Cabling Installation & Maintenance

EXECUTIVE SUMMARY

# Locating and Identification—Finding Cables and Identifying Wires

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AUGUST 4, 2022

## KEY TAKEAWAYS

- Proper cable location and wire identification can reduce costs and damage.
- Fundamental physical phenomena can be applied to location and identification of wires and cables.
- Electrostatic detection is best applied to wire identification.
- Electromagnetic detection is best applied to cable location.
- Tempo provides both electrostatic and electromagnetic detection tools.

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# Locating and Identification—Finding Cables and Identifying Wires

## OVERVIEW

Finding the route and depth of buried cables and identifying the individual conductors of interest within them can reduce costs for utilities and contractors. Proper detection techniques and tools differ depending on the task. Understanding fundamental physics concepts helps users apply the best method and avoid common pitfalls in detection. Tempo Communications develops and manufactures electrostatic and electromagnetic detection tools to aid in cable location and wire identification.

## CONTEXT

Mark Govier discussed why cable location and wire identification are important. Mr. Govier reviewed electricity and magnetism concepts in the context of cable location and wire identification, then shared techniques for both electrostatic and electromagnetic location.

## KEY TAKEAWAYS

**Proper cable location and wire identification can reduce costs and damage.**

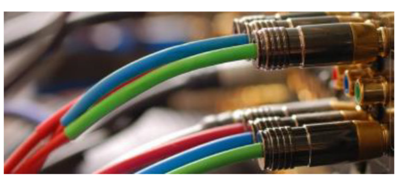
Finding the location of wires and cables buried in the ground or within walls might be necessary to avoid damage to buried cables, or to locate a specific cable to uncover and repair a fault. However, in some cases the presence of cables might not be known. Faults are often caused by someone else's actions—others who may not have been aware of the presence of the cable. Cable location is key to cable avoidance.

> If you know it's there, you can avoid it.
>
> *Mark Govier, Tempo Communications*

Safety is the number one priority but finding the location of cables can also reduce costs for utilities and contractors. There are huge costs associated with damage to buried plant, and cable location decreases risk of damage. Cable location also reduces costs for utilities and contractors by improving service location, reduces maintenance and repair cost, by allowing more precise digging, resulting in fewer and possibly smaller holes.

Once a cable or a set of wires has been located, correctly identifying wires and pairs is important, especially when there is doubt about which wire does what. Wire identification techniques can help by applying a signal to a target wire and seeking that signal elsewhere.

**Figure 1: Examples of different types of wires and cables**



AV Cabling

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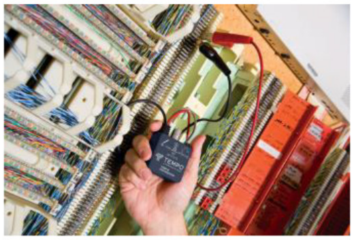

# Locating and Identification—Finding Cables and Identifying Wires

**Fundamental physical phenomena can be applied to location and identification of wires and cables.**

Learning or reviewing key physics concepts can help safely and cost-effectively locate and identify wires and cables. Electromagnetic location techniques can be based upon two closely related physics fundamentals: electricity and magnetism.

**Ground** is the local reference for all potentials and can be thought of as zero volts (0V); however, most soils—particularly if slightly damp or moist—have varying degrees of electrical conductivity. Just like a metal sheath or shield around a conductor, soil prevents "voltages" or electrostatic signals from conductors being detected above ground, but magnetic fields will pass through most soils with little or no attenuation (e.g., slight attenuation in iron-rich clays). The ground can also form a useful return path for currents.

Wherever there is potential difference (voltage), there will be an electrostatic field, this may be **static electricity** or a potential from a battery or generator: one side positive, the other negative, relative to each other. Between the two, there will be a point where the net potential is zero. The E (electric field) may be steady or alternating. Similarly, the earth itself presents a **static magnetic field** nearly everywhere on Earth.

When potential, or voltage, is applied to a conductor such as a cable or metal pipe such that a circuit is formed, a current will flow then a magnetic field is generated around that current, which can cause a current to flow in another nearby conductor. **Induction** between circuits like this is an alternating current (AC) effect caused by alternating or varying magnetic field.

If a given measurement changes in a regular pattern, it is **alternating current**. This is often easier to detect. If a measurement system is only looking for periodic changes in a specific parameter, a detector can be made to effectively ignore static fields and other noise at other frequencies. For practical cable or wire identification, a tone generator or other alternating signal generator is needed to create the alternating field of potential and/or current.

Let's consider the scale of electricity and magnetism measurements in the context of cable location and wire identification relative to likely "static" fields that may be present. Cable location: at one meter from a wire carrying a large tracing current of 40 mA, its magnetic field is approximately 10,000 times smaller than that of the Earth's magnetic field. However, because it alternates at a predictable frequency, it can be readily detected. Wire tracing: Similarly, because the potentials involved in static electricity are always in the kilovolt range (e.g. surface charge on a plastic bag), the static and electric fields must be ignored in favor of searching only for alternating voltage when identifying a wire, using a significantly higher frequency than the local mains power to avoid interference from electric fields from power lines.

## Electrostatic detection is best applied to wire identification.

**Electrostatic detection** detects electric potential near conductors. To identify individual wires from a bundle, an oscillator or a toner can be used to apply an alternating voltage to the wire or the pair to trace. Note that this is extremely difficult to achieve with direct current (DC), as the static electric charges on the surface of insulation cannot be differentiated.

In a case where the signal generator is connected between a conductor and the local ground, the wire and wire tracing probe's tip are **capacitively coupled**—the amplifier is loosely grounded by capacitive coupling to the user's hand, and the conductor carries the electric field (potential, aka voltage) toward its opposite end. That potential creates an alternating electric field around the conductor, and the tip of the amplifier senses the electric field around the conductor. Direct contact is not needed.

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When tracing wires, the conductor **ducts** the electric field to where it is wanted. Intervening soil or grounded metal can ground or shield that field. As the field surrounds the conductor(s), it can couple to other nearby ungrounded conductors (crosstalk). Using twisted pairs helps avoid problems caused by crosstalk, as the field applied across one pair will average to net-zero when looking at adjacent pairs. Because the user acts as the ground, avoid touching the probe tip so as not to short the amplifier and leak away the detectable field.

The cables themselves might also present challenges. Shielded twisted pair (STP) and foil-shielded twisted pair (FTP) cables have become more common. The point of the shielding is to prevent signals from moving in and out, making the wires difficult to trace. However, Tempo offers specific equipment to locate STP and FTP cables, such as 402K coaxial cable tracer and the NC-500 NETcat® Pro2 Wiring Tester.

**Figure 2: Using electrostatic detection in wire identification**


## Electromagnetic detection is best applied to cable location.

For wires that are grounded, whether deliberately or by fault, the potential and therefore the signal detectable electrostatically will diminish rapidly—possibly even to zero—when approaching the ground point, and there will be no potential to detect it is "grounded." Similarly, if the wire is behind a grounded screen or shield, nothing will be detected. Examples of shields include metal conduits, metal foil-backed plasterboard or insulation panels, wet soil, or a large bunch of other wires. Electromagnetic location, which detects the magnetic field around current-carrying conductors, can be used to overcome these challenges. Note that, just as with electrostatic location, this is extremely difficult to achieve with direct current.

By setting up an alternating electric field on the conductor and making a circuit to cause electrical charge to flow, current will form in the conductor that can be used to develop an alternating magnetic field around the conductor. Connect a signal generator or oscillator (sometimes called a transmitter) directly between the conductor and ground. Short the far end to ground to maximize current flow along the entire cable length. If grounding is not possible, the final length of cable will be difficult or impossible to trace as you are relying only on capacitive leakage of the tracing signal to ground to establish a traceable current (tip: use higher frequencies in this case).

Electromagnetic amplifiers are normally equipped with a search coil that develops a signal based upon the magnetic field passing through that coil: The signal generator voltage establishes an electric field along the conductor. Because that conductor forms a loop, due to being shorted to ground at the far end (or via mutual capacitance to ground if not), a current will flow, creating an alternating magnetic field which can be sensed (via electromagnetic induction) using the search coil.

The level of coupling is related by both position and orientation of the search coil relative to the conductor.

Direct connection of the transmitter to the cable is the best option. However, this may not always be possible or desirable, in which case a current clamp can be used to place a temporary magnetic circuit around a cable to directly induce current. Or, most locator transmitters also include an induction antenna within their case. Placing this alongside or above the cable to be located will also induce a traceable current.

# Locating and Identification—Finding Cables and Identifying Wires

If working from an accessible location where a good signal can be applied, and presuming a good current flow can be obtained, magnetic locators can achieve a practical working depth of six meters or more, which covers most applications.

**Figure 3: Using electromagnetic detection in cable location**

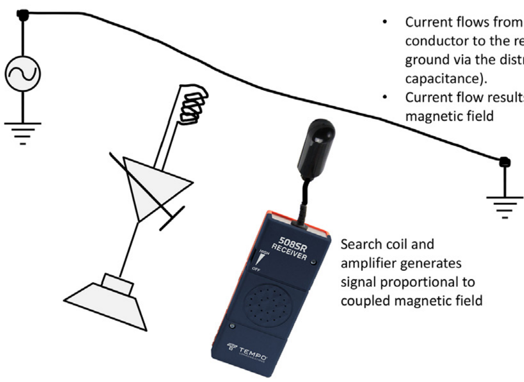


**Figure 4: Tempo offers a range of products for cable location and wire identification**


## Tempo provides both electrostatic and electromagnetic detection tools.

Tempo offers a wide range of telecommunications, Wi-Fi, and varied utility market products to address different use cases.

Electrostatic field detection works well for identifying individual conductors or pairs. It is quick and easy to apply, but it does not work through a grounded shield. Electromagnetic detection is ideal for locating cables and wires underground or buried in walls. It requires current flowing in the wire to generate the detectable magnetic field, and current can be induced by direct connection, current clamp, or induction antenna.

Whether using electrostatic or electromagnetic detection, Tempo offers products for both everyday and more advanced use cases.

## BIOGRAPHY

**Mark Govier**

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Mark Govier is the product manager for TEMPO's wide range of telecommunications, Wi-Fi, and buried utility market products. He has nearly 30 years of experience with TEMPO products as senior engineer and product manager.