American Society of Irrigation Consultants

ASIC Guideline 102-2004 (May 2004)
Wire & Cable Color Code for Irrigation System Equipment

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1.0 Scope

1.0.1 – Defines color coding for wires and cables used to power certain types of control equipment used in irrigation systems (the "branch circuit"), based on the requirements of the National Electrical Code® (NEC®), to ensure personnel safety and code compliance.

1.0.2 – Recommend colors for wires used to connect electric solenoids to irrigation controllers

1.0.3 – "Decoder" system cables

1.0.4 – Communication cables for data transmission between computer equipment, pump stations, weather stations, sensors, etc.

1.1 Purpose

A guide for irrigation industry persons who are involved in the design, manufacturing, distribution, installation and maintenance of electronic equipment in residential, commercial, institutional, golf course, and agricultural projects.

1.2 Applicable NEC® Articles

The National Electrical Code® provides important information regarding safety in design and installation of electrical systems. The NEC® is revised every three years and the latest revision always prevails. The information provided in this guideline is not to be construed as an official interpretation of the NEC®.

1.3 Branch Circuits (Power wires and cables)

The following are excerpts from the 2002 edition of the National Electrical Code® pertaining to the branch circuits of an irrigation system:

210.5 Identification for Branch Circuits.
(A) Grounded Conductor. The grounded conductor of a branch circuit shall be identified in accordance with 200.6.
(B) Equipment Grounding Conductor. The equipment grounding conductor shall be identified in accordance with 250.119.

200.6 Means of Identifying Grounded Conductors.
(A) Sizes 6 AWG or Smaller. An insulated grounded conductor of 6 AWG or smaller shall be identified by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along its entire length.
(B) Sizes Larger Than 6 AWG. An insulated grounded conductor larger than 6 AWG shall be identified either by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along its entire length or at the time of installation by a distinctive white marking at its terminations. This marking shall encircle the conductor or insulation.
(C) Flexible Cords. An insulated conductor that is intended for use as a grounded conductor, where contained within a flexible cord, shall be identified by a white or gray outer finish or by three continuous white stripes on other than green insulation or by methods permitted by 400.22.
(D) Grounded Conductors of Different Systems. Where conductors of different systems are installed in the same raceway, cable, box, auxiliary gutter, or other type of enclosure, one system grounded conductor, if required, shall have an outer covering conforming to 200.6(A) or 200.6(B). Each other system grounded conductor shall have an outer covering of white with a readily distinguishable, different colored stripe other than green running along the insulation, or shall have other and different means of identification as allowed by 200.6(A) or (B) that will distinguish each system grounded conductor.
(E) Grounded Conductors of Multiconductor Cables. The insulated grounded conductors in a multiconductor cable shall be identified by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along its entire length. Multiconductor flat 4 AWG or larger shall be permitted to employ an external ridge on the grounded conductor.

Exception No. 1: Where the conditions of maintenance and supervision ensure that only qualified persons service the installation, grounded conductors in multiconductor cables shall be permitted to be permanently identified at their terminations at the time of installation by a distinctive white marking or other equally effective means.

200.7 Use of Insulation of a White or Gray Color or with Three Continuous White Stripes.
(A) General. The following shall be used only for the grounded circuit conductor, unless otherwise permitted in 200.7(B) and (C):

(1) A conductor with continuous white or gray covering
(2) A conductor with three continuous white stripes on other than green insulation
(3) A marking of white or gray color at the termination

250.119 Identification of Equipment Grounding Conductors.
Unless required elsewhere in this Code, equipment grounding conductors shall be permitted to be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes except as permitted in this section.
(A) Conductors Larger Than 6 AWG. An insulated or covered conductor larger than 6 AWG copper or aluminum shall be permitted, at the time of installation, to be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible. Identification shall encircle the conductor and shall be accomplished by one of the following:

(1) Stripping the insulation or covering from the entire exposed length
(2) Coloring the exposed insulation or covering green
(3) Marking the exposed insulation or covering with green tape or green adhesive labels

(B) Multiconductor Cable. Where the conditions of maintenance and supervision ensure that only qualified persons service the installation, one or more insulated conductors in a multiconductor cable, at the time of installation, shall be permitted to be permanently identified as equipment grounding conductors at each end and at every point where the conductors are accessible by one of the following means:

(1) Stripping the insulation from the entire exposed length
(2) Coloring the exposed insulation green
(3) Marking the exposed insulation with green tape or green adhesive labels

1.4 Branch Circuit Guidelines

The following information is derived from 1.3 above and other referenced publications.

For safety reasons, the NEC® categorizes branch circuit wires as "grounded" and "non-grounded." Grounded conductors are safe to the touch and non-grounded conductors are "live" and dangerous. **The power should always be turned off when working with wires**. In order to minimize the chance of death or injury, the following general rules apply:

The "Equipment grounding conductor", more commonly referred-to as the "green wire" can actually be green or bare copper or green with a yellow stripe. It is best recommended practice of the Institute of Electrical and Electronics Engineers that the equipment ground be an insulated wire (IEEE Std. 1100-1999, section 8.4.5.3.) In most instances, this wire is green and its purpose is to connect the metal chassis of a controller (or equipment) to an earth ground electrode at the service entrance (circuit breaker box.) This wire does not and should not conduct electricity except during an emergency caused by a fault. At that time the green wire completes a circuit that causes a circuit breaker to trip. It may also be identified as the equipment ground by use of green tape, paint, etc. as discussed in 1.3 above. The green color insulation/marking should not be used for any purpose other than the equipment ground.

It takes two wires to make a complete circuit. These are called the "conductors" of electricity. For 120VAC systems, one of these conductors is grounded to earth at the circuit breaker box (service entrance); it is called "the grounded conductor" or "the neutral" and must always be white, gray, or 3 continuous stripes on any solid color except green. The neutral, which is usually a white wire, can also be identified by applying a white tape, or other permitted marking, as discussed in 1.3 above. The white color insulation/marking should not be used for any purpose other than a grounded conductor.

The 2002 NEC® does not address specific colors for non-grounded conductors ("hot" wires), but certain colors have been historically used in the electrical industry, and they have been adopted by many local electrical codes, typically summarized below. The installer shall ensure that wire colors conform to local and national codes.

Single Phase Circuits:

120VAC
Black – Hot (Phase 1)
White – Neutral or Grounded Conductor
Green – Equipment Ground

240VAC
Black – Hot (Phase 1)
Red – Hot (Phase 2)
Green – Equipment Ground

Three Phase Circuits:
Black – Hot (Phase 1)
Red – Hot (Phase 2)
Blue – Hot (Phase 3)
Green – Equipment Ground

For branch circuits using single conductors, usually types UF (for direct burial) or THWN (for in-conduit installation) wires, color requirements are as follows:

(A) For 6AWG and smaller, conductors must have a continuous outer finish (insulation) as per 1.3 above.
(B) For larger than 6AWG, color coding tape can be used to identify the wires.

These color-coding schemes also apply to cables containing multiple conductors, as described in 1.3 above. Two such cables used in irrigation systems are:

- Type UF-B, which contains one each black, white, and bare copper conductors. Since the white color can only be used as the grounded conductor, this cable can be used for 120-volt systems but not for 240-volts.
- Type Tray Cable (TC), which can contain colored conductors or all black (numbered) conductors, shall be color coded based on the source voltage and the respective color requirements of 1.3.

The inner conductors of Tray Cable, sizes 10AWG and smaller, are usually black, red and blue. These can be color coded as follows:

	Branch Circuit	
Conductor Color	120-volt	240-volt
	Tape Color	
Black	none	none
Red	white	none
Blue	green	green

The inner conductors of Tray Cable of sizes 8AWG and larger are usually black and numbered 1, 2, 3, etc. These can be color coded as follows:

	Branch Circuit	
Conductor Color	120-volt	240-volt
	Tape Color	
Black (1)	none	none
Black (2)	white	red
Black (3)	green	green

The same procedure is used for three phase circuits, per 1.3 above, keeping in mind that there are four wires to color code instead of three.

When necessary to mark wires, the appropriate color coding tape shall be used, such as 3M #35 "Vinyl Color Coding Tape(s)", ¾"x66'. The conductors shall be marked everywhere they are exposed, spliced, or terminated. Note that color-coding tape cannot be applied to white or green conductors since these colors are reserved as neutral and equipment ground wires respectively, and it is forbidden by the NEC®.

1.5 Valve wires and cables

These products are used to make electrical connections between the irrigation controller and the electric solenoid of a "block valve" or a "vale-in-head sprinkler." Since these circuits operate at 24 volts (nominal) and do not meet the definition of a branch circuit, the NEC® has no requirements for colors.

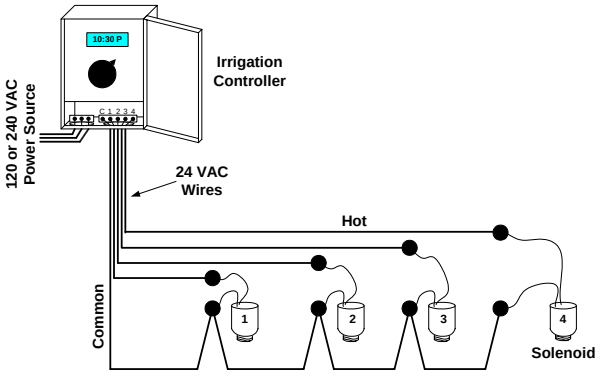

Figure 1.1 – Typical electrical diagram of an automatic irrigation system

It is this guideline's recommended practice that wire 24-volt circuit wire colors are as follows:

1.5.1 – For single conductors, use wire types UF or PE, which are UL listed for the application. Any color wire may be used for the "Hot" wires except white and green. Since the "Common" wire is a grounded conductor, use a white color. If multiple commons are required to be identified, use other colors (except green) or solid white wires with different color stripes.

1.5.2 – For residential/commercial irrigation systems, multi conductor cables are often used, usually 18AWG. In these cables, the colors of the inner conductors follow wire industry standards. A white wire is usually included and it is this guideline's recommended practice that it be used as the "Common" to all solenoids. All other wire colors can be used for the "Hot" wires to the solenoids.

1.6 Decoder Cables

There are many different types of decoder cables used in the irrigation industry. Some are two-wire and others are three-wire systems. Since these circuits usually don't meet the criteria of a branch circuit, it is recommended practice that the guidelines of the system manufacturer be used.

1.7 Communication Cables

Please refer to ASIC Guideline 101-2003, or its latest revision

1.8 Implementation

Specifications for wiring equipment shall be written and administered by the irrigation professional, herein referred-to as "the designer."

1.9 References

The following documents and references were used as a basis for this guideline. This material is subject to revisions.

NFPA 70, *National Electrical Code*®, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269, USA, http://www.nfpa.org/, 2002.

Rosenberg, Paul, Electrical PAL, PAL Publishing Group–Mediatek, Inc., http://www.palpublications.com/ , 1996

Morrison and Lewis, *Grounding and Shielding in Facilities*, John Wiley & Sons, 1990.

2.0 Safety

The requirements of the National Electrical Code® shall prevail, to ensure safety. Local electrical codes may apply additionally as determined by the property owner, designer or installer. Prevailing local codes shall only enhance the requirements of the NEC.

3.0 Definitions

Branch Circuit – The circuit conductors between the final overcurrent device protecting the circuit and the outlets.

Equipment Ground – The conductor used to connect the non-current carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.

Grounded Conductor – A system or circuit conductor that is intentionally grounded.

Grounding Conductor – A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding Conductor, Equipment – The conductor used to connect the non–current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.

Grounding Electrode Conductor – The conductor used to connect the grounding electrode(s) to the equipment grounding conductor, to the grounded conductor, or to both, at the service, at each building or structure where supplied from a common service, or at the source of a separately derived system.

Outlet. – A point on the wiring system at which current is taken to supply utilization equipment.

Service Entrance/Switch Gear Panel – Equipment for delivering electric energy from the serving utility to the wiring system of the premises served, commonly known as the circuit breaker or fuse box.

Service Entrance Ground – Ground circuit installed at the service entrance by the utility company.

Shall – As used in this guideline, designates a mandatory requirement.

Should – As used in this guideline, designates a suggestion or recommendation.

Utilization Equipment – Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes.

4.0 Designer

The design of the electrical system shall be provided by a competent irrigation professional and shall comply with the requirements of national and local electrical codes.

5.0 Installer

An individual, contractor, licensed electrician, or organization chosen by the project owner/consultant, to install and wire the system while meeting all applicable local and national electrical codes.

6.0 Installation Requirements

Electrical & electronic equipment and wires/cables connected to such equipment shall be installed according to the irrigation system specifications and drawings. Wire color code shall be per this guideline unless they are superceded by electrical codes.