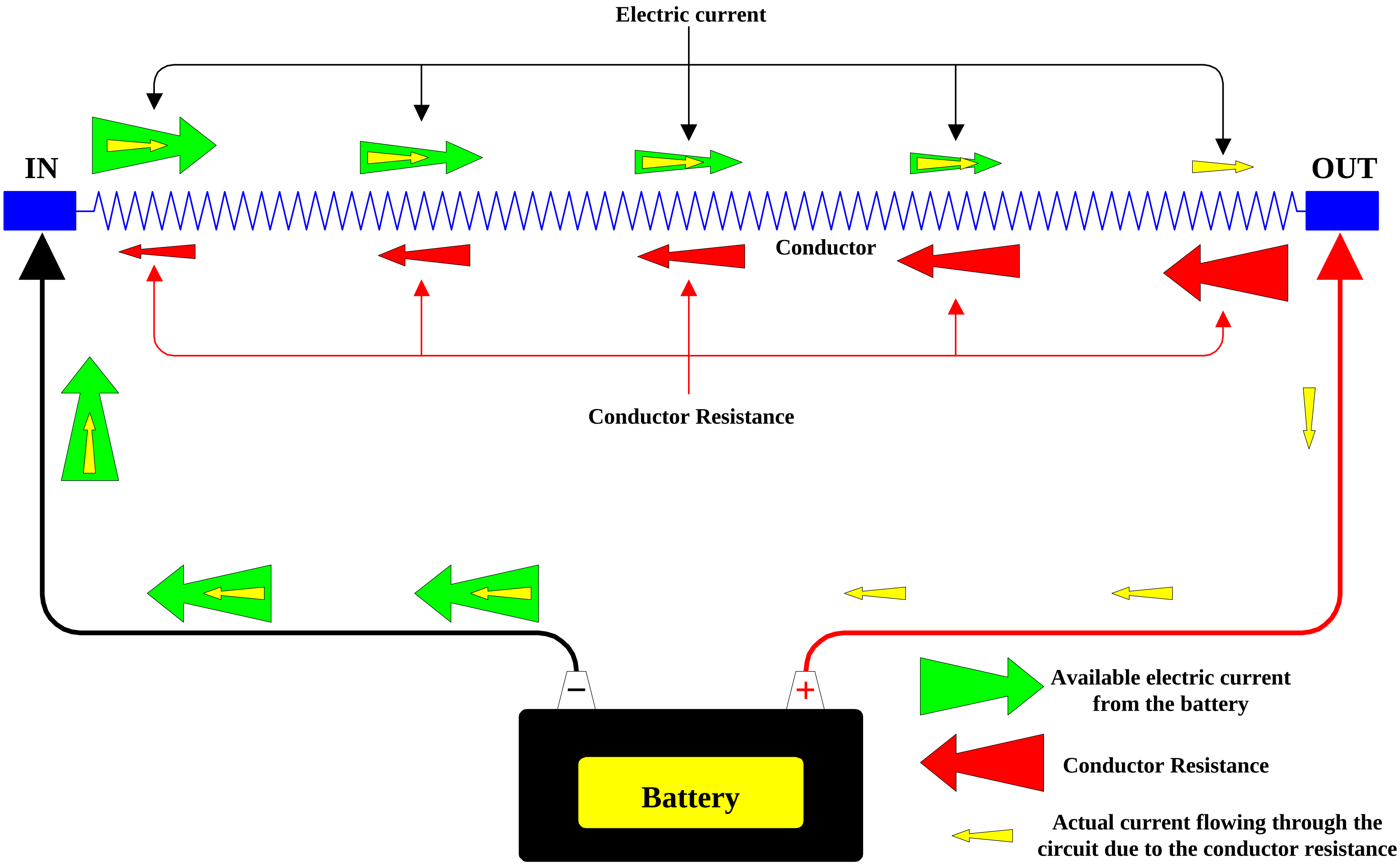
- 16.5 dBm





RESISTANCE
[Definition]

It is a natural characteristic of any conductor (i.e. Copper, Aluminum, Nickel, Silver, Gold, etc.) which opposes the flow of electrical current through it.



OHM

Ω

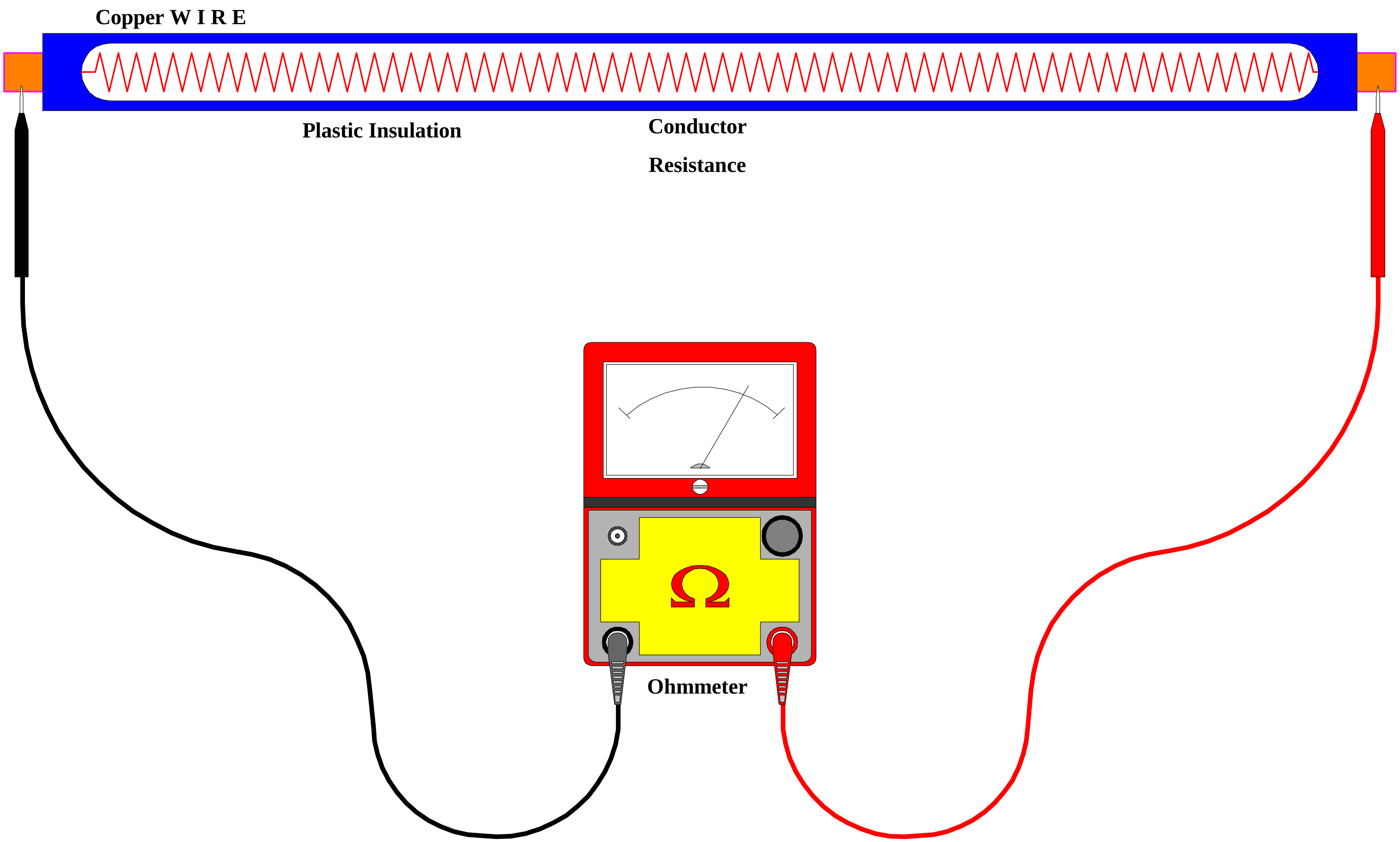
Unit of measure for Resistance

Commonly used units:

Ohm	**=**	**0 to 1**
Ohms	**=**	**2 to 999**
Kilo-Ohms (K)	**=**	**1000 to 999,999**
Mega-Ohms (M)	**=**	**1,000,000 to 999,999,999**

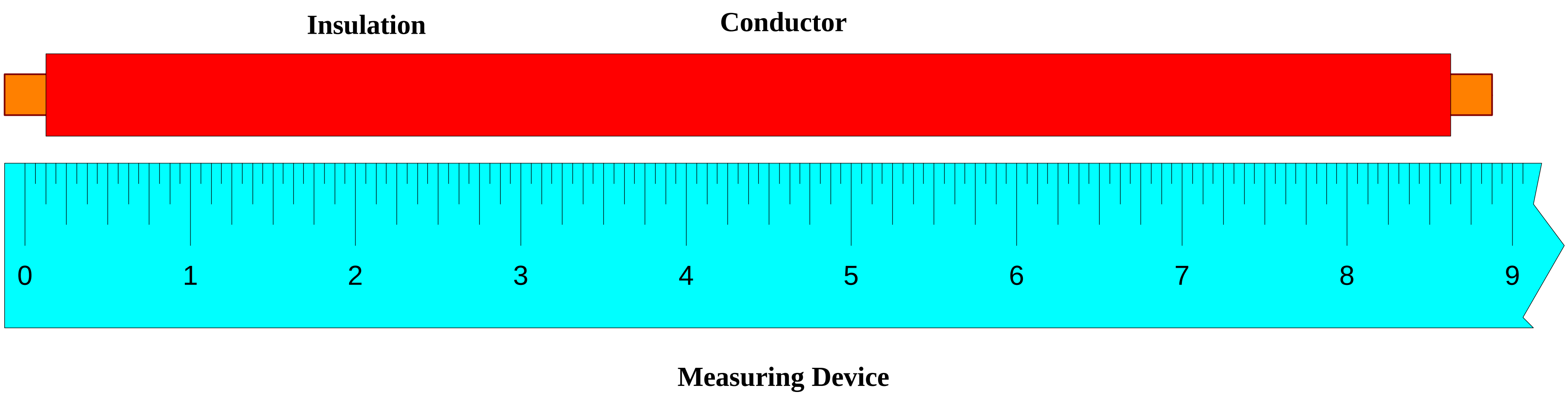
Electrical Length of a Conductor

It is the resistance of a conductor in OHMS measured at a certain temperature in °Farenheit or °Centigrade and then converted into DISTANCE (length).



Physical Length of a Conductor

It is the length measured with the use of a measuring device like a WHEEL or a RULER Tape.



Conductor Resistance To Distance Conversion Table

Gauge [Size] AWG (mm)	Conductor Length per Ohm
19 AWG (0.91 mm)	124.24 ft. (37.87 m)
22 AWG (0.64 mm)	61.75 ft. (18.82 m)
24 AWG (0.51 mm)	38.54 ft. (11.75 m)
26 AWG (0.41 mm)	24.00 ft. (7.32 m)
28 AWG (0.32 mm)	15.08 ft (4.60 m)

Formulas:

1. For cable temperatures ABOVE 68 ºF [20oC] : $Ft = Fa [1 - 0.00218 (t - 68)]$

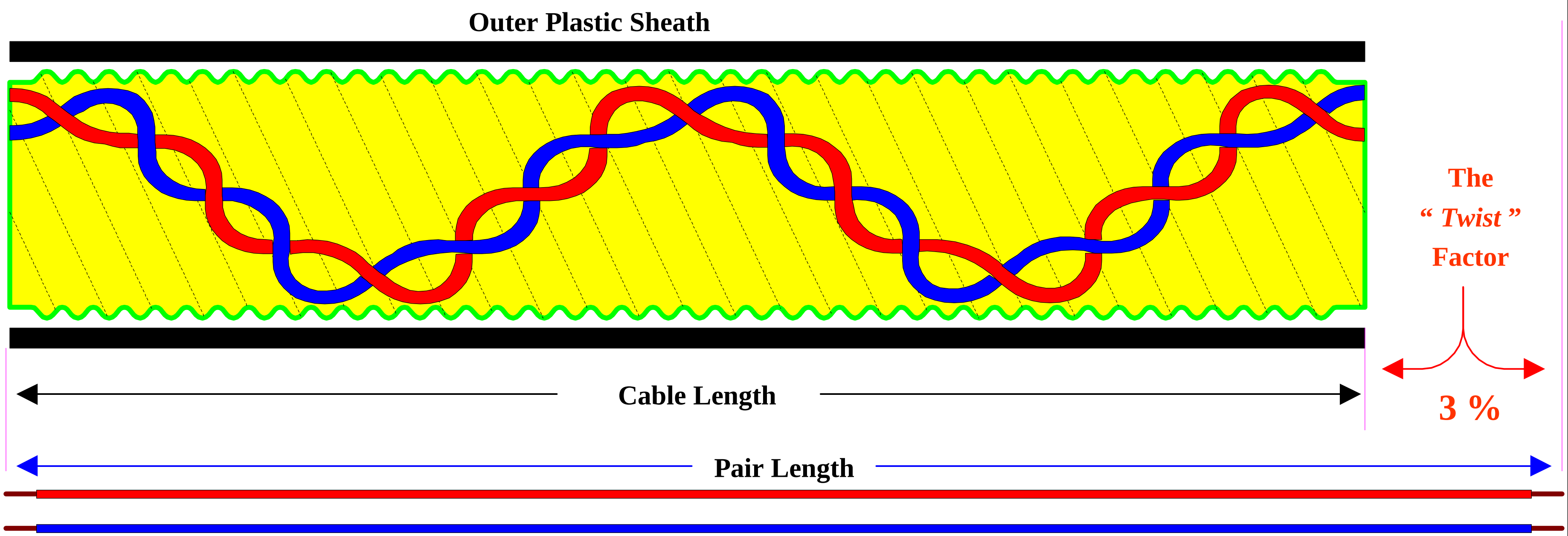
2. For cable temperature BELOW 68 ºF [20oC] : $Ft = Fa [1 + 0.00218 (t + 68)]$

Where:

Ft = Feet / Meters per Ohm @ temperature t (ºF / ºC)

Fa = Feet / Meters per Ohm @ temperature 68 ºF / 20 ºC (see table above).

The " *TWIST* " Factor



Note:

The twisting of the conductors inside the cable makes the physical and electrical length of the pair about 3% longer than cable.

Ex.: If the electrical length of a pair is 103 feet or meters, this can be translated to 100 feet or meters of cable length.

Factors That Affect Resistance

1. Length:

The ***shorter*** the conductor, the ***lower*** its resistance.

The ***longer*** the conductor, the ***higher*** its resistance.

2. Gauge (Size):

The ***bigger*** the conductor, the ***lower*** its resistance.

The ***smaller*** the conductor, the ***higher*** its resistance.

3. Temperature:

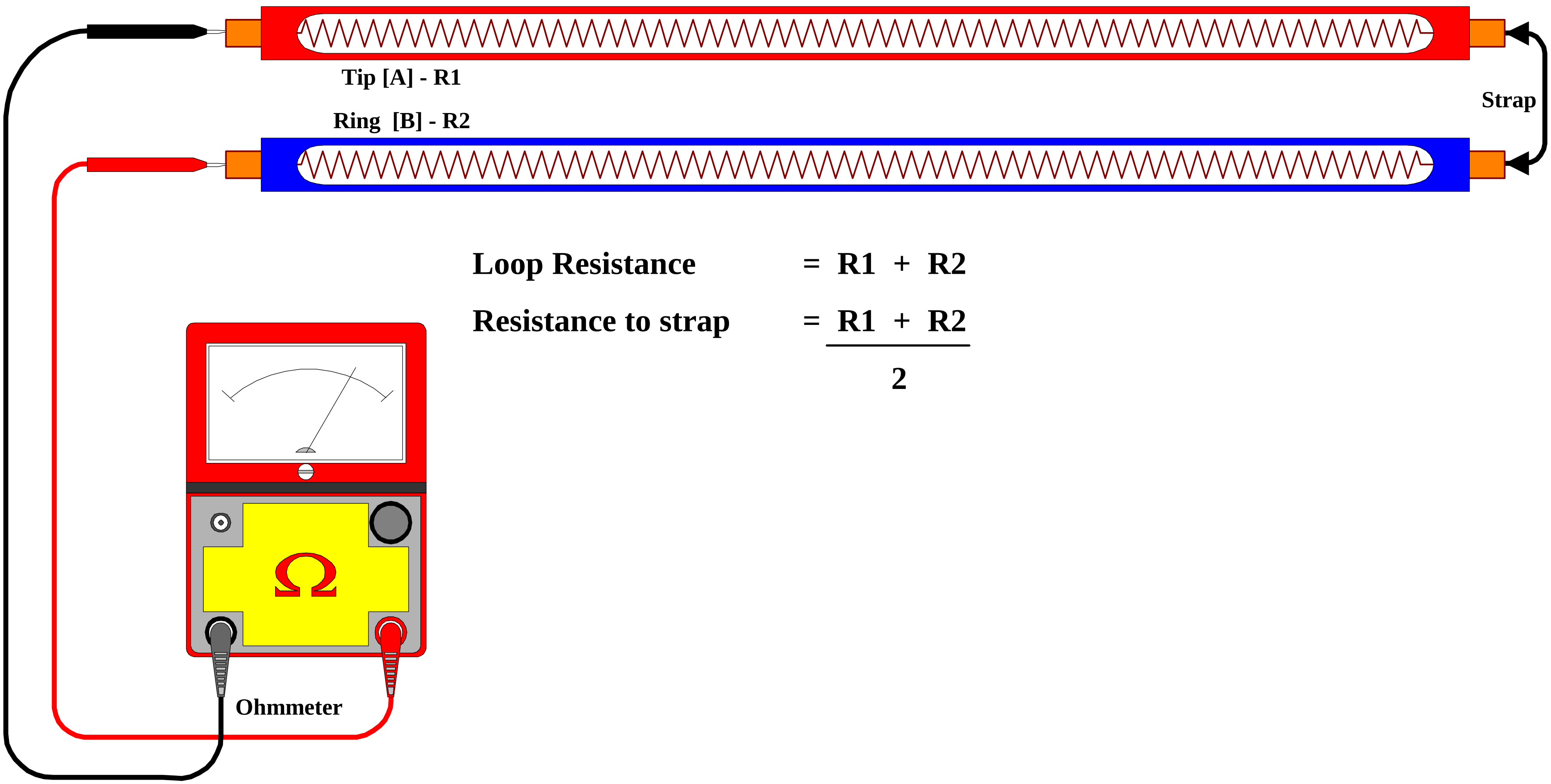
The ***lower*** the conductor's temperature, the ***lower*** its resistance.

The ***higher*** the conductor's temperature, the ***higher*** its resistance.

Therefore:

The ***Length*** of a conductor is a factor of ***Gauge (Size)*** and ***Temperature.***

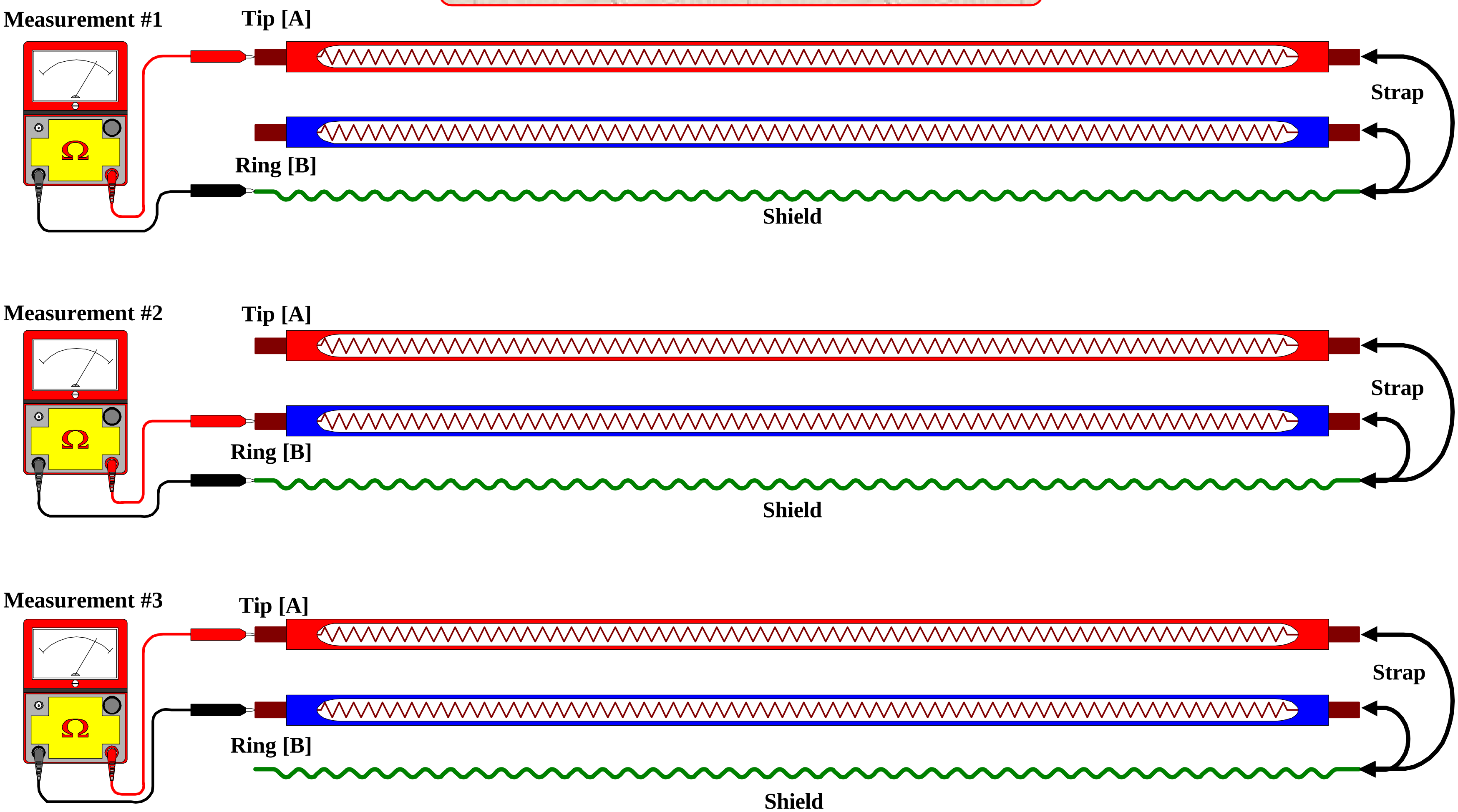
Loop Resistance



$$\text{Loop Resistance} = R1 + R2$$

$$\text{Resistance to strap} = \frac{R1 + R2}{2}$$

Resistive Balance Test

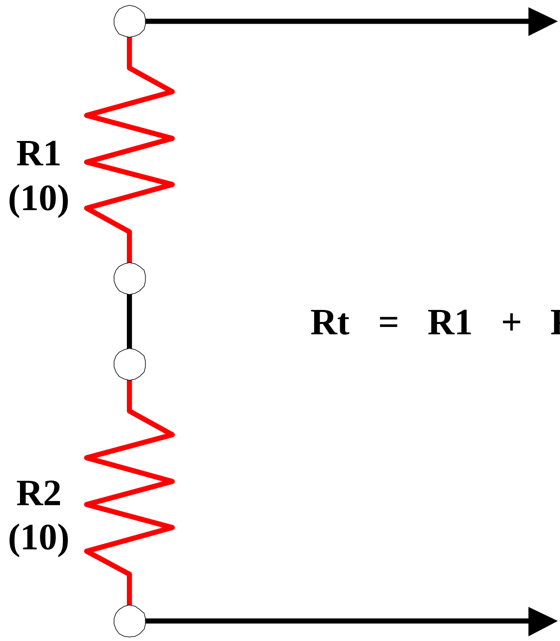


<u>Note:</u> For a normal cable ---

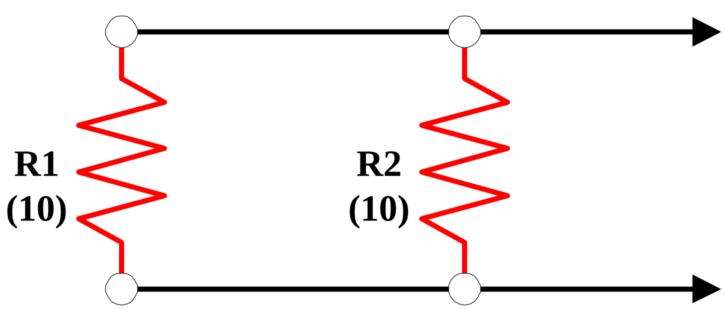
a) Measurement #1 should be equal to Measurement #2 (If they differ by 10% or more, a "partial open" exist in either Tip [A] or Ring [B] or both).

b) Measurement #3 = Measurement #1 + Measurement #2

More About Resistors



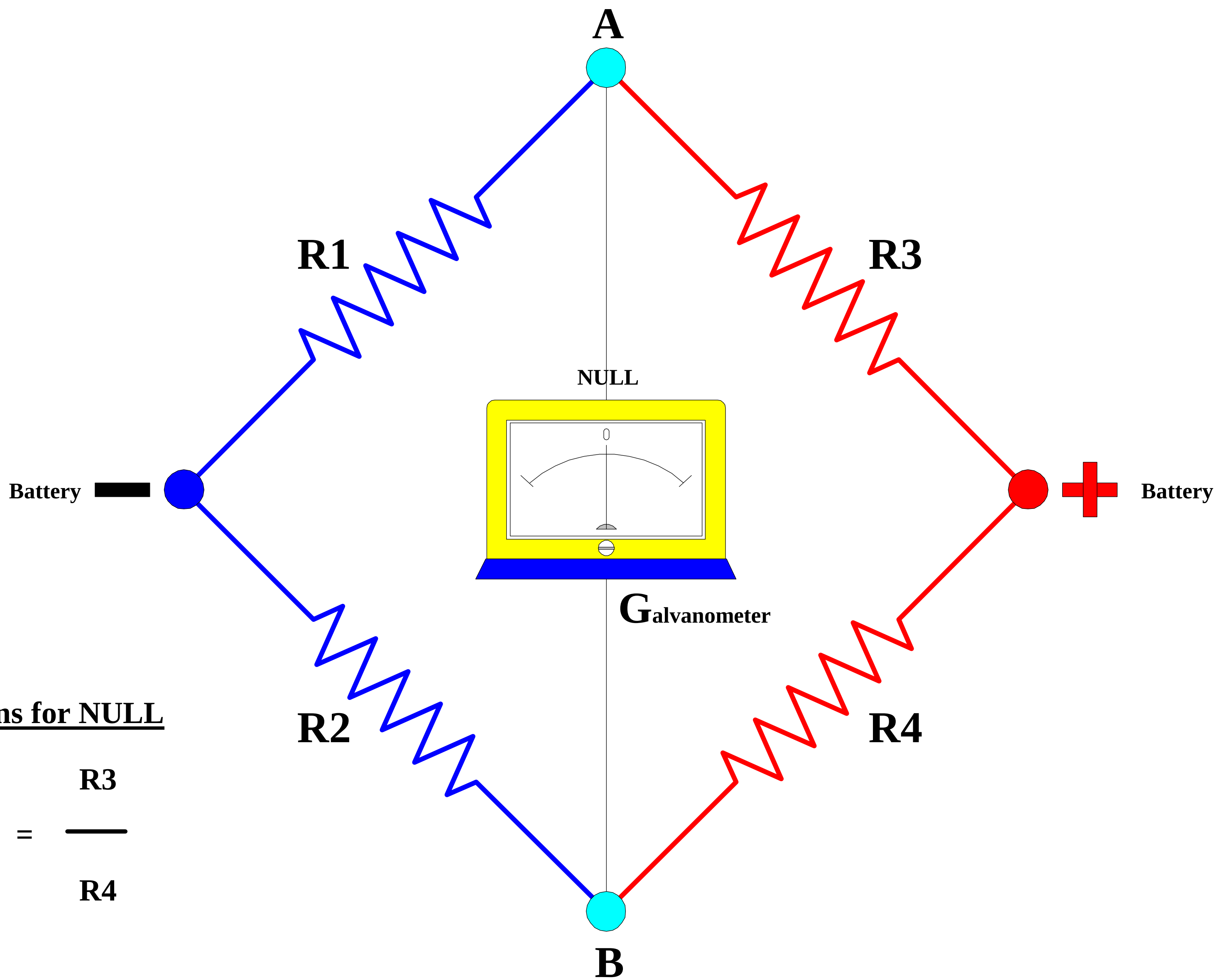
$$Rt = R1 + R2 = 10 + 10 = 20 \text{ Ohms}$$



$$\frac{1}{Rt} = \frac{R1 + R2}{R1 \times R2} = \frac{10 + 10}{10 \times 10} = \frac{20}{100} \quad \text{or}$$

$$\frac{Rt}{1} = \frac{100}{20} = 5 \text{ ohms}$$

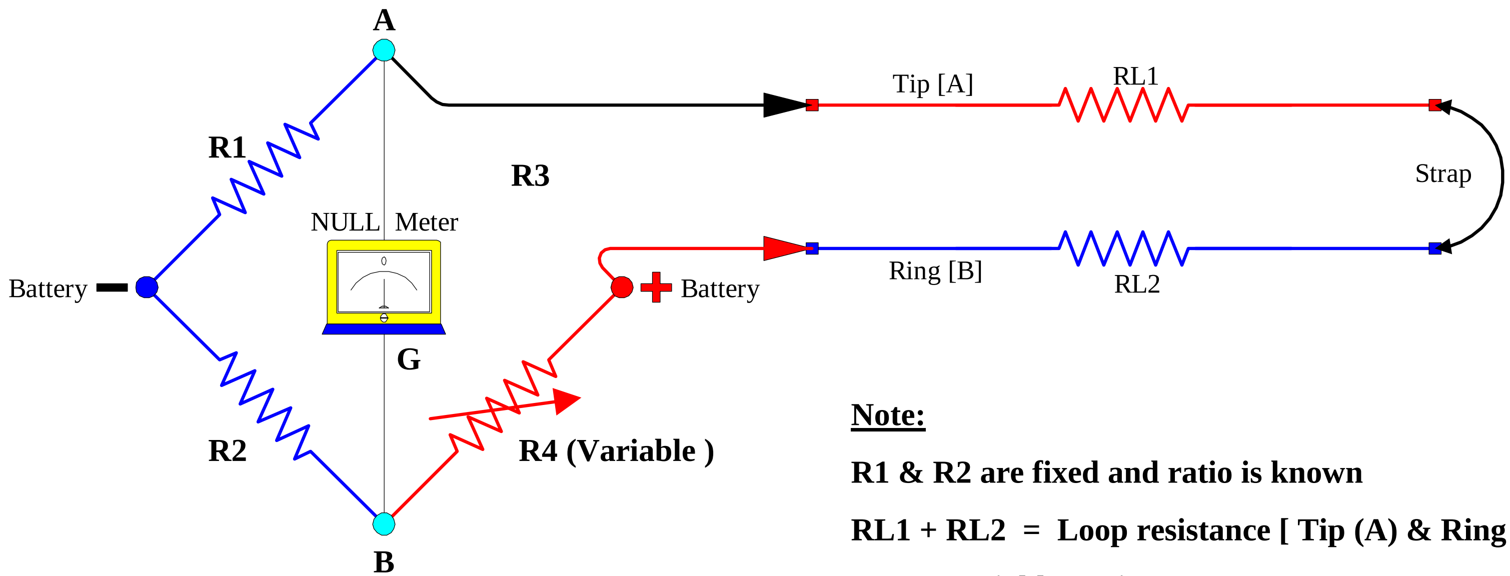
Wheatstone (Resistance) Bridge
[Basic Principle]



Conditions for NULL

$$\frac{R1}{R2} = \frac{R3}{R4}$$

Wheatstone Bridge
[Precision Ohmmeter]



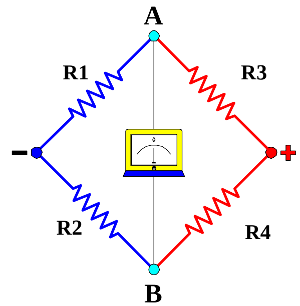
Note:

R1 & R2 are fixed and ratio is known

RL1 + RL2 = Loop resistance [Tip (A) & Ring (B)]

R4 = Variable Resistor

G = Galvanometer [NULL Meter]



Basic Wheatstone Bridge

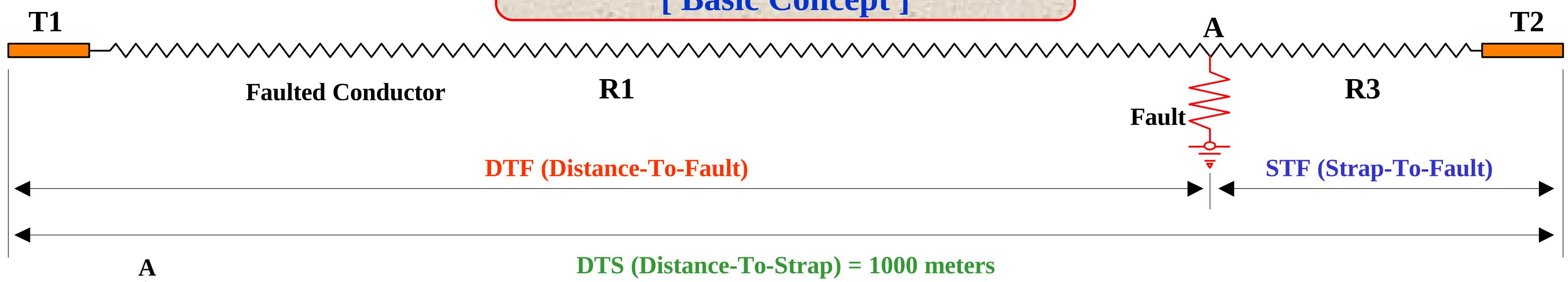
Conditions for NULL

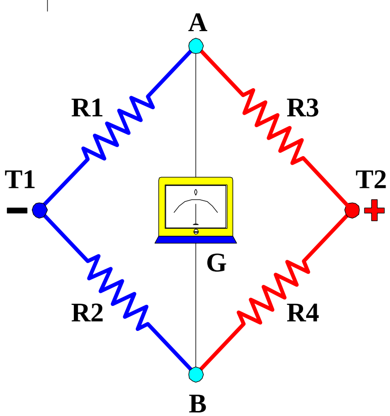
$$\frac{R1}{R2} = \frac{R3}{R4}$$

Resistance Fault Locate

using a Wheatstone Bridge

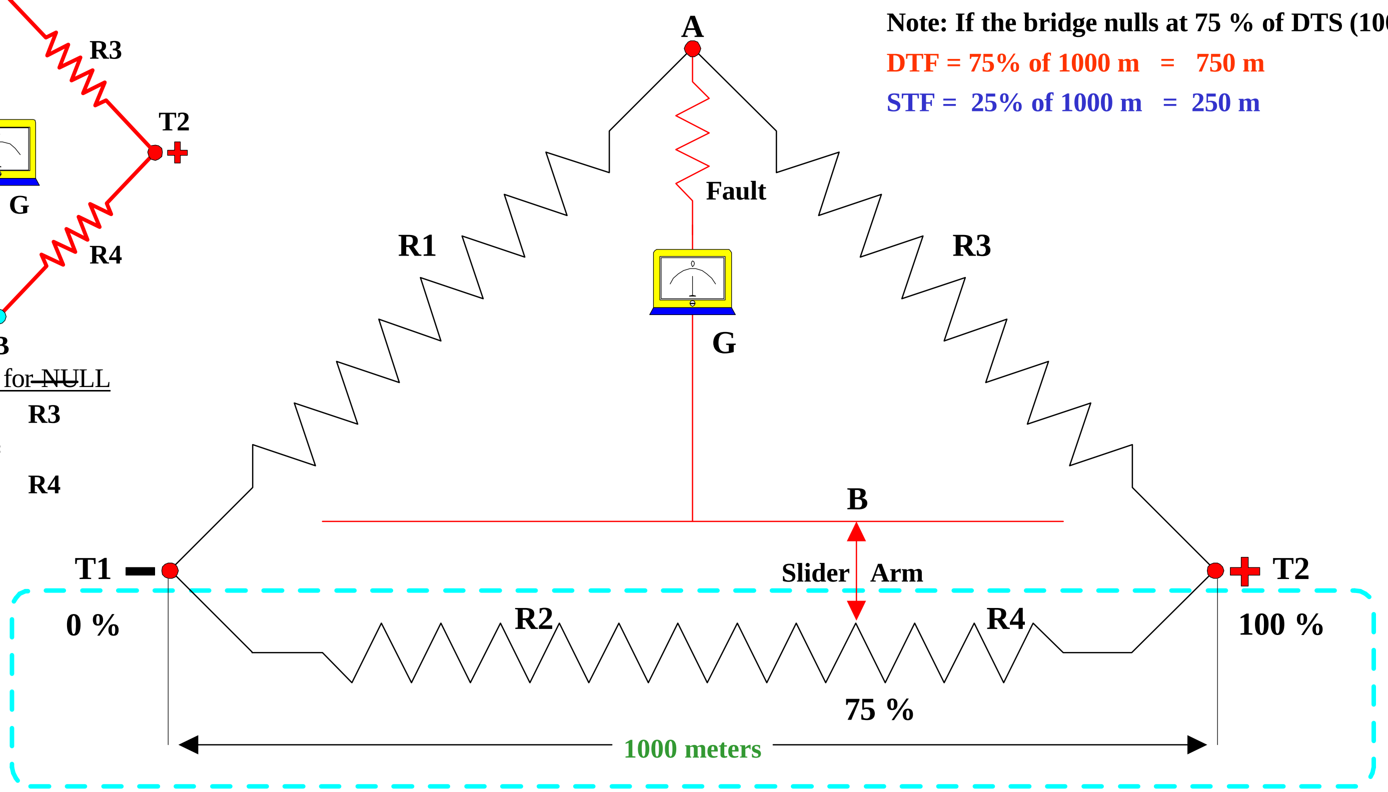
[Basic Concept]





Conditions for NULL

R1		R3
	=	
R4		R4



Note: If the bridge nulls at 75 % of DTS (1000 meters) then -

DTF = 75% of 1000 m = 750 m

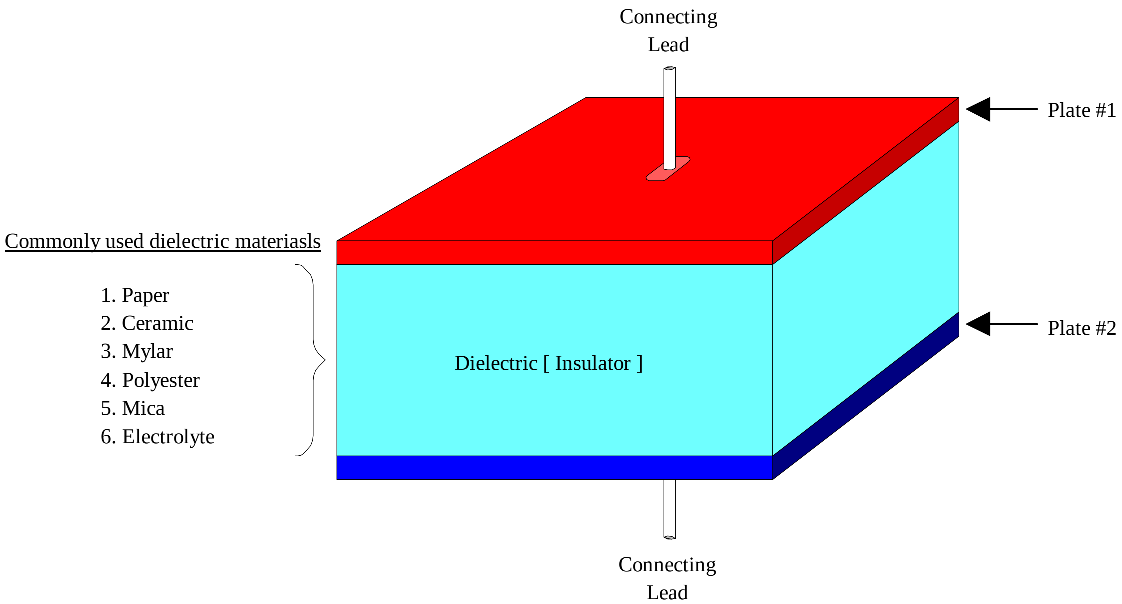
STF = 25% of 1000 m = 250 m

Dynatel 965 Subscriber Loop Analyzer

CAPACITANCE

It is the electrical property of a device called "Capacitor" which is created when two or more metallic plates or conductors are placed close to but insulated from each other.

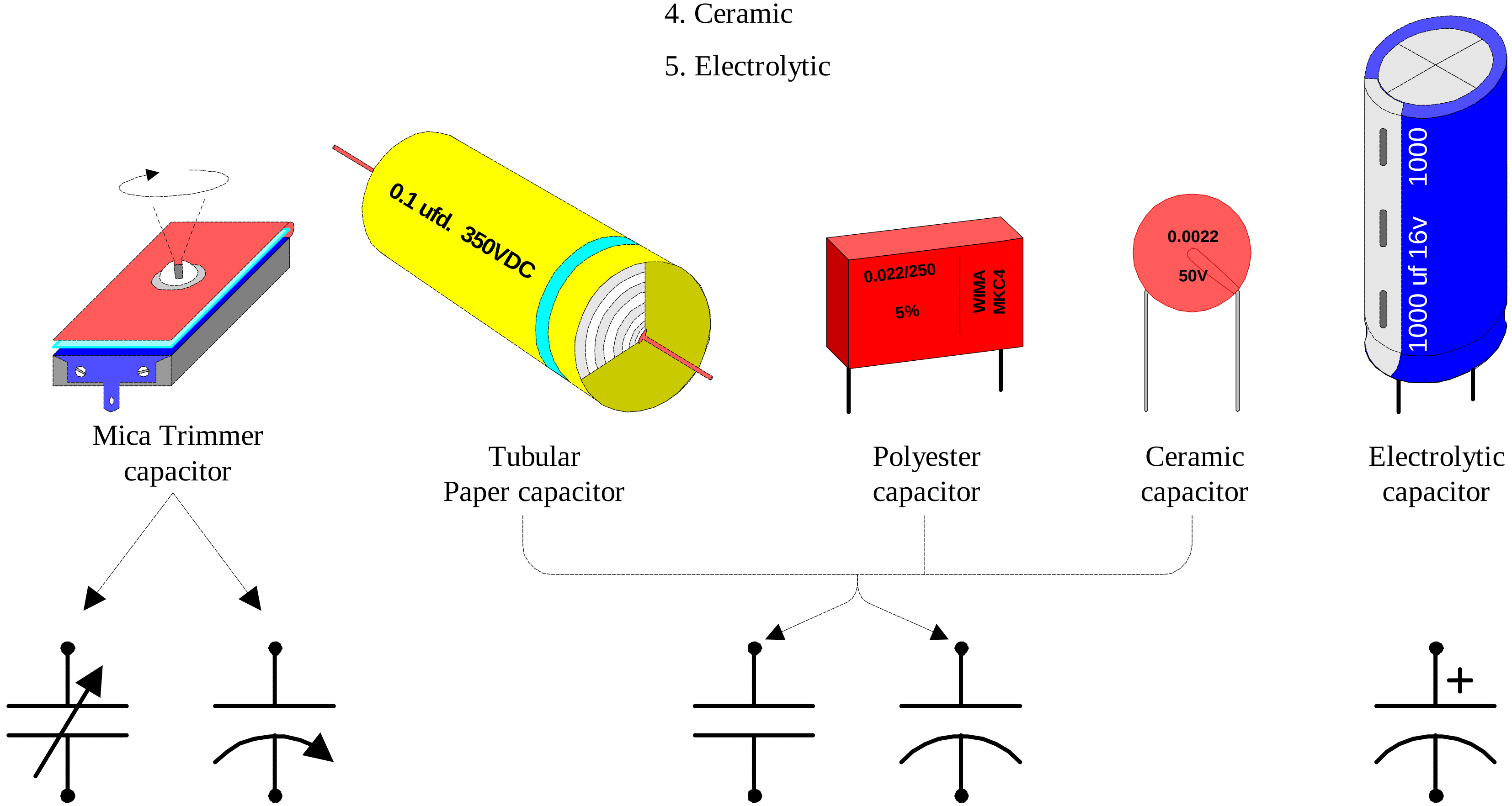
Capacitance permits the storage of electrical energy which means that the capacitor can be charged or discharged similar to a rechargeable battery.



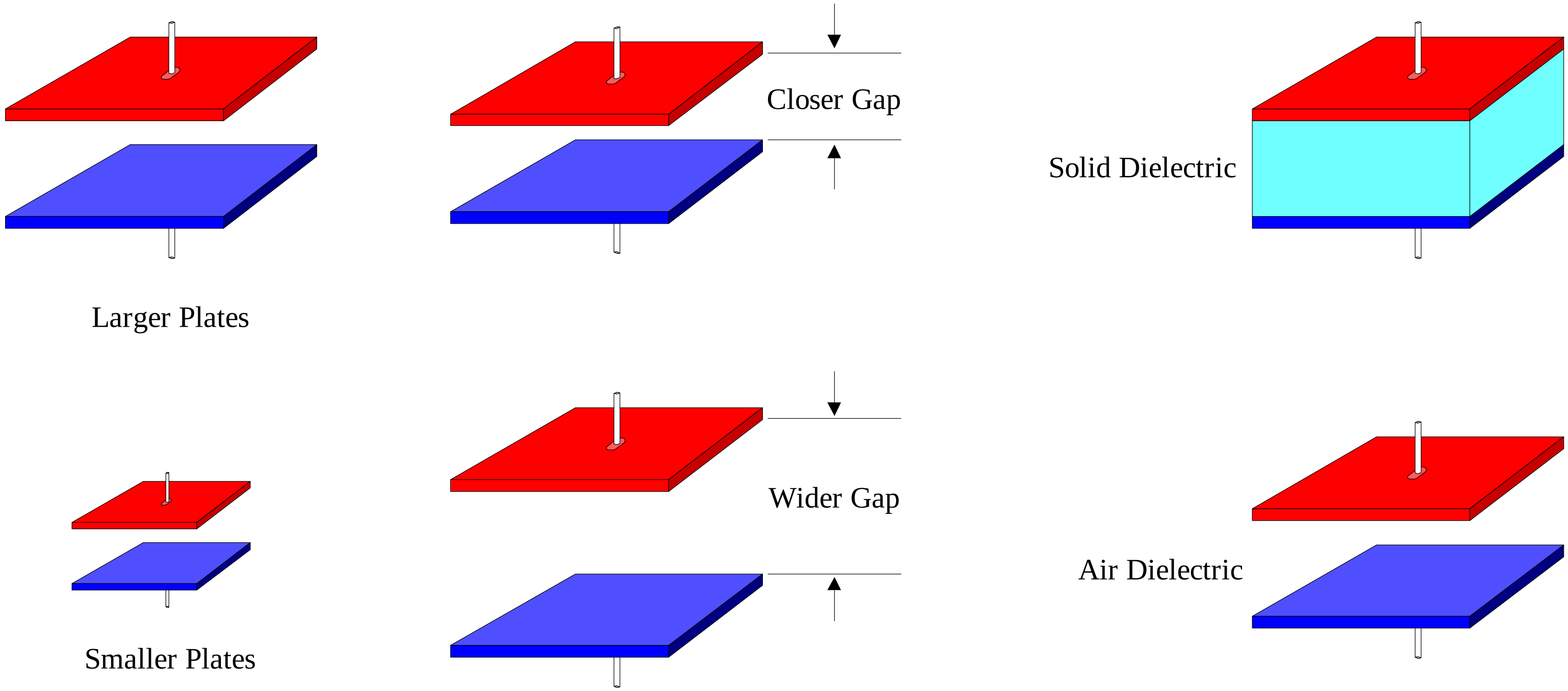
Basic Construction of a Capacitor

Common types of Capacitors

1. Mica
2. Paper
3. Polyester
4. Ceramic
5. Electrolytic

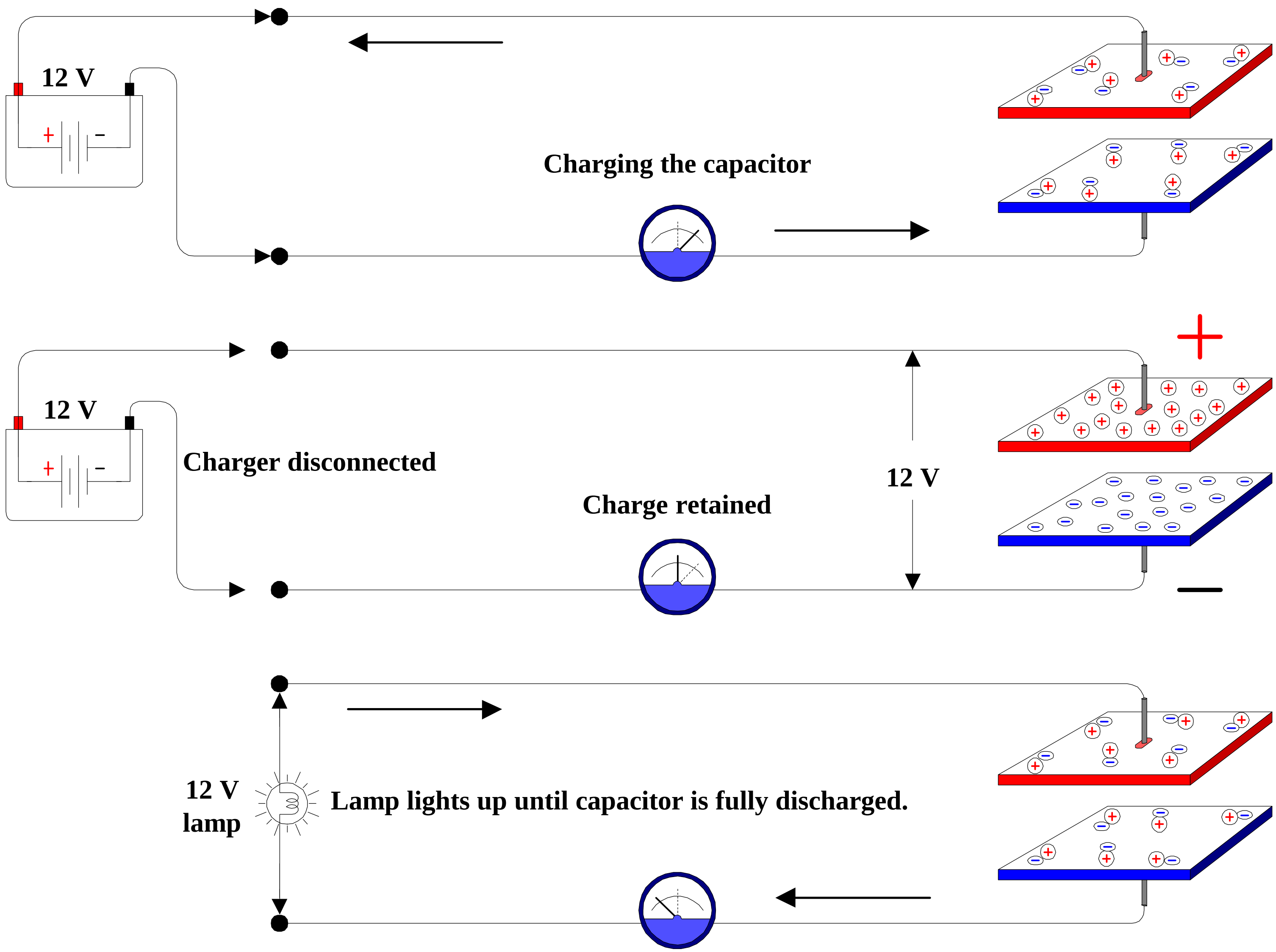


Factors Affecting Capacitance



1. The Larger the plates, the higher the capacitance.
2. The closer the plates, the higher the capacitance.
3. Solid dielectric (insulation) materials increases capacitance compared to air.

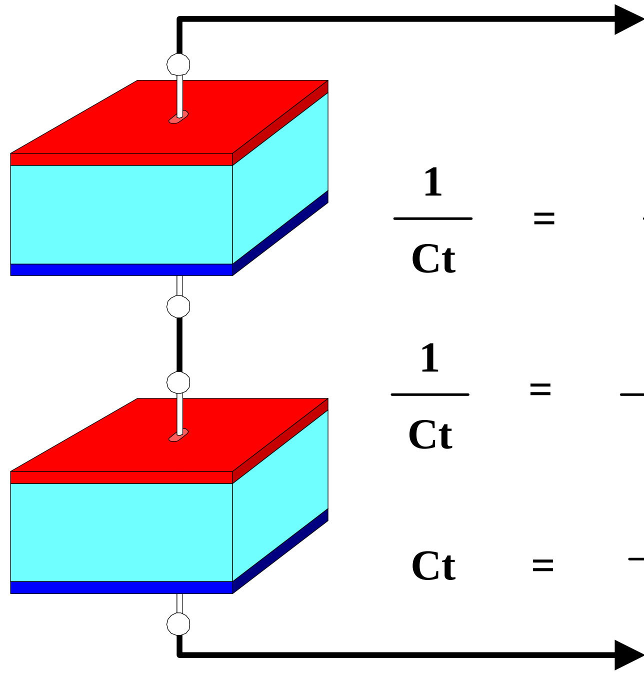
How a Capacitor Works



More about Capacitors

C1 = 1uF

C2 = 1uF



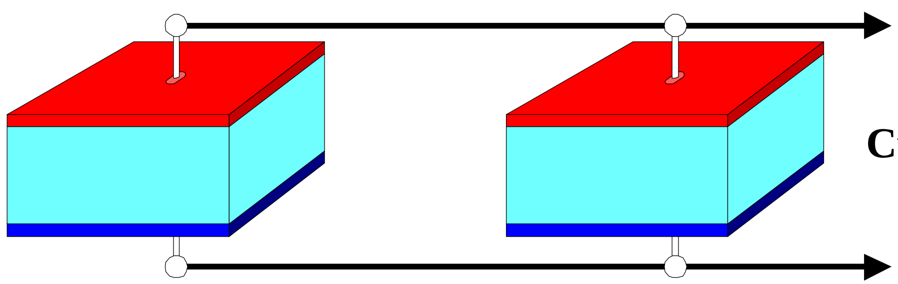
$$\frac{1}{Ct} = \frac{C1 + C2}{C1 \times C2} = \frac{1 + 1}{1}$$

$$\frac{1}{Ct} = \frac{2}{1} \quad \text{or}$$

$$Ct = \frac{1}{2} = 0.5\ uF$$

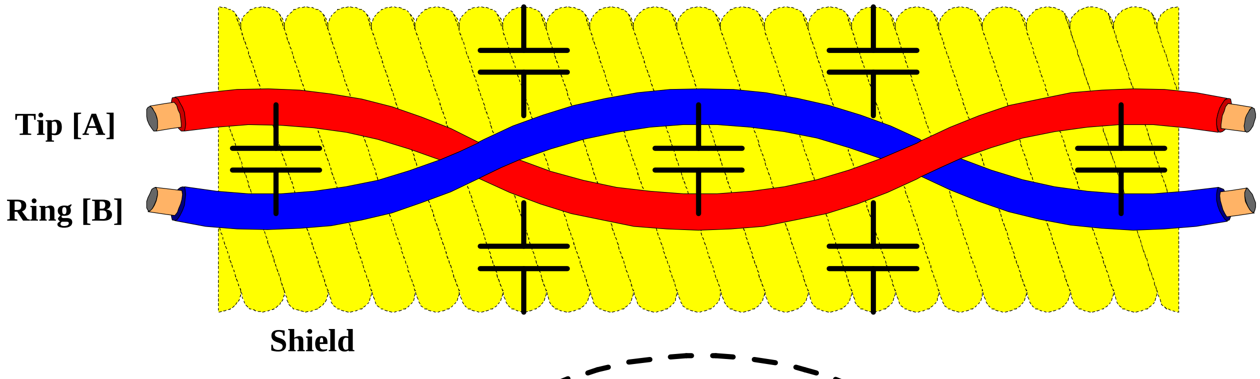
C1 = 1uF

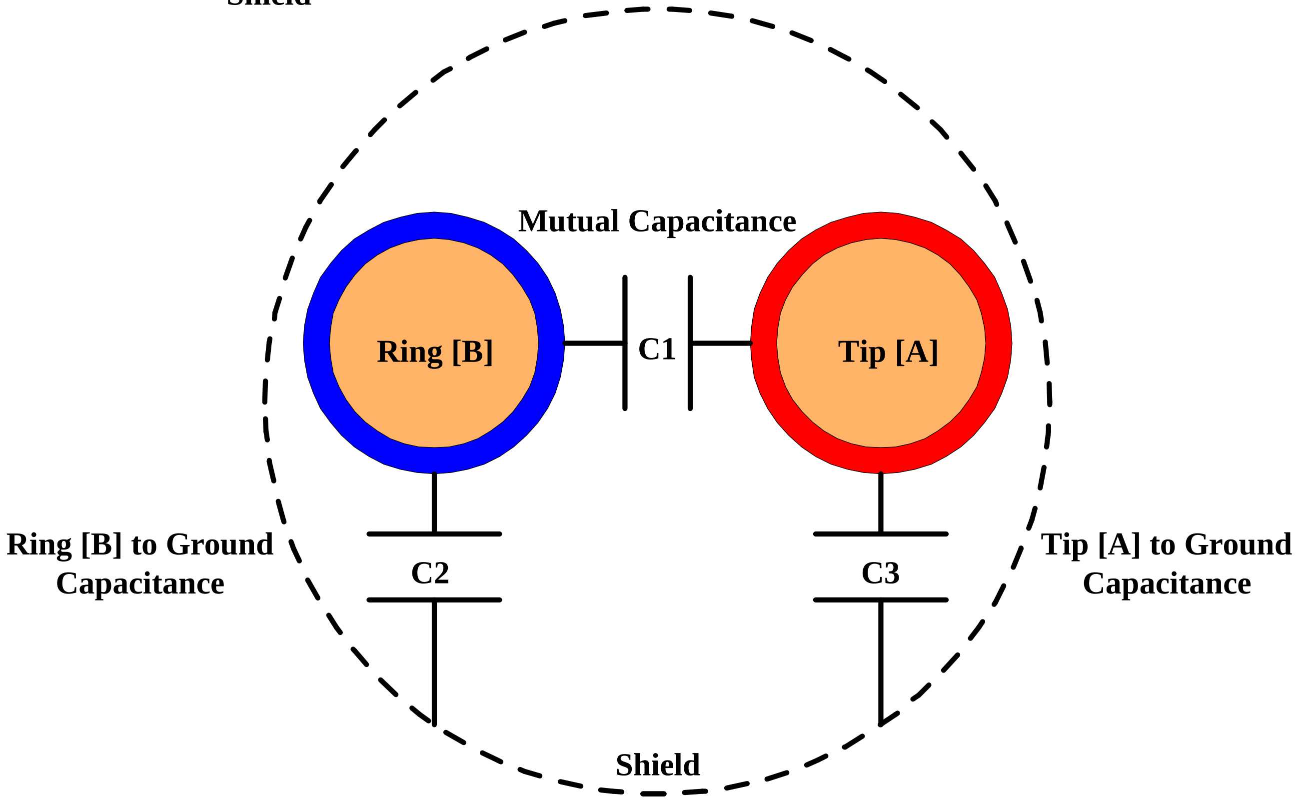
C2 = 1uF



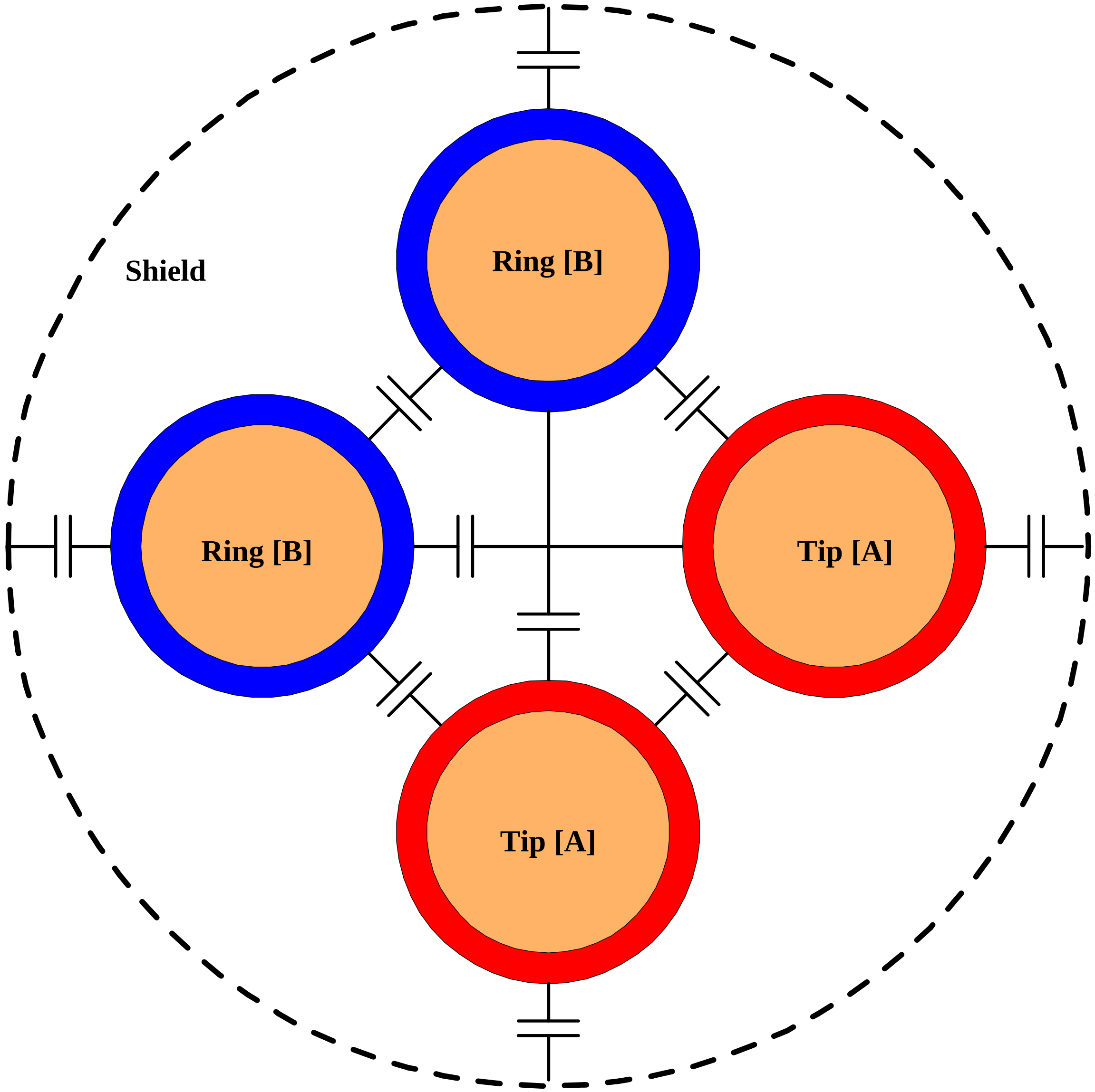
$Ct = C1 + C2 = 2uF$

Capacitances on a telephone pair





Capacitances in a telephone cable



FARAD

Unit of measure for capacitance

Commonly-used capacitance units:

Microfarad (uF) = 1 millionth of a FARAD

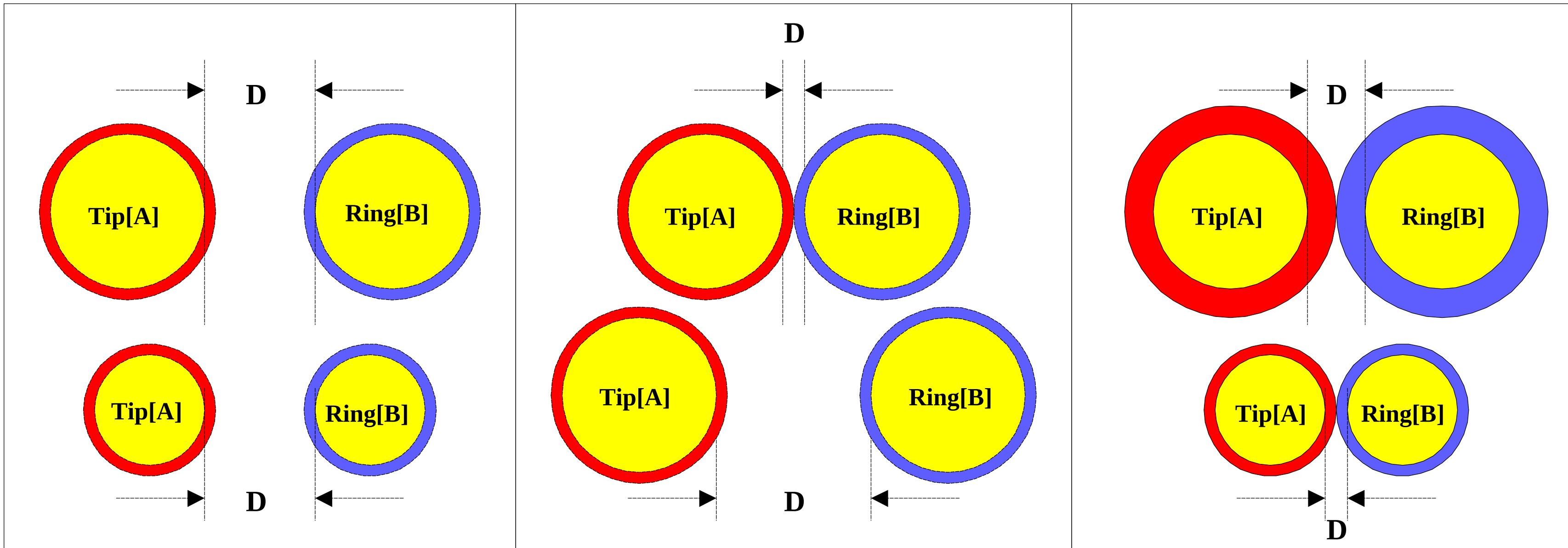
Nanofarad (nF) = 1 thousanths of a Microfarad

Picofarad (pF) = 1 millionth of a Microfarad

Standard Capacitances Of Telephone Cables

Type	Mutual	Tip[A] / Ring[B] To Ground
Aircore	0.083 uF/Mile [0.052 uF/Km]	0.125 uF/Mile [0.078 uF/Km]
Jelly-Filled	0.083 uF/Mile [0.052 uF/Km]	0.140 uF/Mile [0.087 uF/Km]
2-Pair Drop	0.083 uF/Mile [0.052 uF/Km]	0.155 uF/Mile [0.096 uF/Km]
5-Pair Drop	0.083 uF/Mile [0.052 uF/Km]	0.150 uF/Mile [0.093 uF/Km]

How A Uniform Mutual Capacitance Of A Telephone Cable Pair Is Achieved Irrespective Of The Different Conductor Sizes (Gauges)

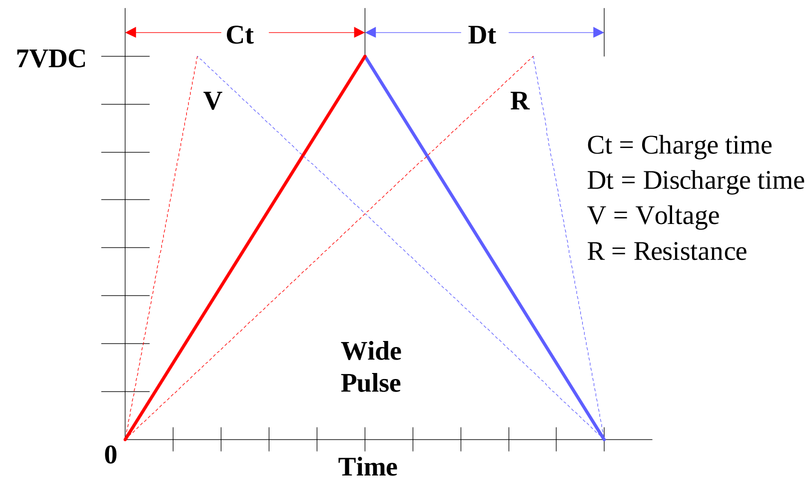


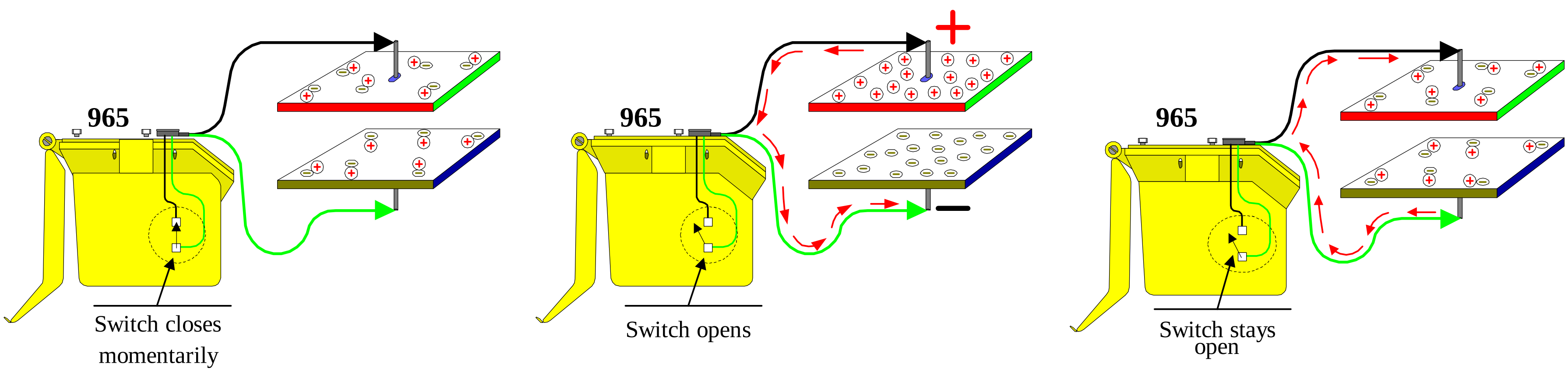
'D'istance	**=**	**the same**
Insulation Thickness	**=**	**the same**
Size/Gauge	**=**	**not the same**
Mutual Capacitance	**=**	**not the same**

'D'istance	**=**	**not the same**
Insulation Thickness	**=**	**the same**
Size/Gauge	**=**	**not the same**
Mutual Capacitance	**=**	**not the same**

'D'istance	**=**	**not the same**
Insulation Thickness	**=**	**not the same**
Size/Gauge	**=**	**not the same**
Mutual Capacitance	**=**	**the same**

How A 965 "OPEN" Meter Measures Capacitance





1. An electronic switch inside the unit closes, momentarily to discharge any existing capacitor charge.

2. As the switch opens, the unit turns ON a current source to charge up the capacitor until it reaches a fixed voltage level. This process is called "Electrometer" method of measuring capacitance. The "Charge" time is then monitored (see RED trace above).

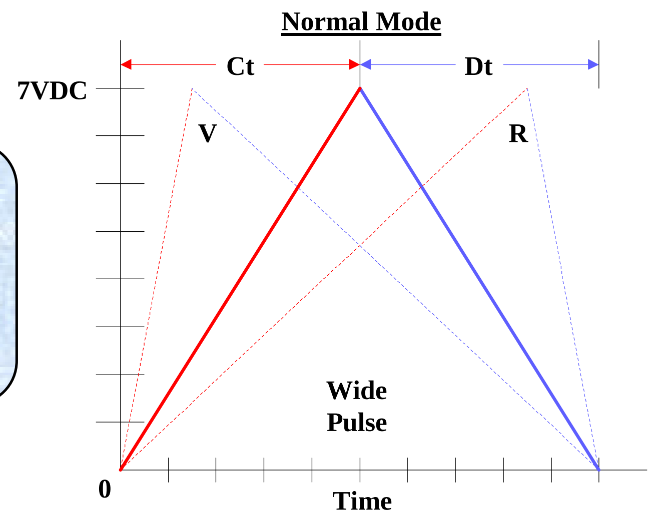
3. Once the threshold voltage (7VDC) is reached, the current source reverses direction which causes the capacitor to discharge. "Discharge" time is again monitored (see BLUE trace above).

Note: Capacitance is directly proportional to the TIME it takes to charge and discharge the capacitor.

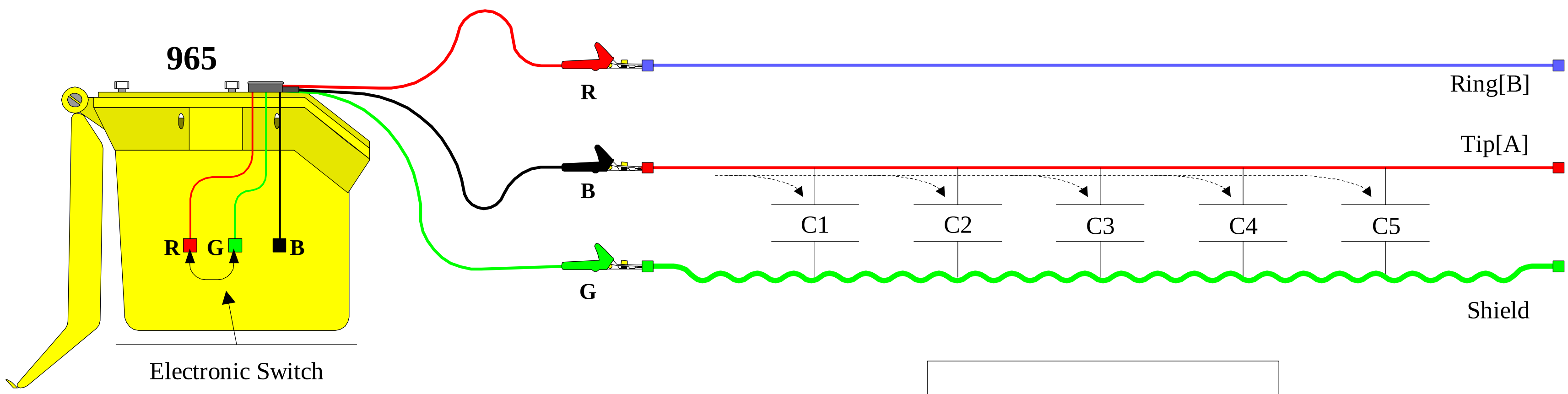
How Length Of A Conductor Is Measured

With A 965 “OPEN” Meter

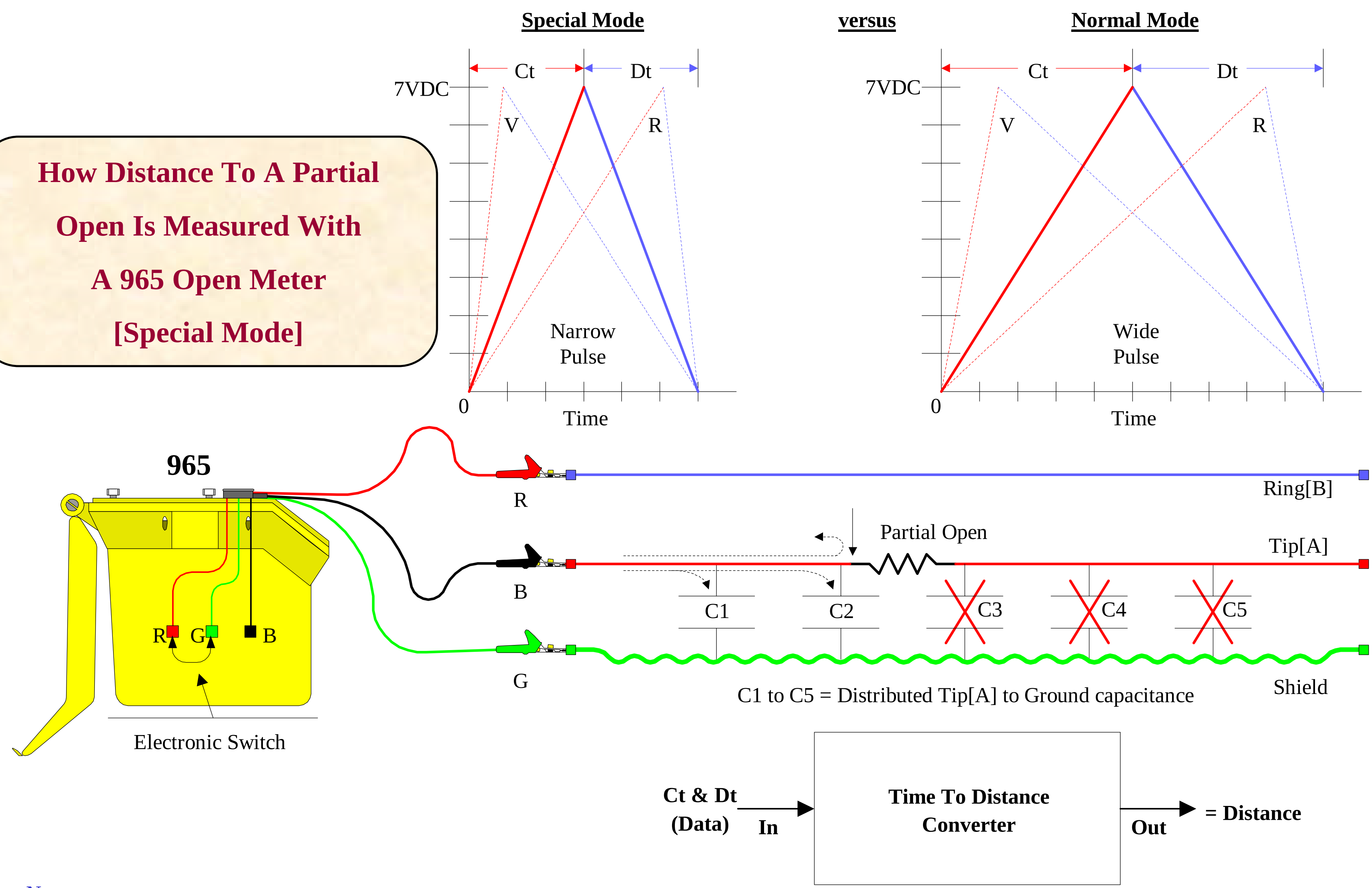
[Normal Mode]



Note: Normal mode is used to measure distance to complete “OPENS” only (not recommended for locating partial or dirty “OPENS”).



How Distance To A Partial Open Is Measured With A 965 Open Meter [Special Mode]



Note:

Special mode is used to measure distances to partial opens, dirty opens and load coils. A partial open acts as a very high impedance path to the high frequency charge current (narrow pulse). This allows C1 and C2 to be charged but not C3, C4 and C5. The charge on C1 and C2 represents the distance to the partial open.

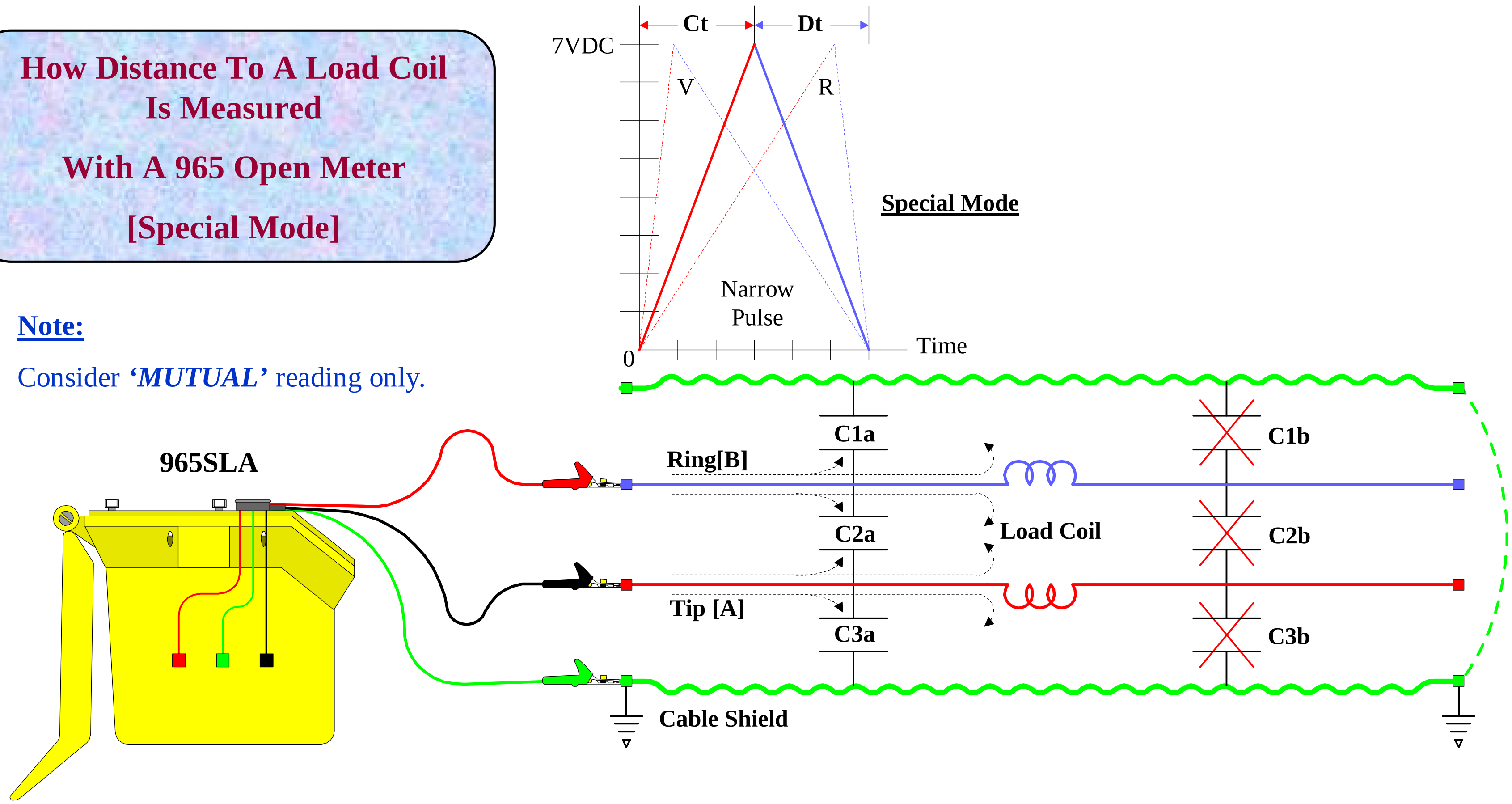
How Distance To A Load Coil Is Measured

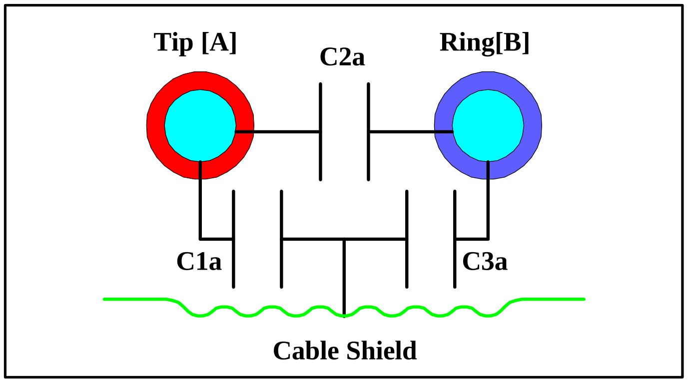
With A 965 Open Meter

[Special Mode]

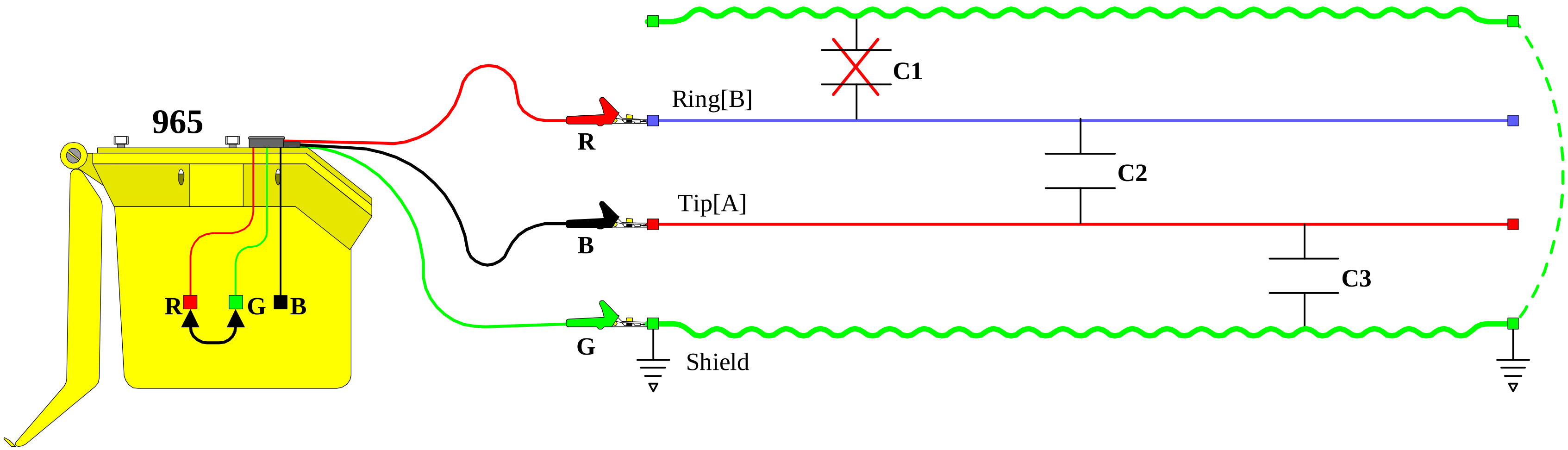
Note:

Consider ***'MUTUAL'*** reading only.





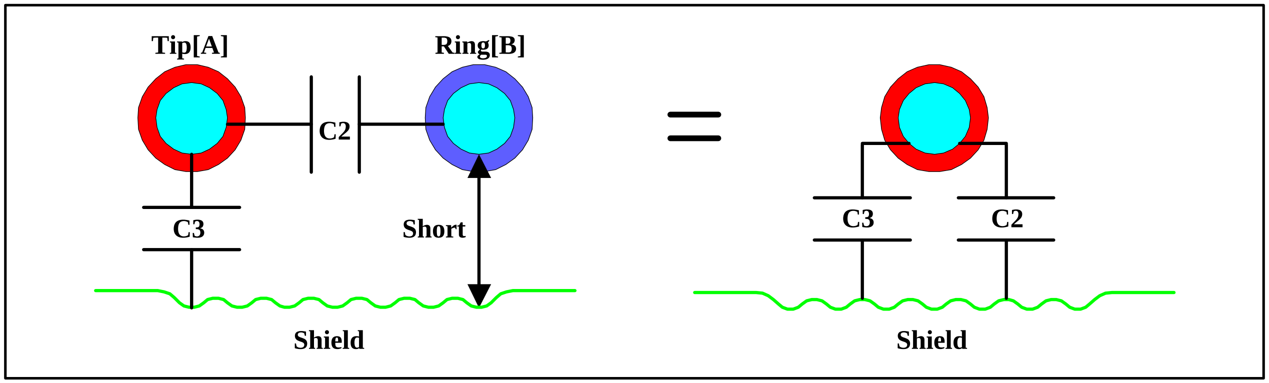
How Length Of Tip[A] Is Measured With A 965 Open Meter



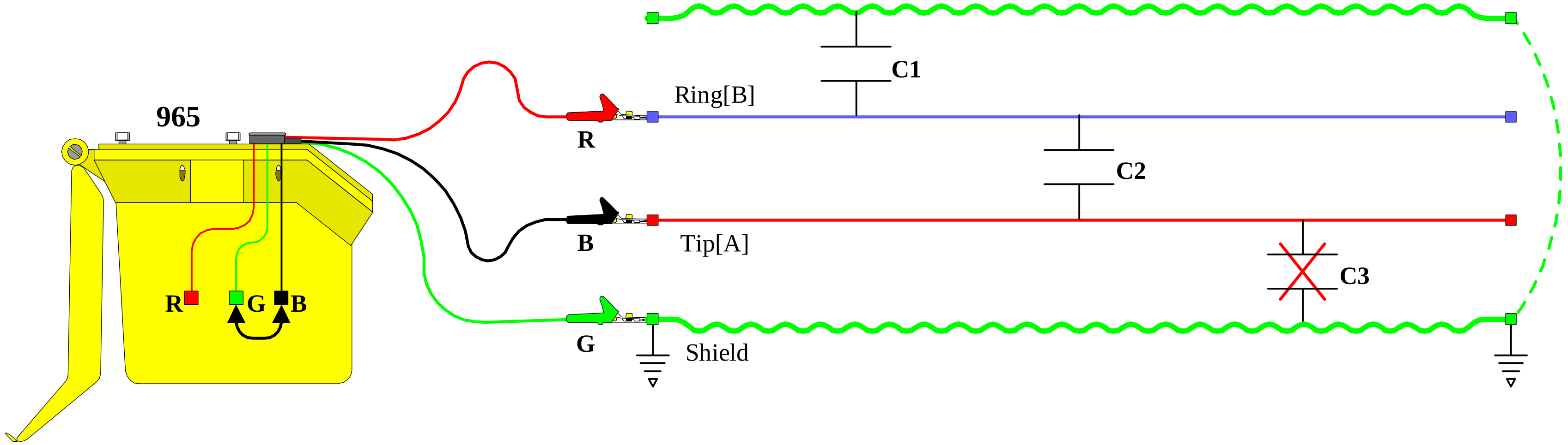
Note:

Length of ***'Tip[A]'*** is the capacitance measured between the ***'Tip [A]'*** conductor and ***'Ground'***. Also, the ***'Ring[B]'*** conductor is shorted to ***'Ground'*** through the switch inside the 965 unit (see illustration above). This eliminates ***C1*** in the circuit and at the same time connects ***'C2'*** in parallel to ***'C3'***, as shown below.

The combined capacitances of ***'C3'*** and ***'C2'*** will then represent the capacitive length of ***'Tip[A]'***.

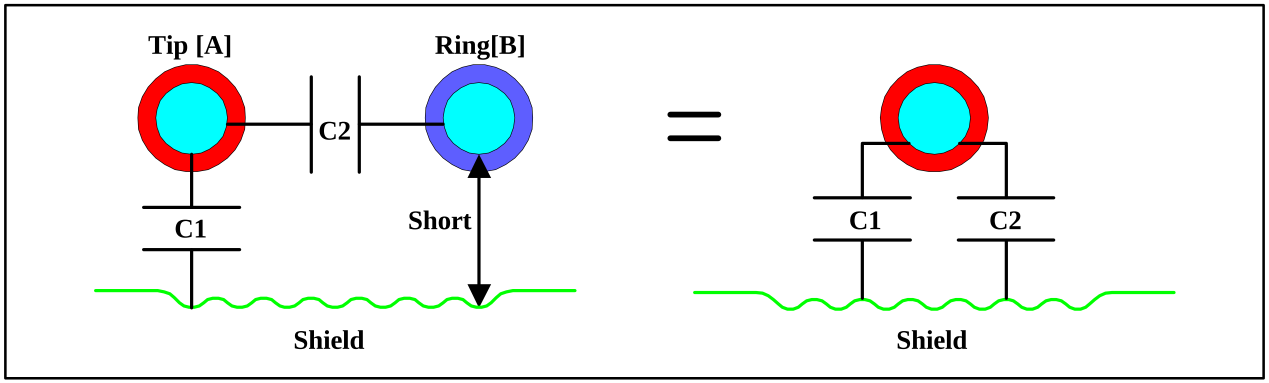


How Length Of Ring[B] Is Measured With A 965 Open Meter

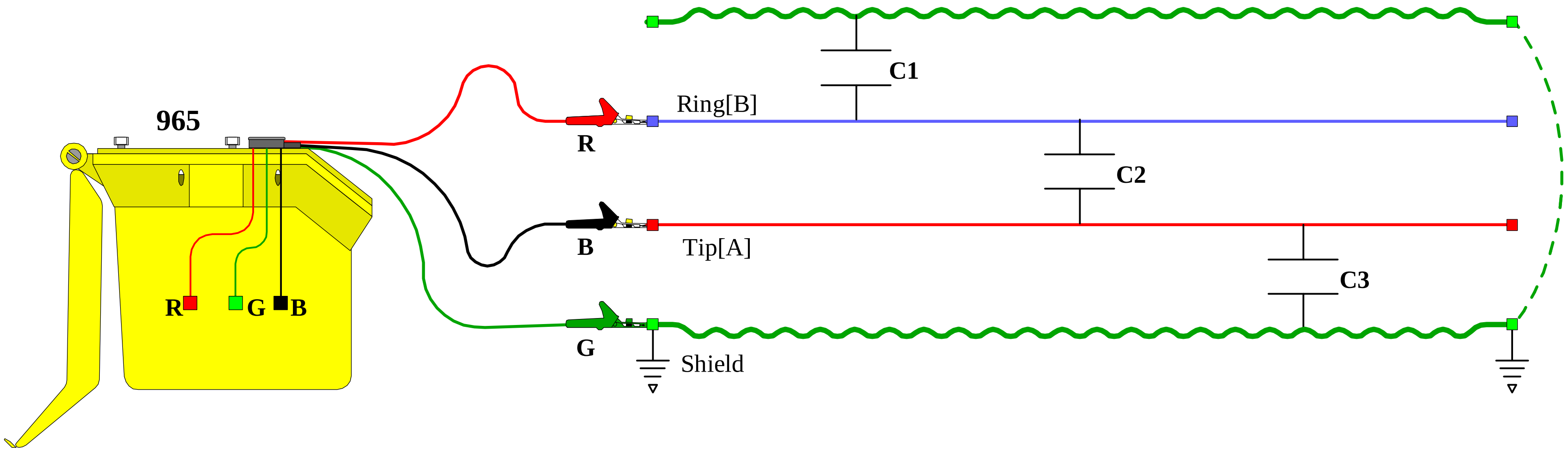


Note:

Length of ***'Ring [B]'*** is the capacitance measured between the ***'Ring [B]'*** conductor and ***'Ground'***. Also, the ***'Tip [A]'*** conductor is shorted to ***'Ground'*** through the switch inside the 965 unit (see illustration, above).This eliminates ***'C3'*** in the circuit and puts ***'C2'*** in parallel to ***'C1'***, as shown in below. The combined capacitances of ***'C1'*** and ***'C2'*** will then represent the capacitive length of ***'Ring [B]'***.



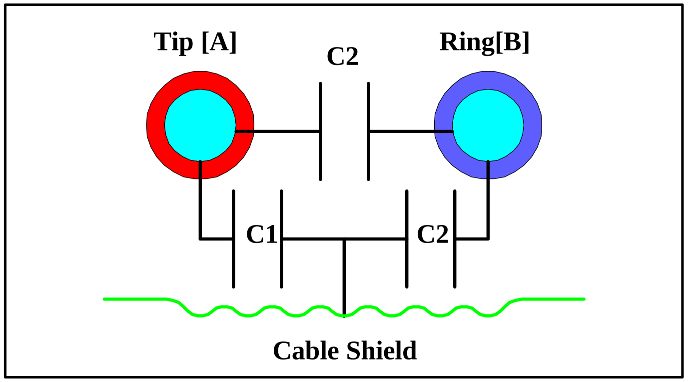
How Mutual Length Is Measured With A 965 Open Meter



<u>Note:</u>

'Mutual' length is the capacitance measured between ***'Tip [A]'*** and ***'Ring[B]'*** with the cable ***'Shield'*** floating (see switch illustration in the 965 unit).

Also, ***'C1'*** and ***'C2'*** are connected in series through the cable shield, as shown below. The ***'Mutual'*** capacitance will then be the series capacitances of ***'C1'*** and ***'C3'*** in parallel to ***'C2'***.



Categories & Types Of Cable Faults

A. Resistance Faults:

1. Ground
2. Short
3. Cross
4. Battery Cross

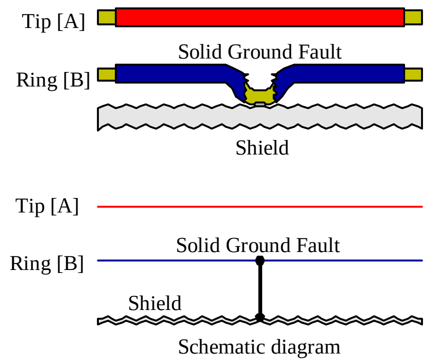
B. Capacitance Faults:

1. Complete Open
2. Partial Open
3. Dirty Open
4. Split

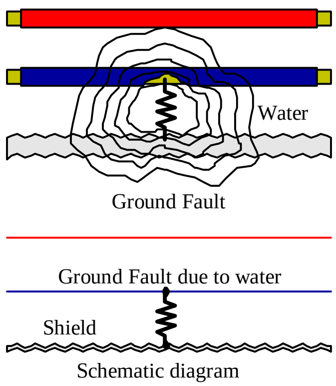
A: Resistance Faults

1. GROUND :

A fault between ***'Tip [A]'*** and ***'Ground'***, ***'Ring [B]'*** and ***'Ground'*** or both conductors and **'Ground'**.

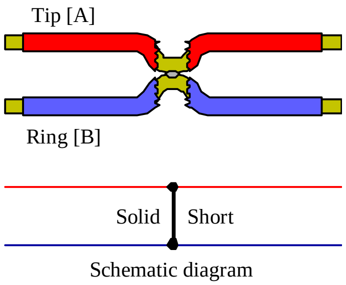


OR

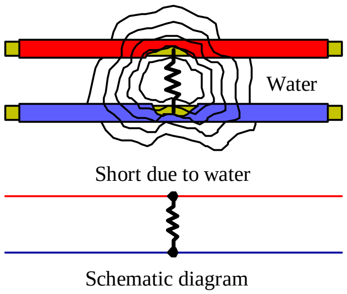


2. SHORT :

A fault between ***'Tip [A]'*** and ***'Ring [B]'*** conductors.



OR



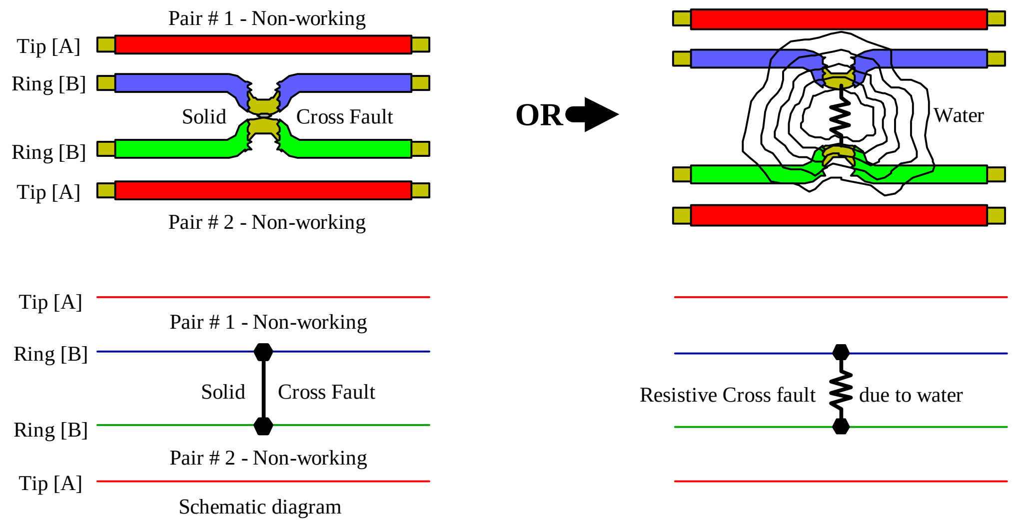
Resistance Faults (con't)

3. CROSS :

A fault between a non-working (pair under test) and another or other non-working pairs.

Note:

To locate a ***'CROSS'***, the pairs involved must be identified, initially.



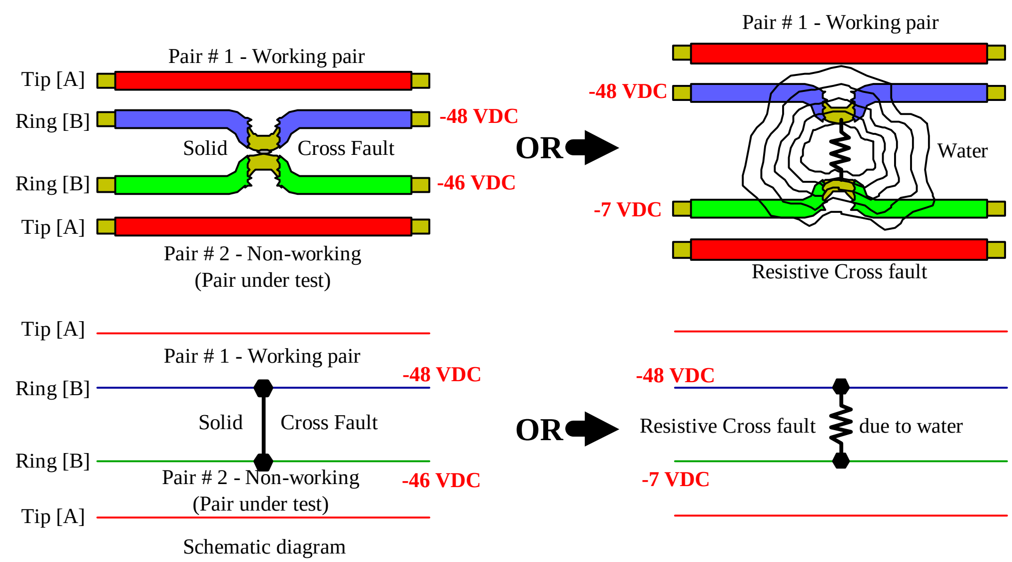
4. Battery CROSS :

A fault between a working pair and a non-working pair (pair under test).

Note:

a) To locate a ***'Battery CROSS'***, there is ***no need*** to identify the working pair. The fault locate procedure is the same as locating a ***'GROUND'*** due to the battery's internal resistance to ***'GROUND'***

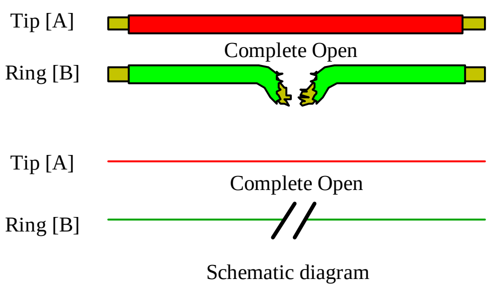
b) In a ***'Solid Cross Fault'***, the voltage reading on the pair under test is quite high (the same or very close to the CO battery voltage) while in a ***'Non-solid Cross Fault'*** the voltage reading is very much lower.



B: Capacitance Faults

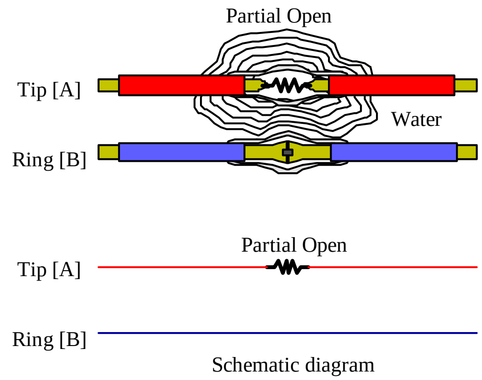
1. Complete OPEN:

A fault where a conductor is cut off completely.



2. Partial OPEN:

A fault where a high resistance path developed on a conductor. (Ex. Corroding splice)

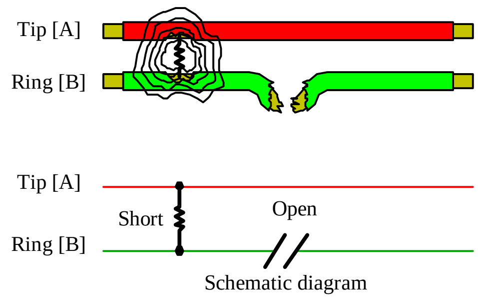


B: Capacitance Faults (con't)

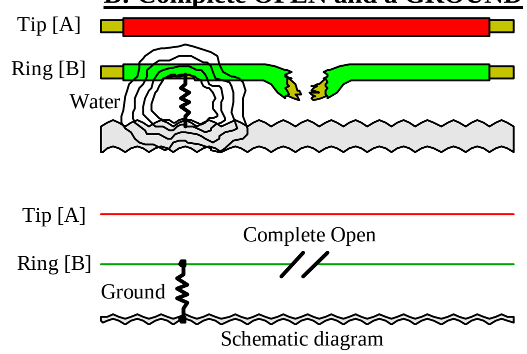
3. Dirty OPEN:

Any combination of a '*RESISTANCE*' and '*CAPACITANCE*' faults

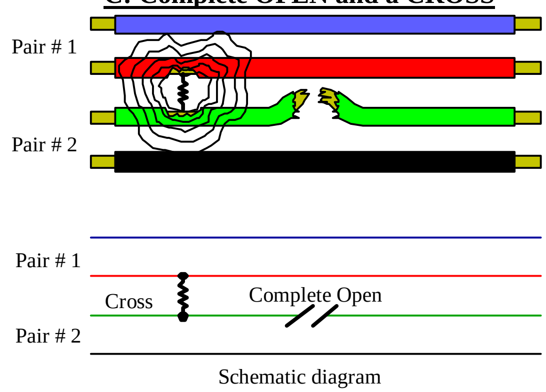
A: Complete OPEN and a SHORT



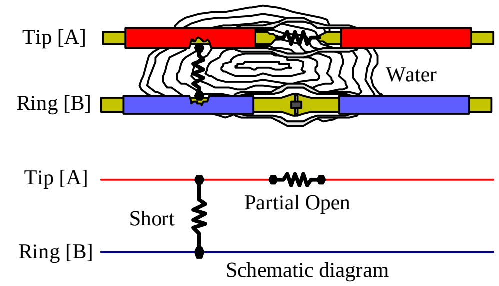
B: Complete OPEN and a GROUND



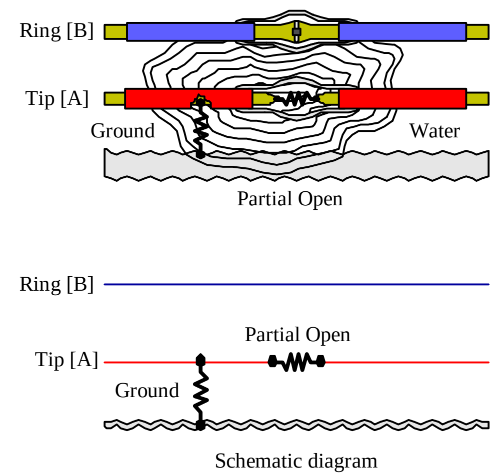
C: Complete OPEN and a CROSS



D: Partial OPEN and a SHORT



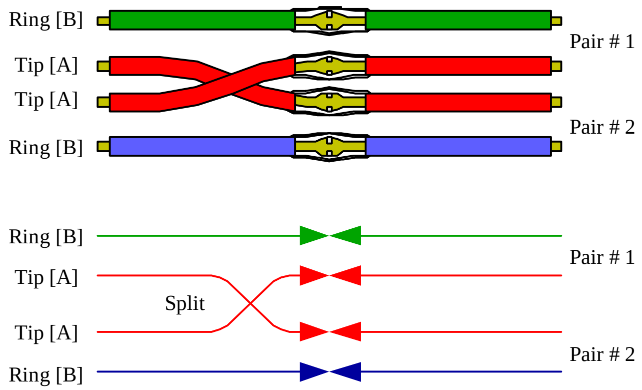
E: Partial OPEN and a GROUND



B: Capacitance Faults (con't)

4. SPLIT:

A splicing error where one conductor of a pair (normally ***'Tip [A]'*** because they the same color) is spliced to ***'Tip [A]'*** of another pair.



Schematic diagram

Cable Fault-Locating Procedure

1. Fault Analysis:

- Analyze symptoms carefully.
- Determine the category and type of fault or faults.

2. Fault Locate to a Cable Section:

- Determine the faulted cable section and isolate other sections without fault.
- From a measured fault location, always consider the nearest access point (Splice, X-Connect box, or a Terminal) as the prime suspect.

3. Fault Locate (Pinpoint).

- Determine the exact physical length of the cable section under test and calibrate the test set to that length. (i. e. If the section length is 500 feet or meters, select "DTS (Distance-To-Strap) Known" in RFL Setup and enter this length).
- Use a separate good pair, as much as possible.

Note:

For short cable sections it is better to run your own *"good pair"* using a roll of MDF jumper wire rather than look for one in the cable.

4. Repair or Fix the Fault or Faults.

5. Verify that the line works.

Cable Fault Analysis Procedure

1. Check and Measure possible Voltages (AC & DC) on the line:

a) between Tip[A] and Ring[B]

b) between Ring[B] and Ground

c) between Tip[A] and Ground

2. Check and Measure Insulation (Leakages) Resistances

a) between Tip[A] and Ring[B]

b) between Ring[B] and Ground

c) between Tip[A] and Ground

3. Perform a Resistance Balance Test:

a) Strap Tip[A] and Ring[B] to Shield/Ground at the far-end.

b) Measure Tip[A] to Shield/Ground Resistance.

c) Measure Ring[B] to Shield/Ground Resistance.

d) Measure Loop Resistance (Tip[A] + Ring[B] ohms)

Note:

Measurements (b) and (c) should be equal or within 10% , otherwise an "open" or a "partial open" exists.

Factors that can cause errors in fault locate measurements

1. Poor Connections will affect RFL measurements.

a) Test Leads

b) Strap

Note:

A 1/4 (0.25) ohm resistance introduced into a 22AWG (0.61mm) conductor will constitute and error of about 16 feet (5 meters).

2. Incorrect assumption of conductor gauge (size) will affect RFL measurements.

A one gauge higher or lower assumption will result into a 40% to 50% error.

3. In equalities of conductor resistances will affect RFL measurements.

a) Variations of gauge created during the cable manufacturing process.

b) Unequal twisting of pairs.

c) Resistances introduces by connectors used during splicing.

d) Inequalities of temperature along the cable length.

4. Random distribution of moisture or water in the cable will affect OPEN measurements.

5. Induced currents (from Power lines, lighting and traction circuits) during the fault locate process will affect both RFL and OPEN measurements.

CRAFTSMAN'S GOLDEN RULE

95%

OF ALL TELEPHONE CABLE FAULTS ARE LOCATED

IN AN ACCESS POINT

(ex: Splices, Terminals, Cross-Connect Boxes, etc.)

AND THE OTHER

5%

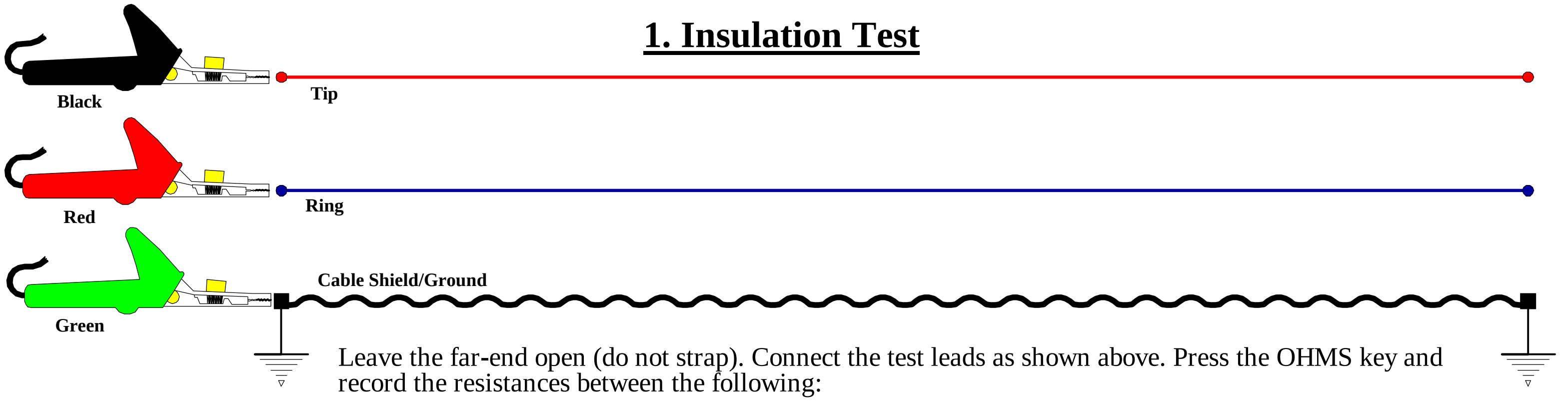
CAN BE IN MID-SPAN.

CABLE FAULT LOCATING

- **It is "*NOT*" an "*EXACT SCIENCE*".**
- **It is an "*ART*".**
- **The name of the game is "*SKILL*".**

Fault Analysis Sheet

1. Insulation Test



Leave the far-end open (do not strap). Connect the test leads as shown above. Press the OHMS key and record the resistances between the following:

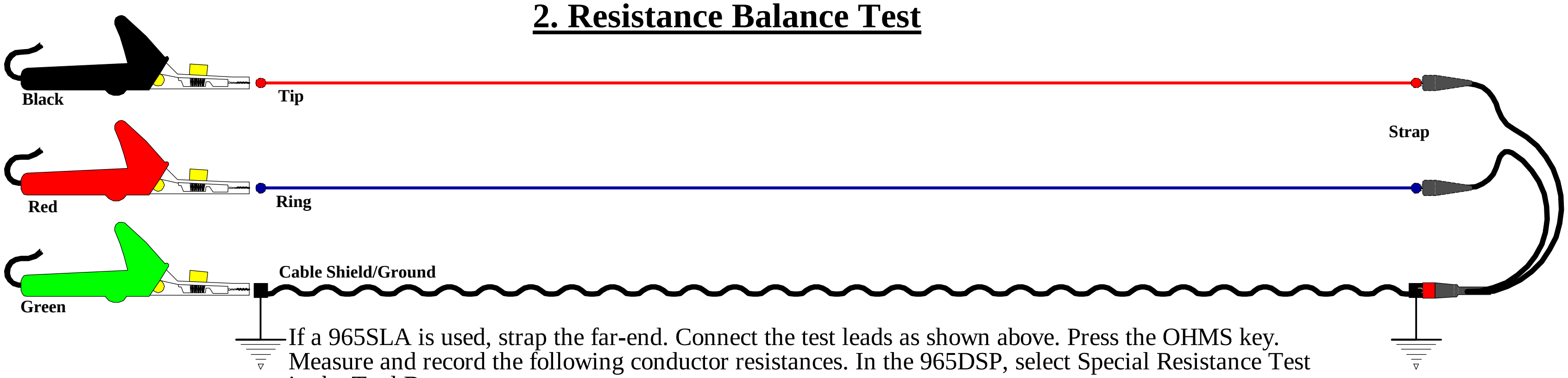
Tip/Ring = ________________ Ohms

Ring/Ground = ________________ Ohms

Tip/Ground = ________________ Ohms

Note: A resistive fault of 3.3 Meg-Ohms or less is a service-affecting and can be located using RFL in the 965SLA or 965DSP.

2. Resistance Balance Test



If a 965SLA is used, strap the far-end. Connect the test leads as shown above. Press the OHMS key. Measure and record the following conductor resistances. In the 965DSP, select Special Resistance Test in the Tool Box.

Tip/Ring (Loop) = ________________ Ohms

Ring/Ground = ________________ Ohms

Tip/Ground = ________________ Ohms

Note: Ring/Ground and Tip/Ground reading should be the same or be very close. If they differ by 10% or more, a partial open may exists. An infinity reading indicates a complete open.

RFL SETUP & TEST LEADS HOOKUP SHEET

RFL SETUP:

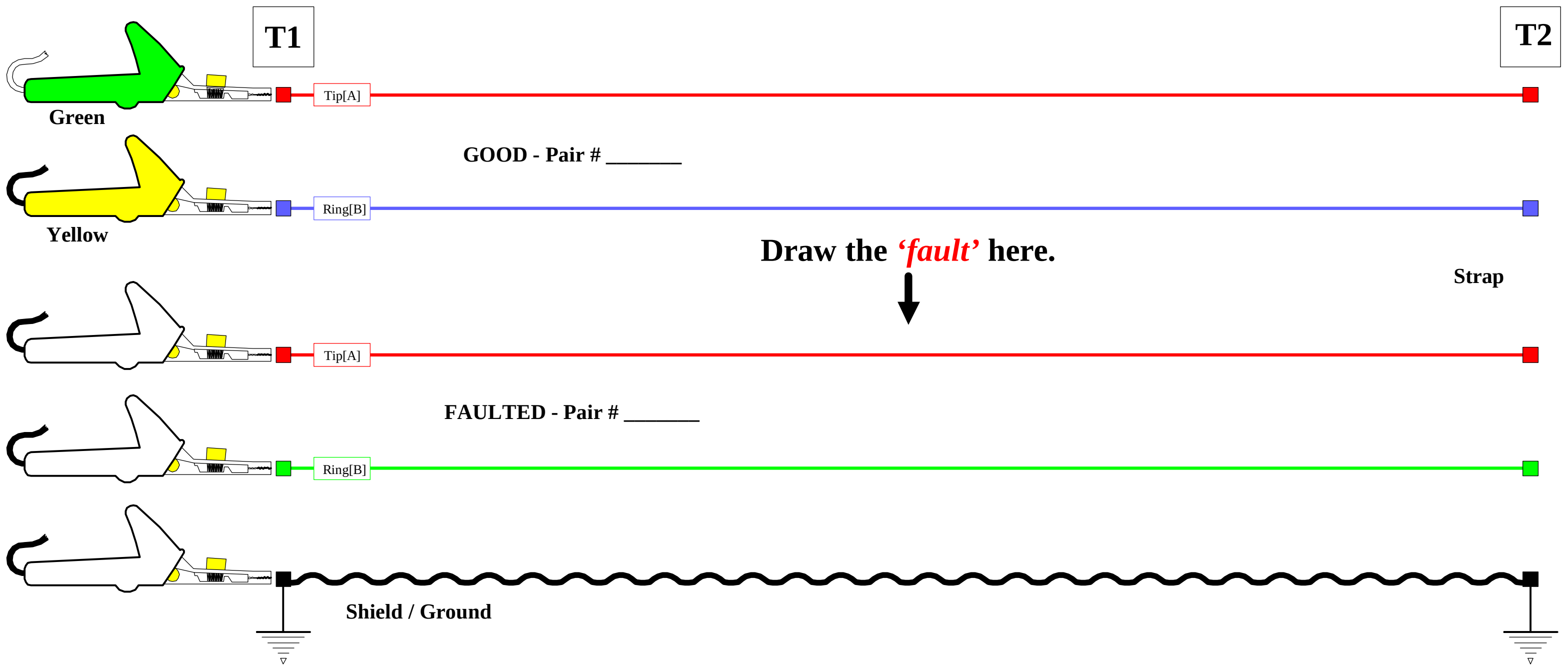
- UNIT MEASURE DTS
- DTS KNOWN
- DISPLAY IN METERS OR FEET
- DISPLAY IN OHMS
- CABLE TEMPERATURE________°C or °F
- GAUGE / SIZE________ Millimeters or AWG
- DISTANCE TO STRAP (DTS)____________Feet or Meters
- SEPARATE GOOD PAIR
- SINGLE PAIR

TEST RESULTS:

DTF = _________________ Meters or Feet

STF = _________________ Meters or Feet

DTS = _________________ Meters or Feet



OPENS FAULT LOCATE SETUP

OPENS SETUP:

- **NORMAL:**
- **SPECIAL**
  - **CALIBRATE TO CABLE**
    - **LENGTH OF CABLE ___________METERS or FEET**
    - **COMPUTED CABLE CAPACITANCE**

      TIP [A] or RING [B] to GROUND:________nF / MILE________uF / MILE

      MUTUAL:__________nf / MILE__________ uF / MILE
  - **AIRCORE**
  - **JELLY-FILLED**
  - **2-PAIR DROP**
  - **5-PAIR DROP**

TEST RESULTS:

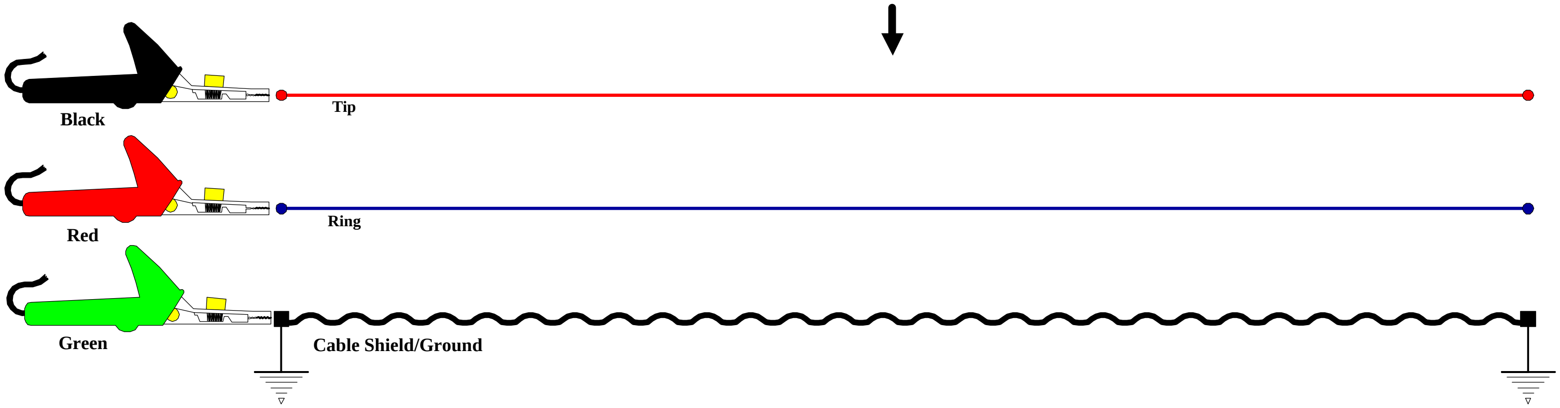
TIP [A] LENGTH _________________ METERS or FEET

RING [B] LENGTH _______________ METERS or FEET

MUTUAL LENGTH _______________ METERS or FEET

Note: Consider the ***'shortest'*** measurement only, for distance to the open fault. Disregard all others.

Draw the *'open fault'* here.



Resistance Fault Locate

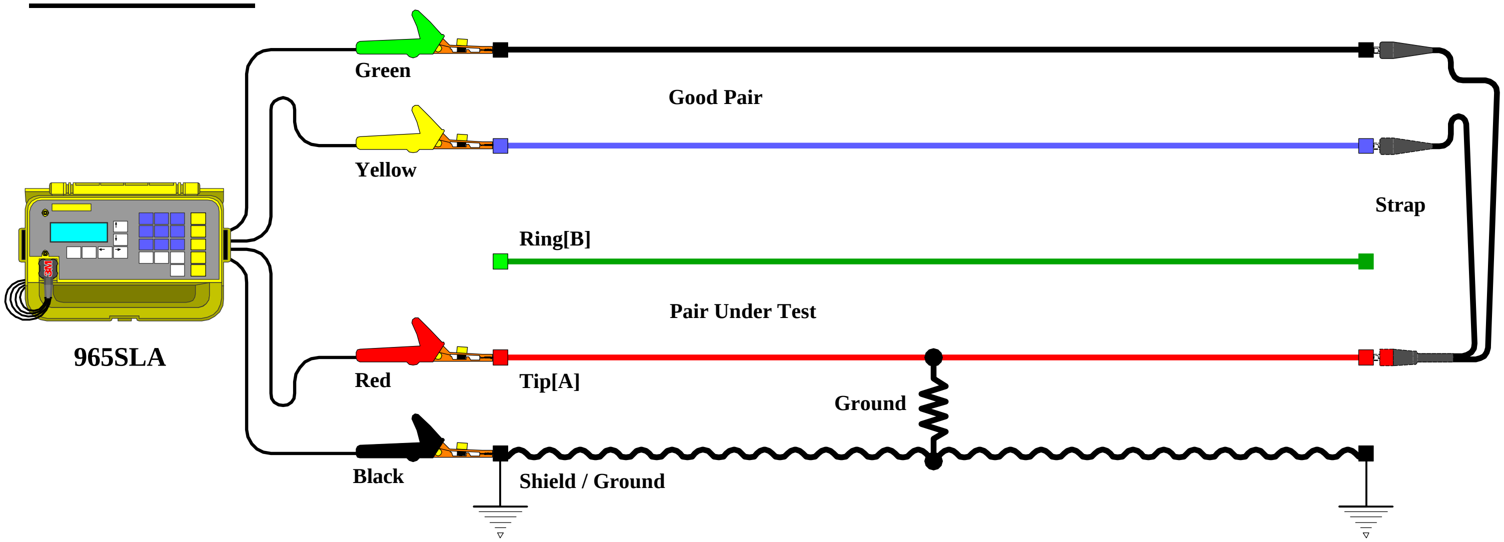
[R F L]

Hookups

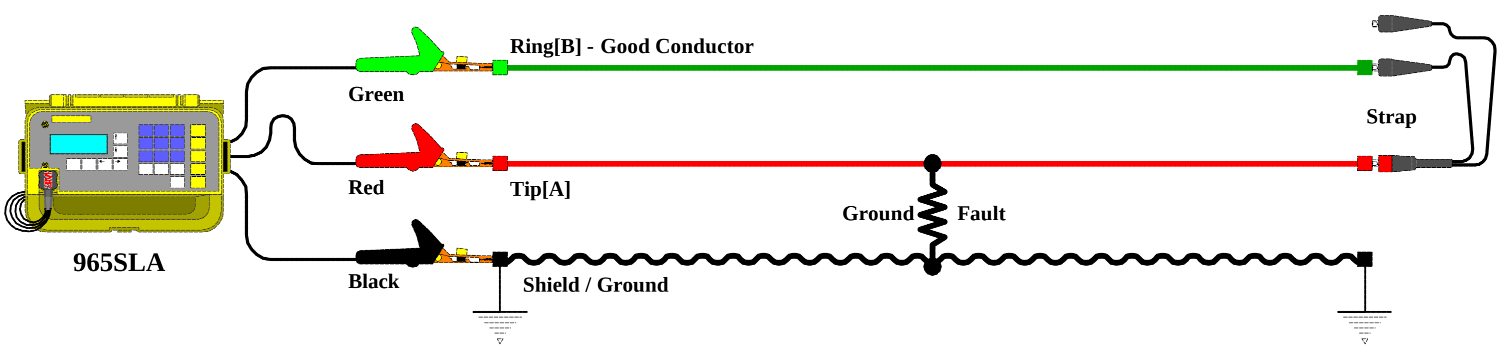
RFL Hookups

1. Ground:

Option A: Using a Separate Good Pair



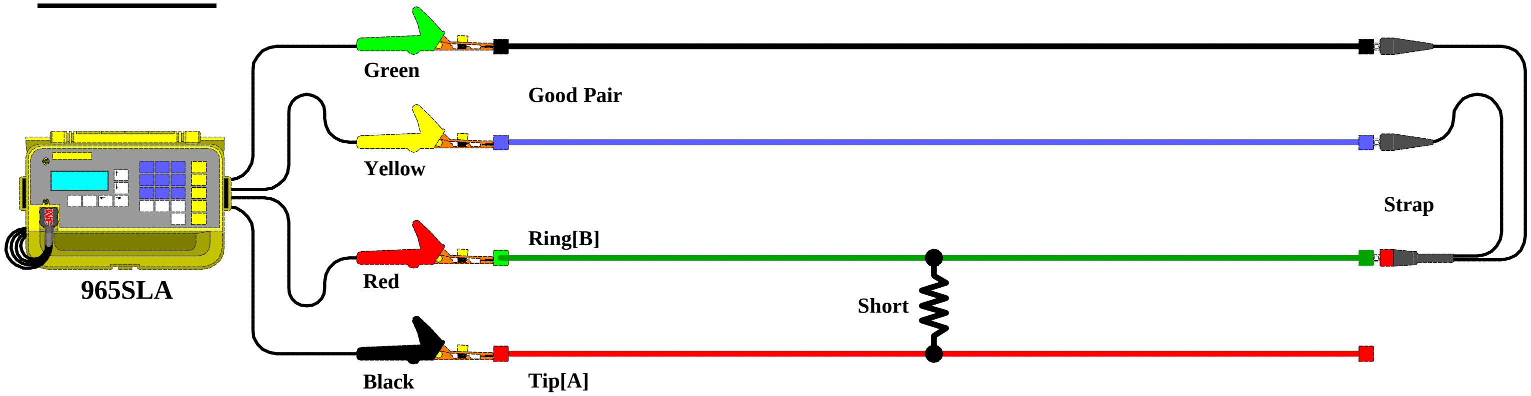
Option B: Single Pair (Single Good Conductor)



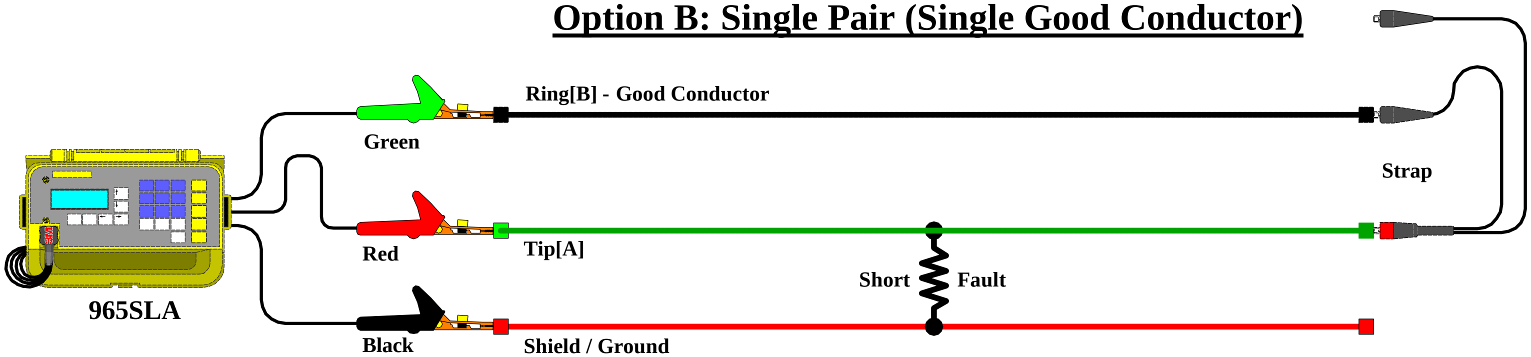
RFL Hookups (con't)

2. Short:

Option A: Using a Separate Good Pair



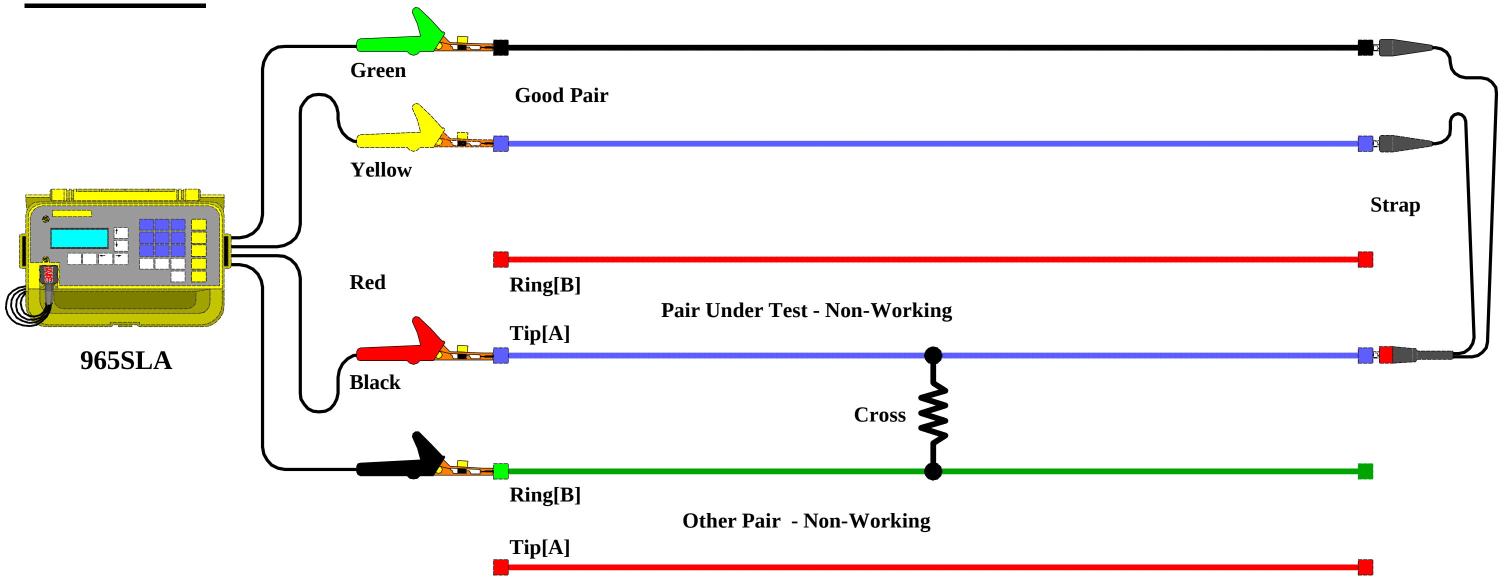
Option B: Single Pair (Single Good Conductor)



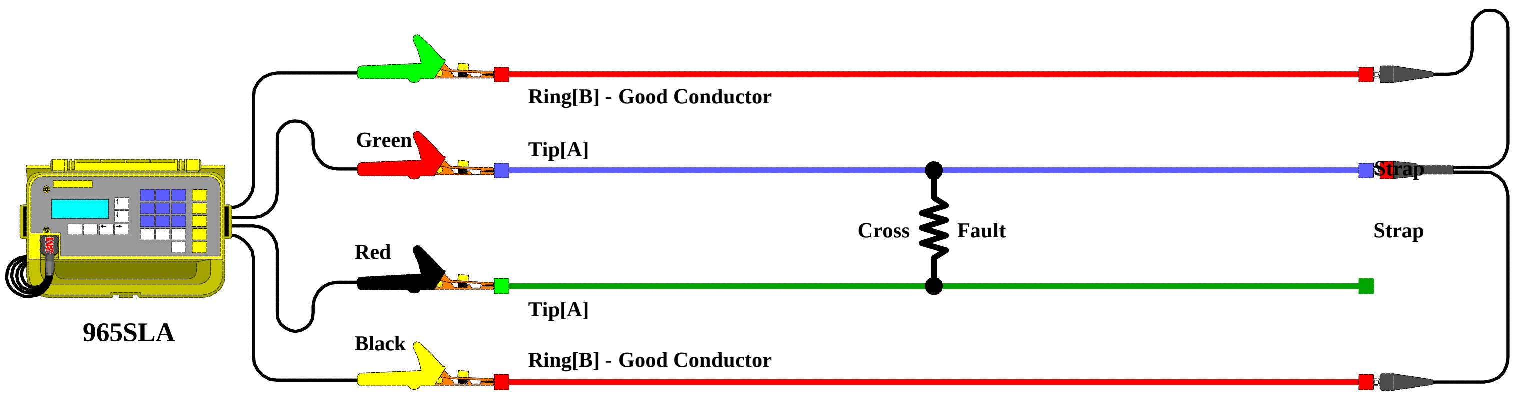
RFL Hookups (con't)

3. Cross:

Option A: Using a Separate Good Pair



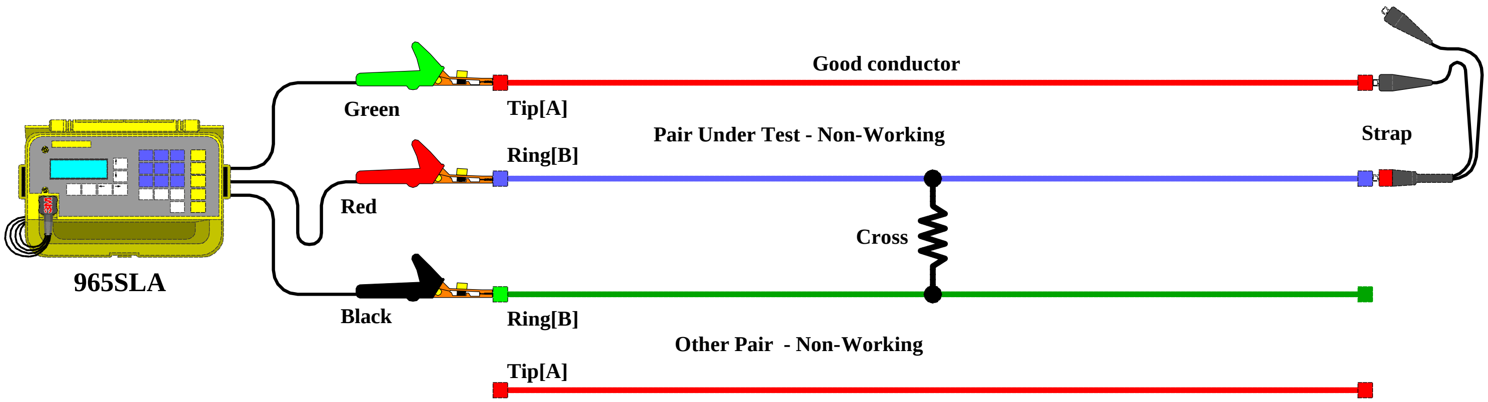
Option B: Ring [B] conductors of each pair can be used as a GOOD pair if they are clean (no faults).



RFL Hookups (con't)

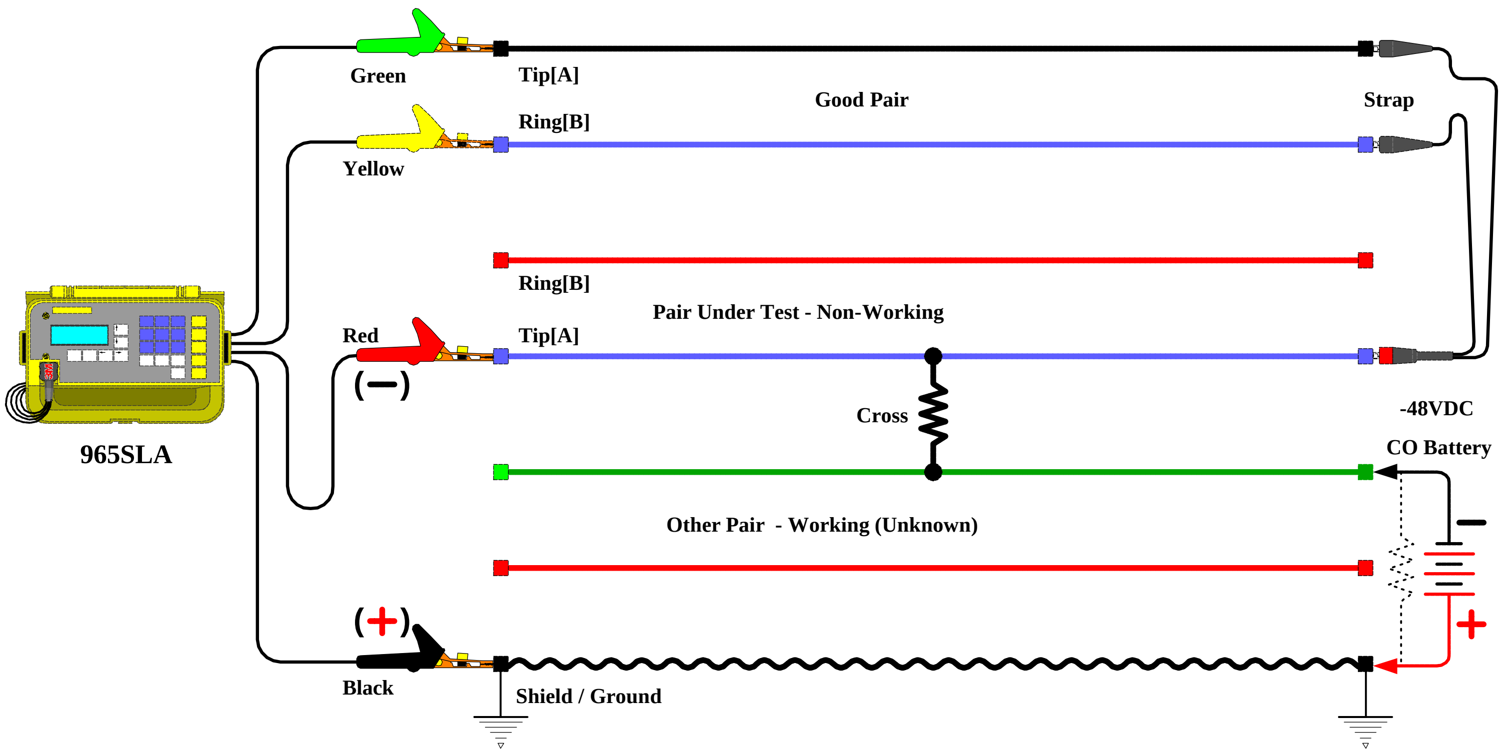
C. Cross:

Option C: Using a Single Good Conductor



4. Battery Cross:

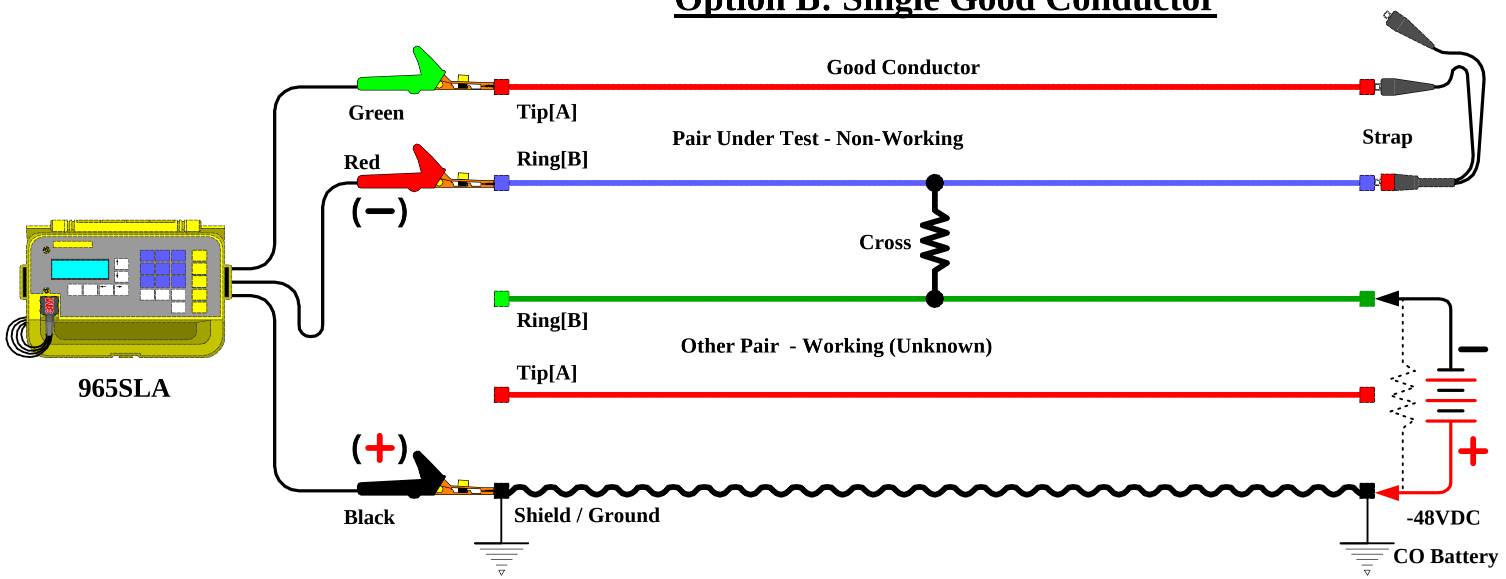
Option A: Separate Good Pair



RFL Hookups (con't)

4. Battery Cross:

Option B: Single Good Conductor



Fault Locating Tips

RFL:

1. Always draw a diagram of the faulted pair for better fault analysis.

2 . There are always three factors to be considered in Resistance Fault Locating - Gauge, Length and Temperature of the cable. Cable temperature is the most difficult factor to determine.

The best approach is to know the 'Gauge and Length' of the cable section under test. This information can be entered into the computer during 'SETUP' and the test equipment will compute the cable temperature.

3. Always use a 'Separate Good Pair Hookup' if possible.

4. A pair that has some faults in it can be used as a 'Good Pair' as long as it is at least 200 times better than the faulted one.

5. A 'Good Pair' can be of any other gauge or length which is different to the faulted pair and can also come from another cable.

6. Sectionalize a long cable. Go to the middle of a long section and open the pair under test. Check for the fault in one direction and then the other and then isolate the clean side. Repeat the process until the the cable section is short enough where the length of the section can be precisely determined by physical measurement. Also, a short cable section will allow the technician to use his/her own good pair without going into cable.

7. For short cable sections 1000 feet (300 meters), use your own "GOOD PAIR" a roll of #24 gauge CO jumper wire.

8. The procedure in locating a 'Battery Cross' and a 'Ground' fault is the same.

9. In a 'Single Pair Hookup', the best good conductor to use is the mate of the faulted one and the next best is any good conductor from any of the pairs in the same group.

10. If DTF and DTS are equal, the fault is either at the strap or beyond.

Fault Locating Tips

<u>OPENS Locate:</u>

1. The GREEN clip must always be connected to the cable shield (ground) when locating opens.

2. ‘Normal’ mode should only be used in ‘complete opens’.

3. ‘Special’ mode is primarily used for ‘partial and dirty opens’ and is limited to no more than 6000 feet (1800 meters) of cable .

4. Cable gauge and temperature will not affect cable capacitance.

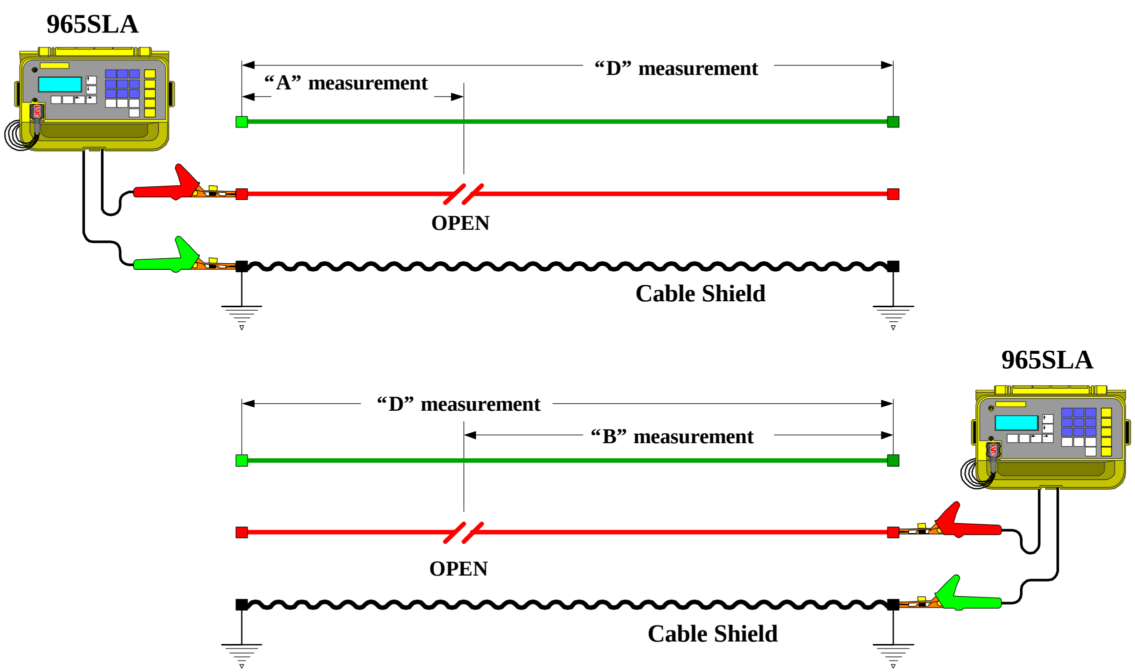
5. For most accurate OPENS measurement, calibrate the unit to a good pair in the same cable as the faulted one.

6. OPENS Locate does not require a strap. Use it first in analyzing cable faults.

7. If ‘MUTUAL’ measurement is longer than Tip [A] or Ring [B], the cable shield can be open.

Locating OPENS by Ratio

Measuring distance to an open.



Note: Since the **RED** and **GREEN** leads are used, consider the **Ring [B]** measurement only.

Requirement: Length of cable section under test must be known.

Procedure:

1. Connect the 965 unit as shown in the illustration and make the "A" measurement.
2. Move the 965 unit to the far-end and make the "B" measurement.
3. Calculate distance to the open using the formula, below:

$$d = \frac{(A \text{ or } B) \times D}{C} \text{ meters to open}$$

Where:

d = Distance-To-Open

(A or B) means whichever is shorter.

D = Length of cable section under test.

C = **A + B**

Example:

D = 290 m

A = 110 m

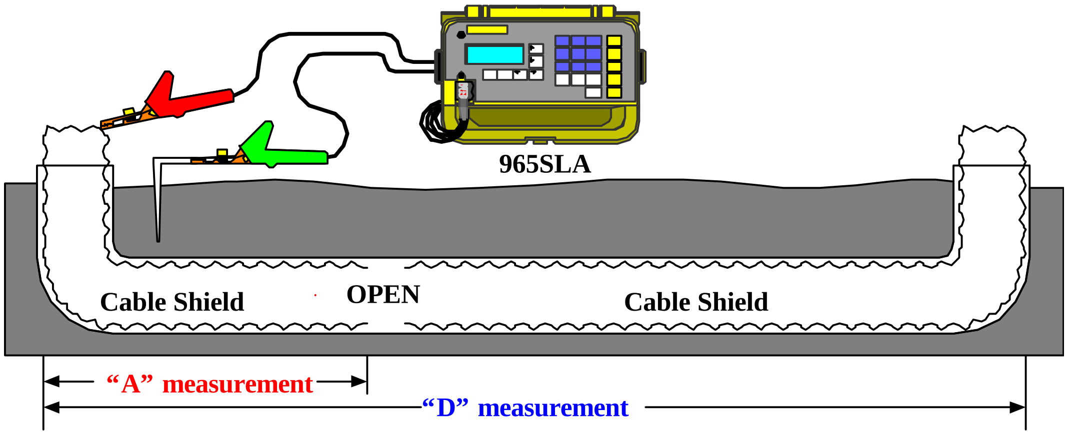
B = 240 m

C = **A + B** = 110 + 240 = 350 m

$$d = \frac{A \times D}{C} = \frac{110 \times 290}{350} = 91.14 \text{ m}$$

Locating OPENS by Ratio

Measuring distance to an open shield.



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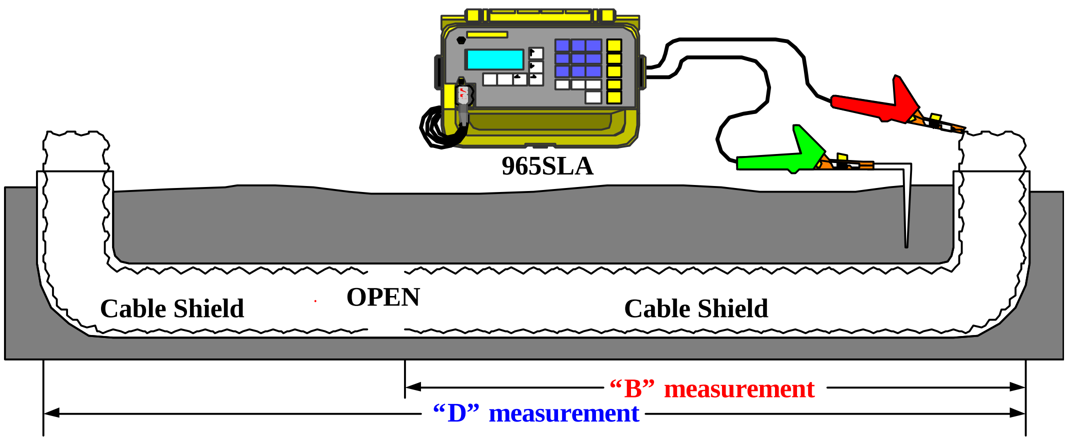

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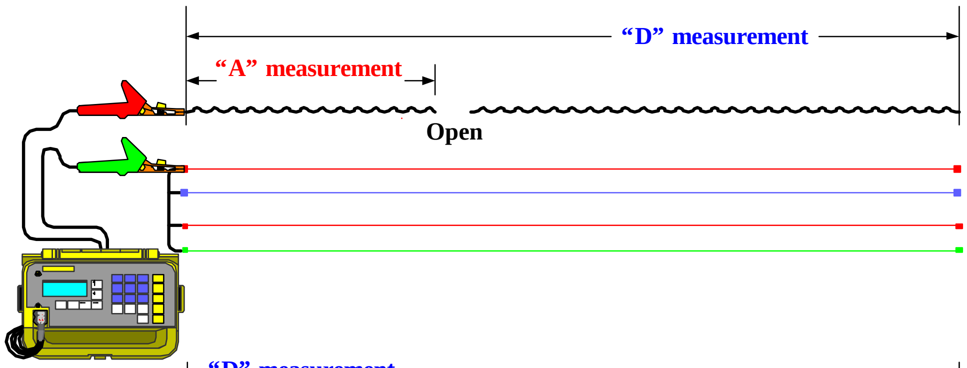
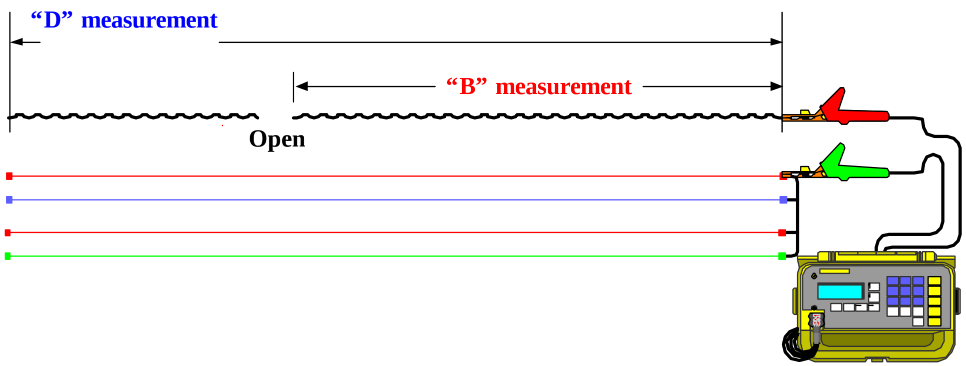
Locating OPENS by Ratio

Measuring distance to an open shield.





Note: Since the **RED** and **GREEN** leads are used, consider the **Ring [B]** measurement only.

Requirement: Length of cable section under test must be known.

Procedure:

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B = 240 m

C = **A + B** = 110 + 240 = 350 m

$$d = \frac{A \times D}{C} = \frac{110 \times 290}{350} = 91.14 \text{ m}$$

Estimating Cable Temperatures

Aerial Cable:

1. If cable is not in direct sunlight. Add 20°F or 15°C whichever is used, to the air temperature.

2. If cable is in direct sunlight. Add 40°F or 30°C whichever is used, to the air temperature.

Buried Cable:

1. Use temperature of tap water. Let water flow out of a water faucet for several minutes.

2. In cold climates, use soil temperature at cable depth.

Gauge (Size) Conversion Table

FROM GAUGE	TO GAUGE	MULTIPLY BY
19	22	0.497
--	24	0.310
--	26	0.193
--	28	0.121
22	19	2.010
--	24	0.624
--	26	0.389
--	28	0.244
24	19	3.220
--	22	1.600
--	26	0.623
--	28	0.391
26	19	5.180
--	22	2.570
--	24	1.610
--	28	0.628
28	19	8.240
--	22	4.090
--	24	2.560
--	26	1.590

Example: Convert the following into 19AWG.

400 feet of 24AWG + 350 feet of 22AWG + 800 feet of 19AWG

400 x 3.220 = 1,288 feet of 19AWG

350 x 2.010 = 703 feet of 19AWG

800 x 1.000 = 800 feet of 19AWG

Total = 2,791 feet of 19AWG

How To Determine Length of Cable In A Reel

Option #1:

1. Create a "SHORT" fault on Pair #2 at the far-end and strap it to Pair #1, as shown below.

2. Press the RFL key and do the following:

a) Press the "#" key to change setups.

B) Select the options:

UNIT MEASURE DTS

DISPLAY IN FEET

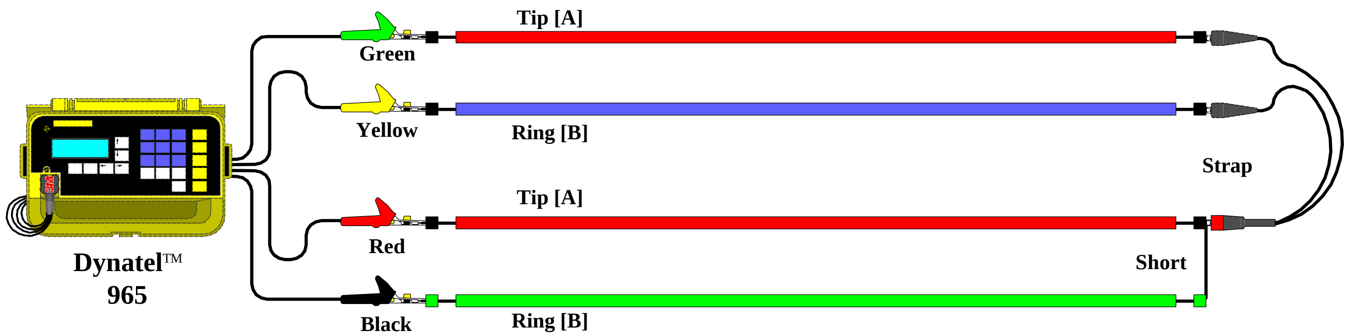
TEMPERATURE (Enter cable temperature).

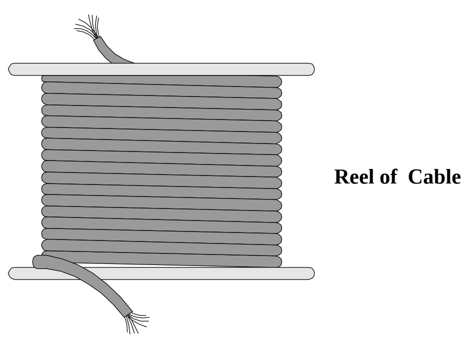
GAUGE (Select)

SEPARATE GOOD PAIR

3. Press the (*) star key to use new setup.

4. The DTF (Distance-To-Fault reading will be the length of the cable.





How To Determine Length of Cable In A Reel

<u>Option #2:</u>

1. Short the pair at the far-end and connect the 965 test clips, as shown below.

2. Press the RFL key and do the following:

a) Press the "#" key to change setups.

b) Select the options:

UNIT MEASURE DTS

DISPLAY IN FEET

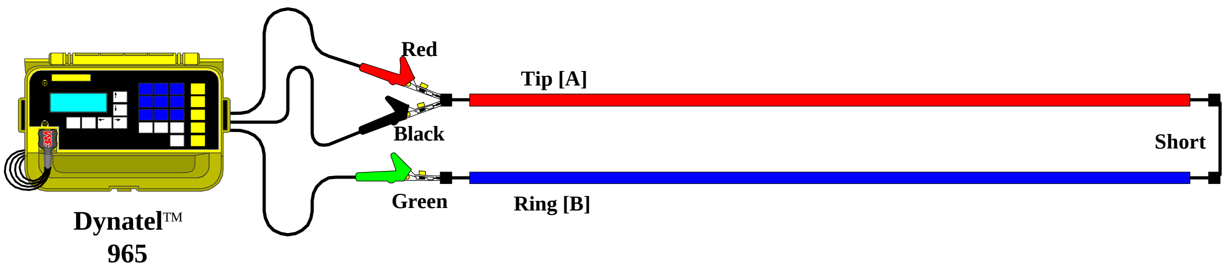
TEMPERATURE (Enter cable temperature).

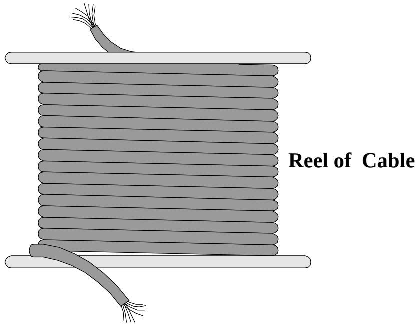
GAUGE (Select)

SINGLE PAIR

3. Press the (*) star key to use new setup.

4. The DTS (Distance-To-Strap) reading will be the length of the cable.





Measuring Distance To A Solid Short

<u>**Note: This procedure only applies to a solid "short" (0 ohm) resistance.**</u>

1. Connect the 965 test clips, as shown below.

2. Press the RFL key and do the following:

a) Press the "#" key to change setups.

b) Select the options:

UNIT MEASURE DTS

DISPLAY IN FEET

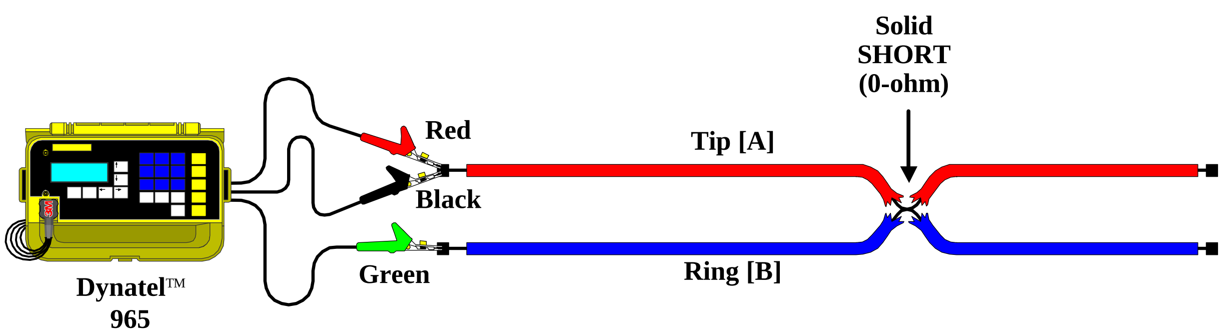
TEMPERATURE (Enter cable temperature).

GAUGE (Select)

SINGLE PAIR

3. Press the (*) star key to use new setup.

4. The DTS (Distance-To-Strap) reading will be the length of the cable.



Dynatel 965DSP
Subscriber Loop Testing & Analysis

Subscriber Loop Components

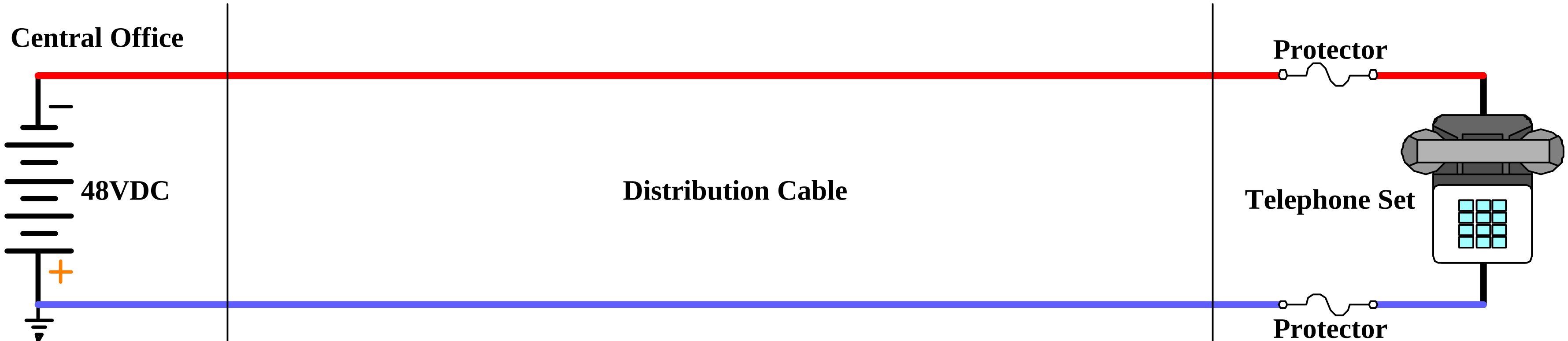


Fig. 1: Standard Telephone Circuit

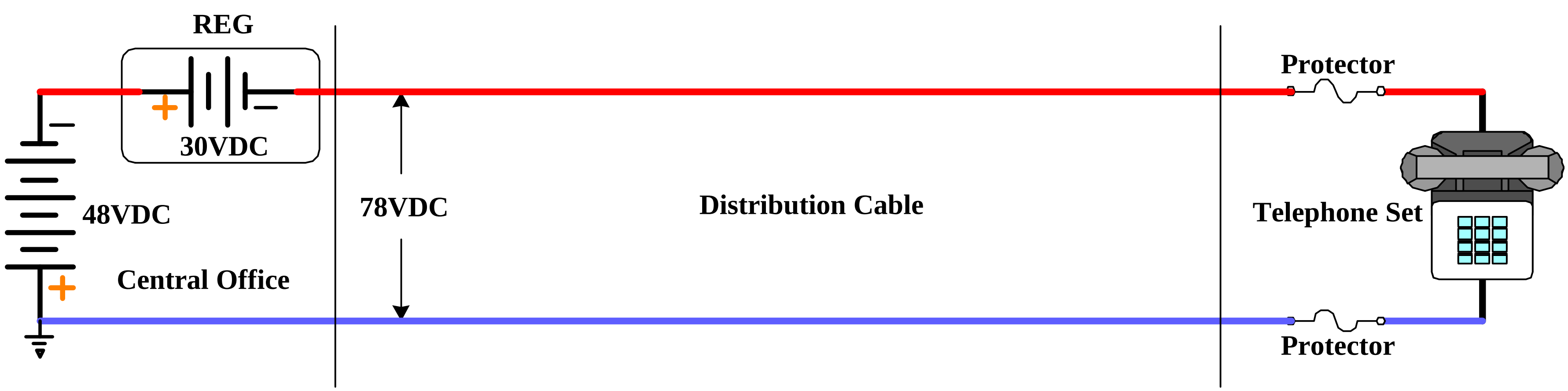


Fig. 2: Telephone Circuit with REG (Range Extender with Gain).

Why analyze a Subscriber Loop?

A: To evaluate a cable pair before it is put into service.

Generally Accepted Criteria for POTS (Plain Old Telephone Service)

Parameter		Acceptable	Marginal	Unacceptable
Voltage	=	48 to 52VDC	________________	________________
Loop Current	=	-23 mA or more	-20 mA to <-23 mA	< -20 mA
Circuit Loss	=	-8.5 dBm or less	________________	> -8.5 dBm
Power Influence	=	80 dBrnC or less	> -80 dBrnC to < -90 dBrnC	-90 dBrnC or more
Circuit Noise	=	20 dBrnC	> 20 dBrnC to < 30 dBrnC	-30 dBrnC or more
Balance	=	60 dB	> 50 dB to < 60 dB	50 dB or less
Station Ground Resistance	=	25 ohms or less	________________	> 25 ohms
Slope	=	7.5 dB or less	________________	> 7.5 dB

Parameter	Insulation Good	Light Fault (Service Affected)	Heavy Fault (Out Of Service)
Insulation Resistance	3.3 Meg or more	> 2.8 K ohms to < 3.3 Meg	2.8 K ohms or less

Why analyze a Subscriber Loop?

B: To identify and isolate the cause of a problem on a partially working cable pair..

Common Subscriber complaints:

1. No dial tone.

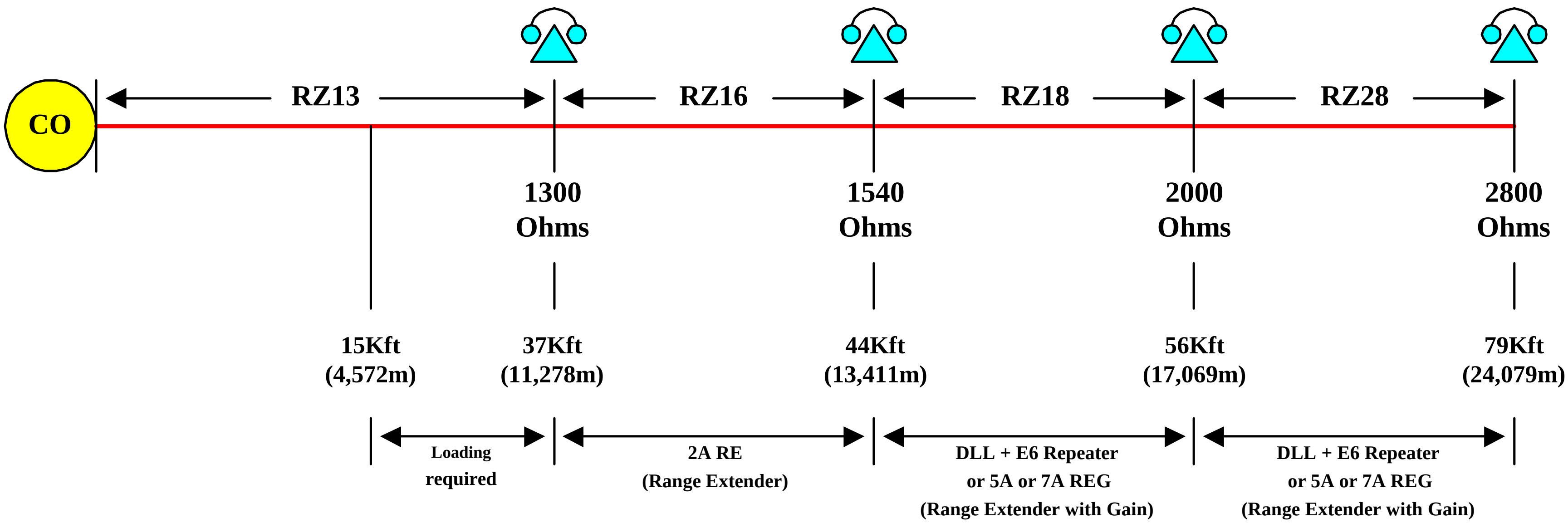
2. Continuous dial tone.

3. Signal is too weak can not hear on long distance calls.

4. Occasionally get wrong numbers.

5. Line is too noisy.

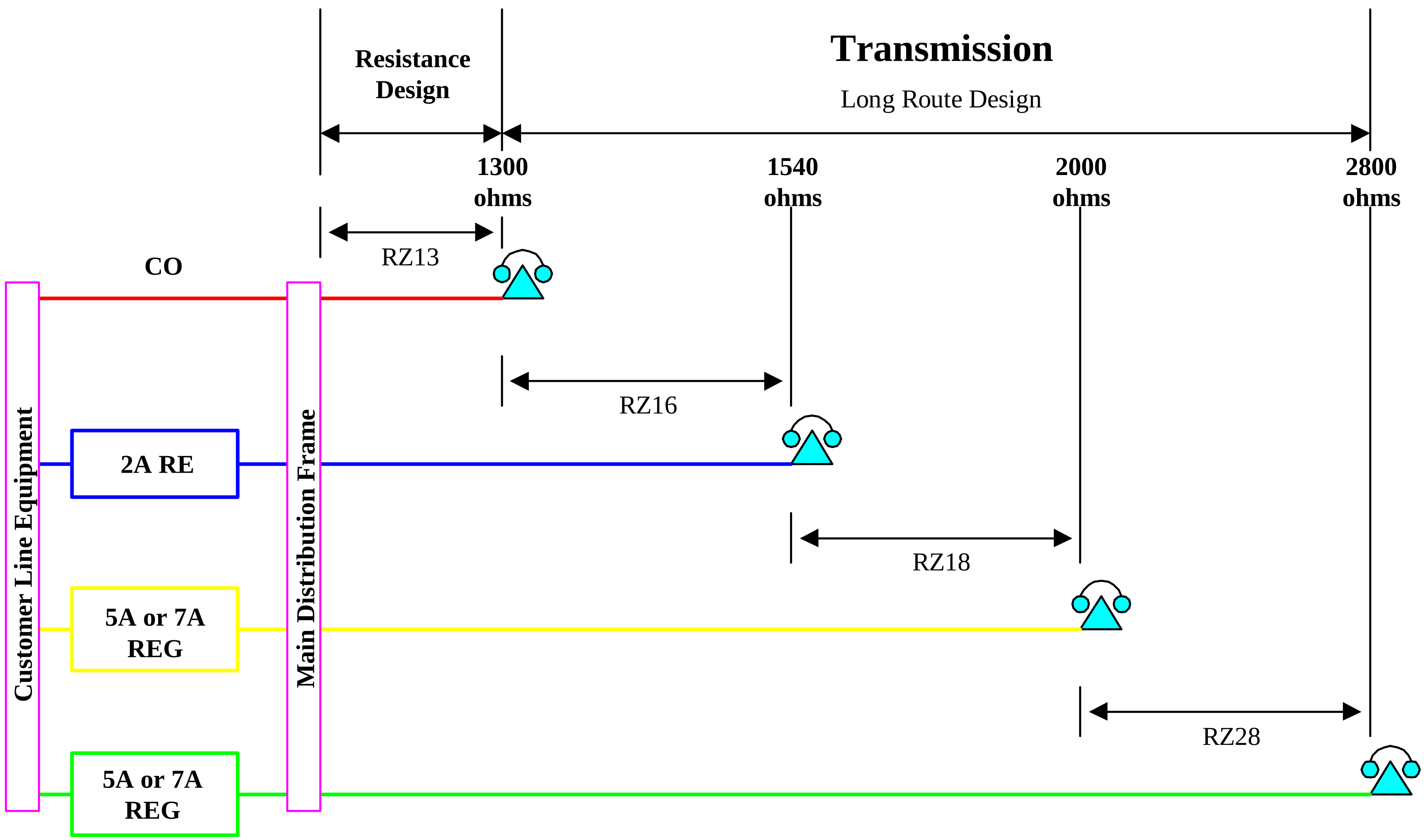
Resistance Zones and CO Equipment



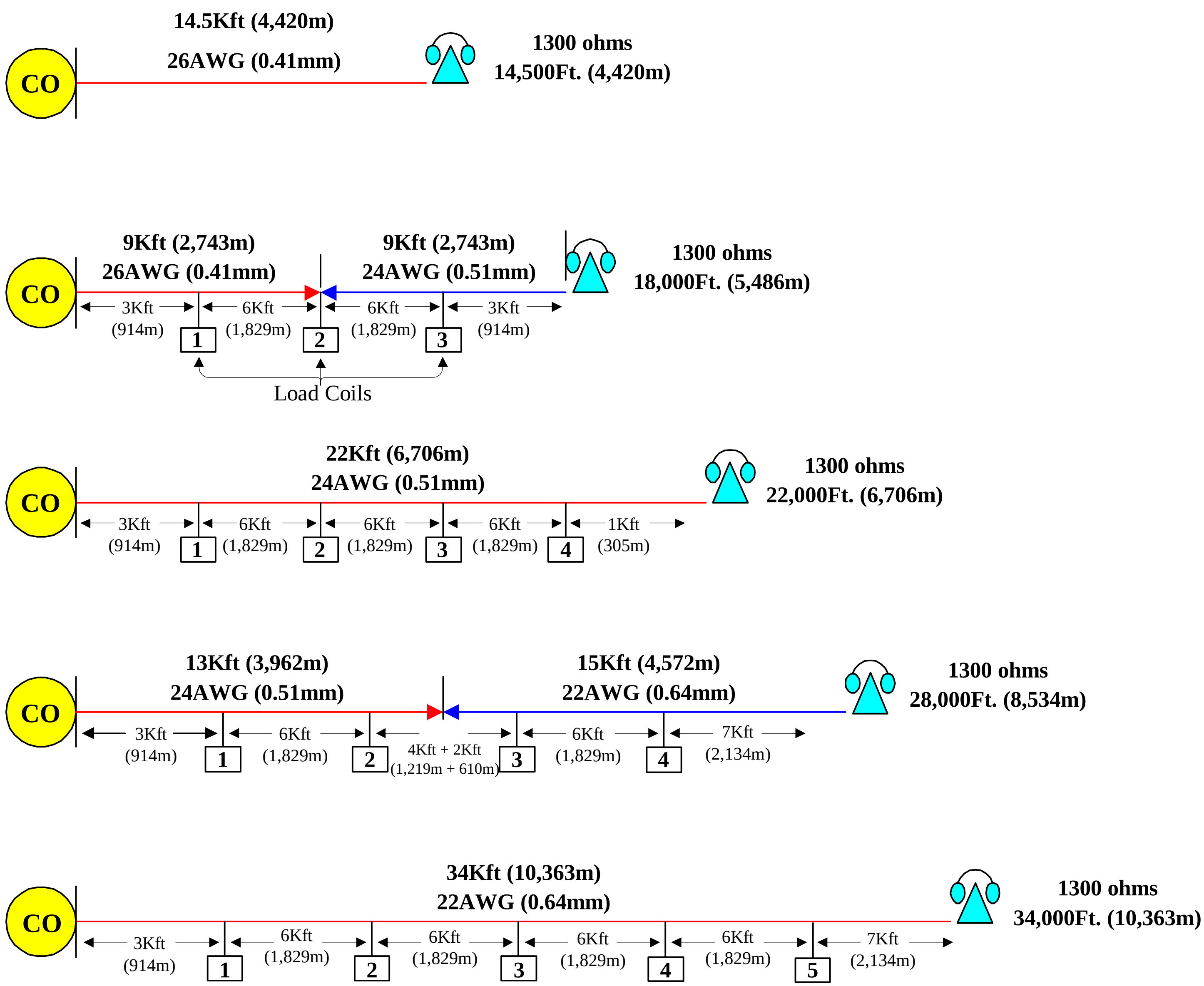
Note:

This example shows distances of the RZs based on a 22AWG (0.64mm) cable.

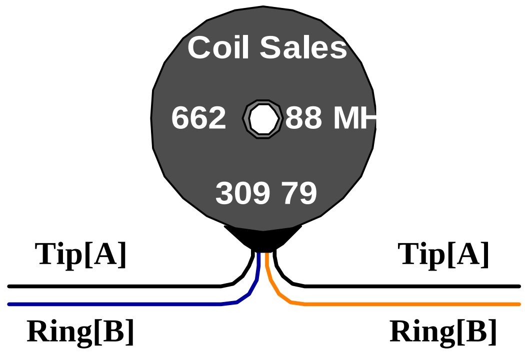
If the Engineers undergauge, RZ18 could start as close as 18Kft. (5,486m).

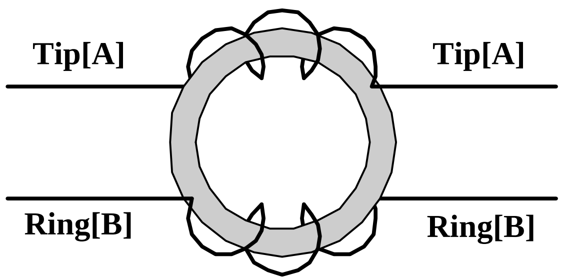

Transmission
Long Route Design
Resistance Design
1300 ohms
1540 ohms
2000 ohms
2800 ohms
RZ13
RZ16
RZ18
RZ28
CO
Customer Line Equipment
Main Distribution Frame
2A RE
5A or 7A REG
5A or 7A REG

Resistance Design Examples



Load Coil


Coil Sales
662
88 MH
309 79
Tip[A]
Tip[A]
Ring[B]
Ring[B]


Tip[A]
Tip[A]
Ring[B]
Ring[B]

Noise and Power Influence Measurements

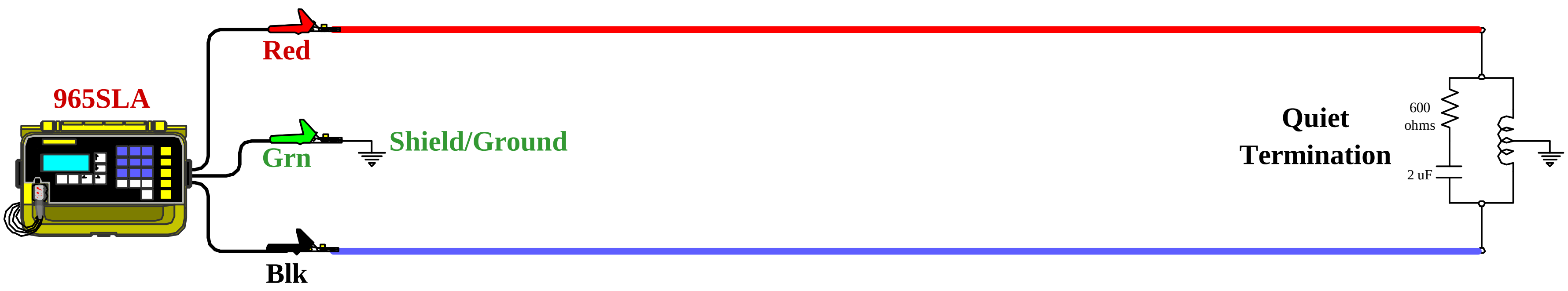


Fig. 1:Circuit Noise (Noise Metallic) is measured between Tip[A] & Ring[B]

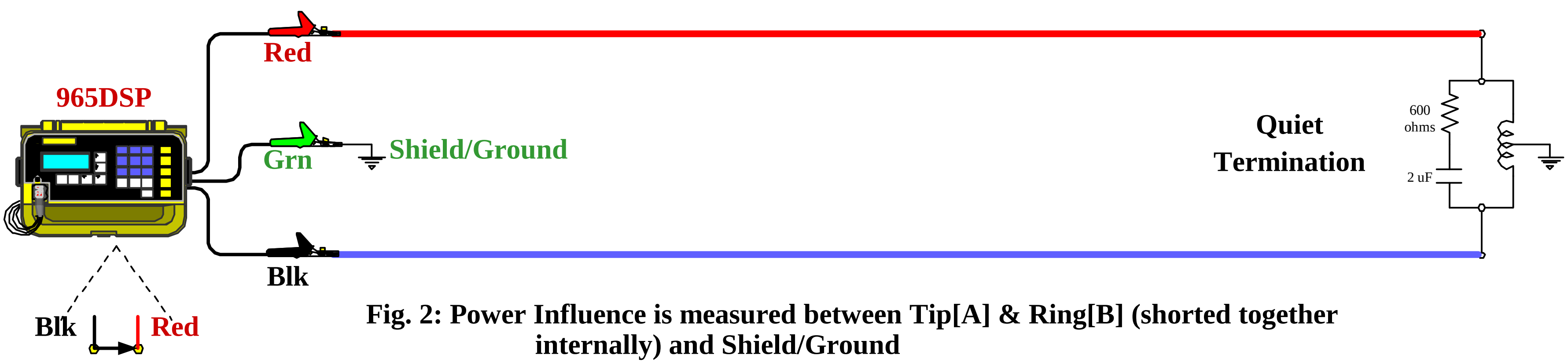


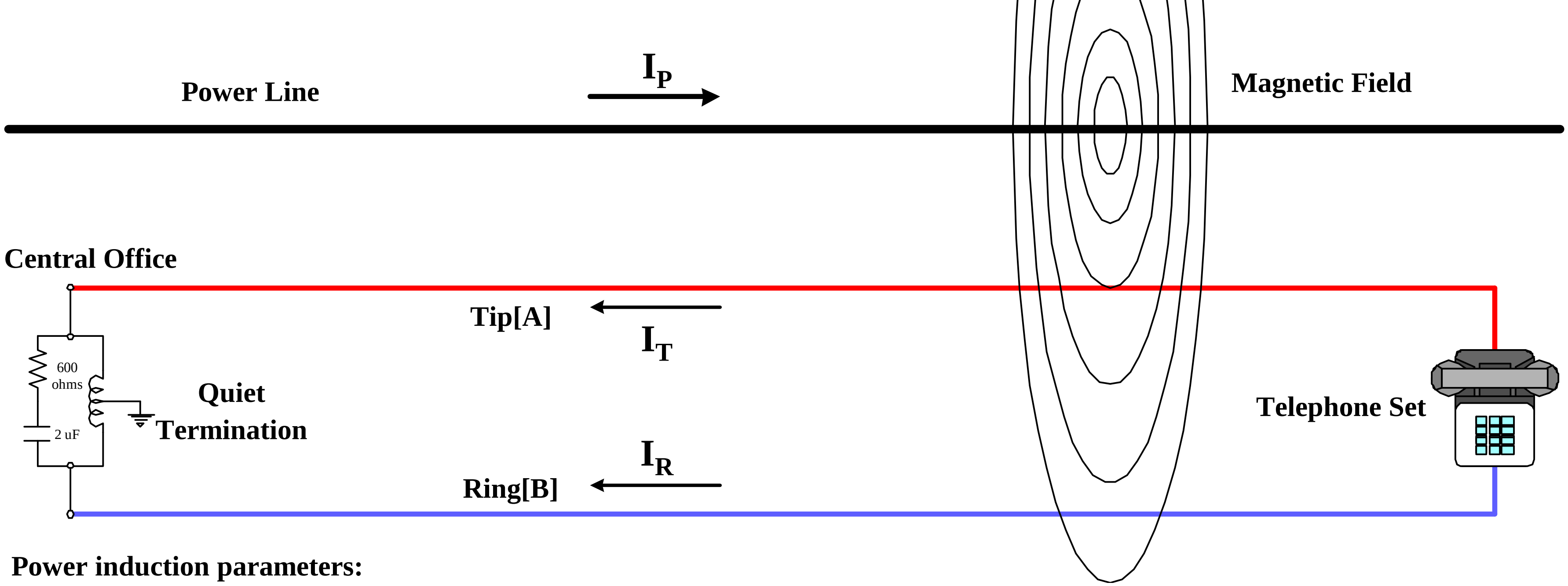
Fig. 2: Power Influence is measured between Tip[A] & Ring[B] (shorted together internally) and Shield/Ground

Circuit Noise Basics

I_P - Current flowing through the power line.

I_T - Induced current on the Tip[A] conductor from the power line.

I_R - Induced current into the Ring[B] conductor from the power line.



Power induction parameters:

1. Influence - depends on power utility load; therefore it varies during the day.

2. Coupling - depends on the length of exposure and separation between Telco and Power utility.

3. Susceptibility - depends on cable pair balance, shield continuity and low resistance grounds. If the pair is well-balanced, I_T and I_R will be equal and self-cancellation occurs and Noise = 0.

Note: 1 & 2 above, usually are beyond the control of the Telco and rarely can they do anything about them.

Circuit Noise Basics
(con't)

I_P - Current flowing through the power line.

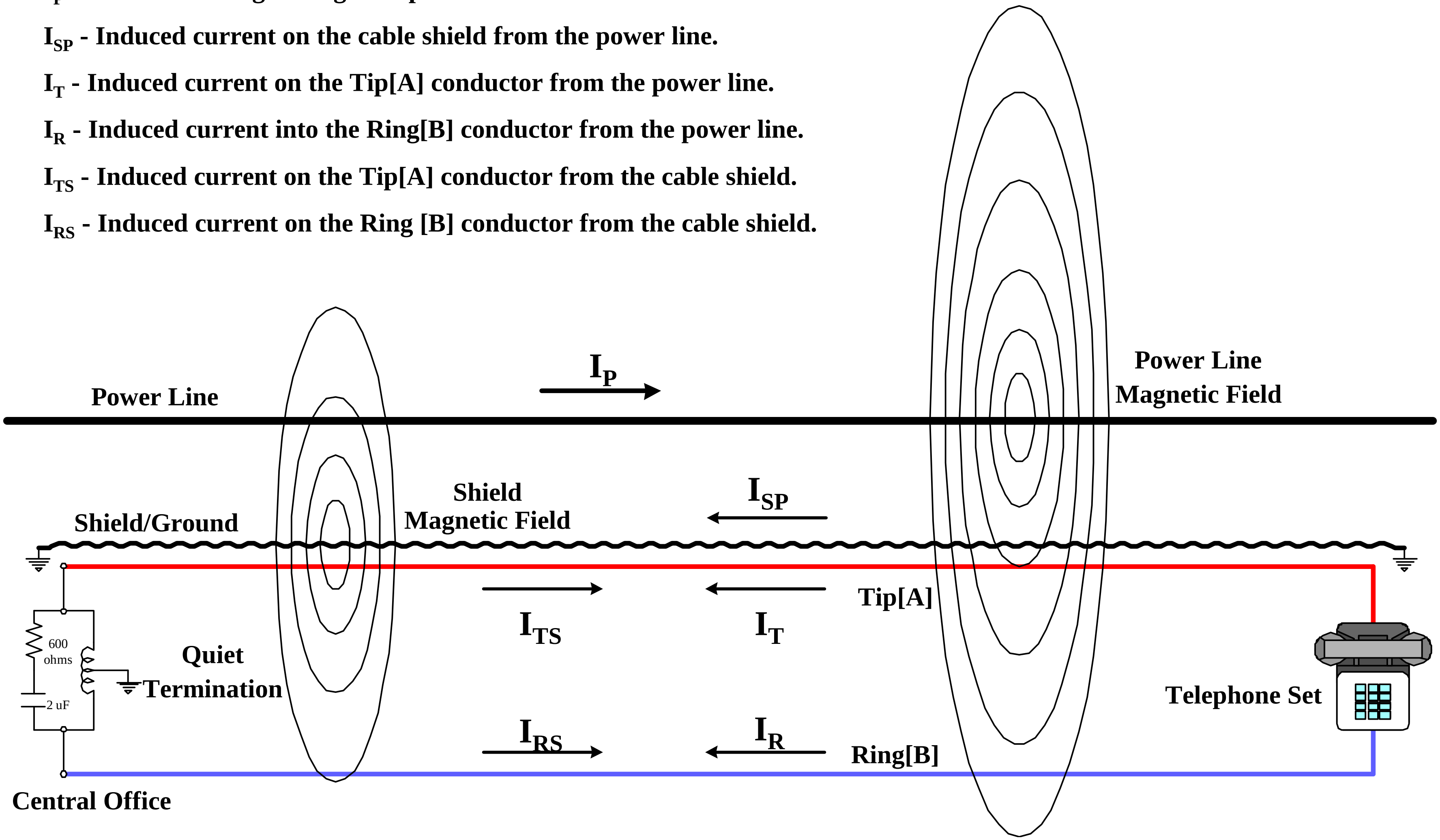
I_{SP} - Induced current on the cable shield from the power line.

I_T - Induced current on the Tip[A] conductor from the power line.

I_R - Induced current into the Ring[B] conductor from the power line.

I_{TS} - Induced current on the Tip[A] conductor from the cable shield.

I_{RS} - Induced current on the Ring [B] conductor from the cable shield.

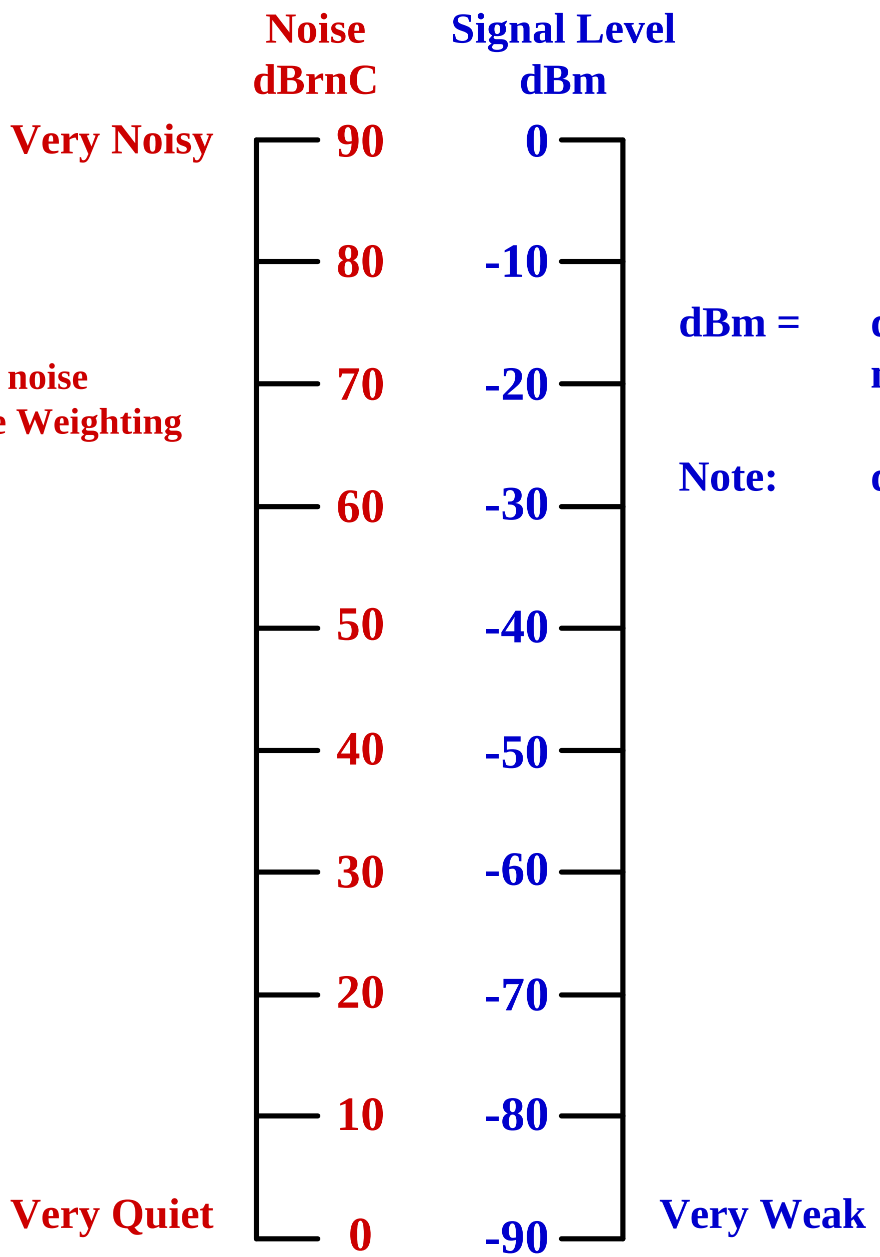


Note: 1. If the pair is well balanced, the opposing currents I_T vs I_R and I_{TS} vs I_{RS} will be equal and therefore cancel out.

2. A perfectly balanced pair can be noise-free even without a cable shield.

3. A good shield continuity and low resistance grounds can reduce Power Influence by 15dBrnC.

Relationship between dBrnC and dBm



dBrnC = **dB reference to noise with C-Message Weighting**

dBm = **dB reference to milliwatt**

Note: **dBm - dBm = dB**