TORO Count on it.

GDC System Product Guide

GDC System Product Guide

Table of Contents

GDC System Product Guide

Section 1

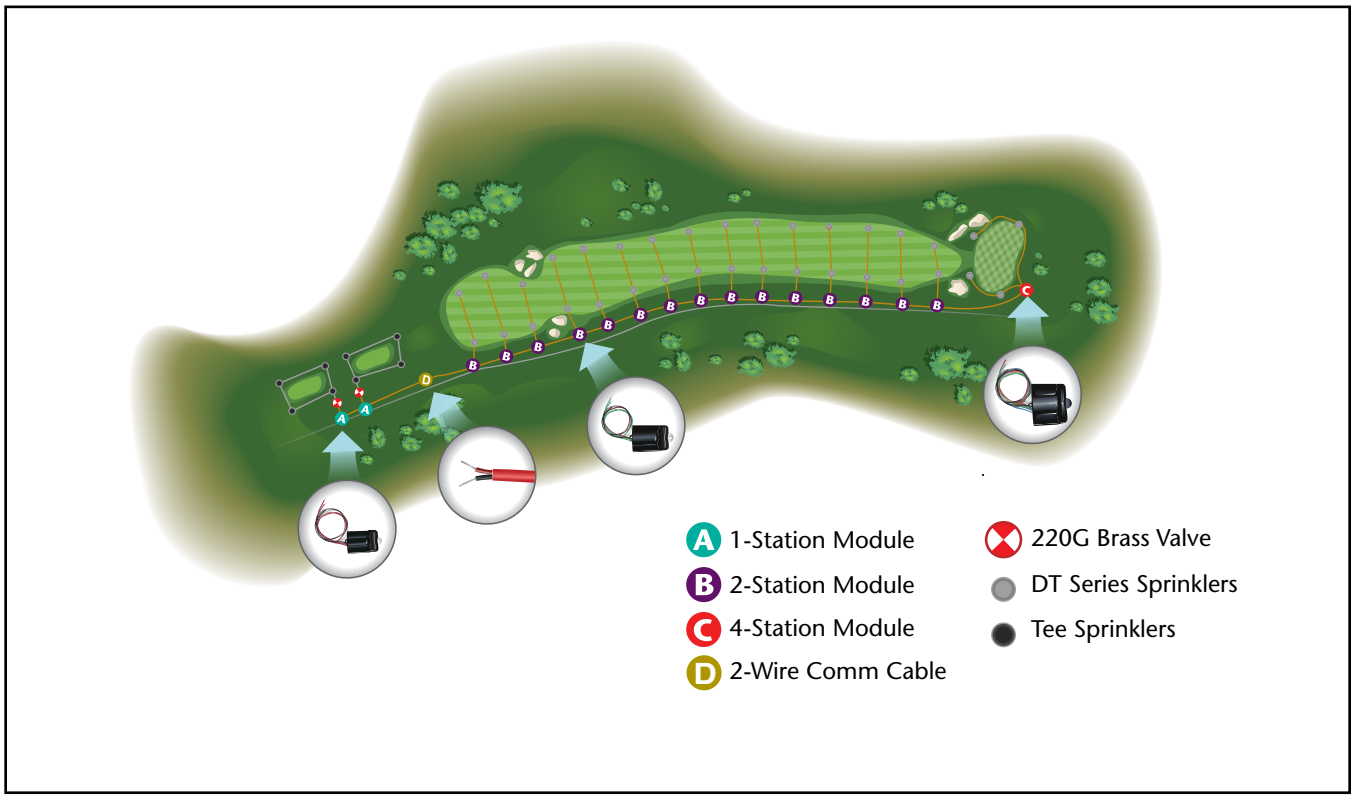
System Design

1 Overview

Two-wire systems are an alternative to traditional controller systems – they work just like conventional controllers but are installed below grade in a valve box with the irrigation valve, or alongside a valve-in-head sprinkler. What makes a 2-wire system unique is that both power and data is transmitted simultaneously on one two-wire cable. The Toro GDC modules come in three basic configurations: one-, two-, and four-station. The GDC provides 20,000- volt surge protection at the controller with proper grounding. The following illustrations show application options for module placement on standard par 4 layouts.

1.1 Applications

One-station modules are used for the block valves that control four sprinklers on the tee areas, two-station modules are used to control the two sprinklers on each fairway lateral, and the 4-station modules control the four sprinklers covering the green.



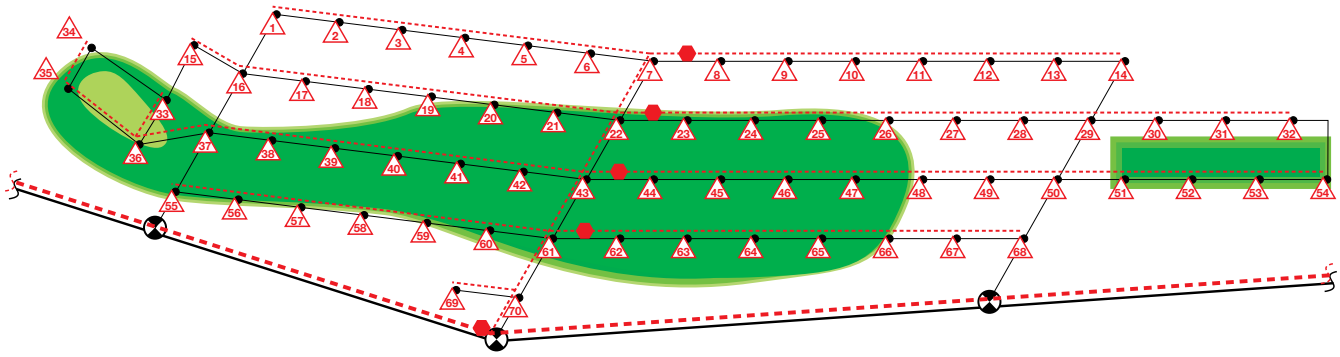
1.2 Benefits

Two-wire systems are simple, reliable, and easy to expand. There are a number of advantages a 2-wire system has over a traditional satellite system:

- More resistant to vandalism
- Less costly & less wire
- Less sensitive to flooding
- More aesthetically pleasing
- No high voltage power on the course

1.3 Toro GDC Integrated Design Looped Lateral Piping Systems

Figure 1 Control system layout with one station module or integrated module at each sprinkler



FEATURES

Looped lateral designs have typically fewer supply points (taps) to the main line and are normally characterized by one to three pipes which cut across the fairway to supply water to the laterals and several lateral pipes which connect to the sprinklers and run along the length of the fairway. This design is more typically used for systems with three or fewer rows of sprinklers. Because of the reduced number of supply taps to the mainline and the length of the lateral pipe used, larger pipe sizes are normally required in order to have sufficient watering capacity. This is the preferred option for designers who use the Rain Bird® IC System.

TORO GDC ADVANTAGES

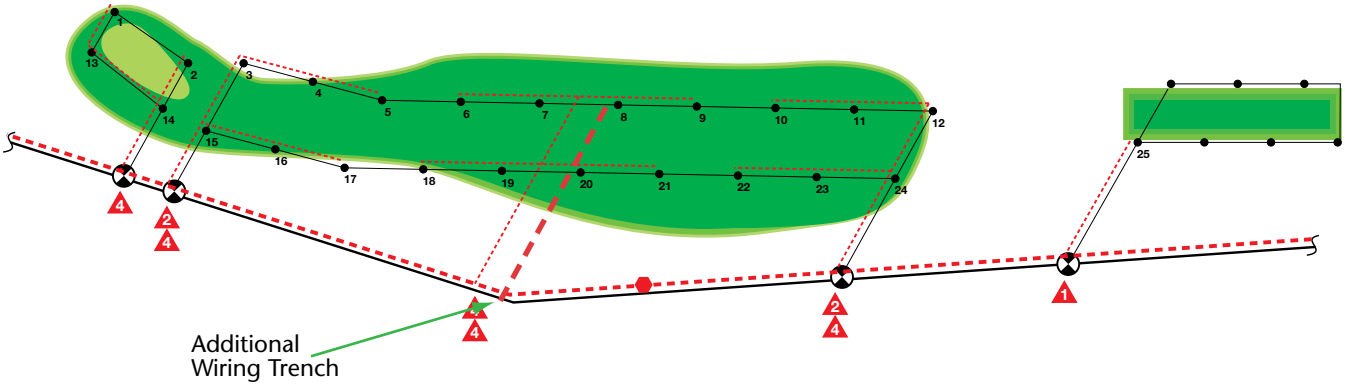
For looped lateral designs, it is customary to use either an integrated module like the DTi series or by connecting a 1-station module directly to or next to the sprinkler head. This is the preferred style for some designers, however the Toro GDC System still has a number of advantages with this design style.[1]

- Fewer surge ground points than the Rain Bird IC System (50% less)
  ✓Lower initial cost ✓Reduced ongoing maintenance
- Module can be replaced without removing the solenoid
  ✓Lower maintenance costs
- The Toro GDC System offers higher surge protection than the Rain Bird IC System
  ✓Better reliability ✓Lower maintenance costs
- The GDC module can be placed next to the head where both it and the wiring can be protected by a valve box, the Rain Bird IC System cannot protect any wiring around the head
  ✓Lower maintenance costs
- If possible, you can reduce costs by operating two sprinklers with a single station, and potentially make use of multiple station modules, with a 2-station module operating up to four sprinklers or a 4-station module operating up to 8 sprinklers
  ✓Cost savings

[1]Note: While using this approach for the Toro GDC it provides the same design and benefits of the Rain Bird IC System it only makes the two systems equal. This choice is easy to implement, but will not take advantage of the other Toro benefits, so this option provides the fewest Toro benefits, sales advantage and virtually no cost savings, but is the same as the Rain Bird approach.

1.4 Toro GDC Off-Fairway Design Looped Lateral Piping Systems

Figure 2 Control system layout with modules "off-fairway" on a simple 2 run looped lateral design



FEATURES

Looped lateral designs typically minimize the number of taps on the main line. Normally, the 2-wire communication layout follows the pipe layout. However, with the addition of just one or two additional trenches (see figure 2) for the DTS wire, it is possible to create an off-fairway design and place the modules in secure valve boxes out of the field of play without changing the pipe layout plan.

TORO GDC ADVANTAGES

By simply modifying this looped lateral design to an off-fairway control system layout, you can now divide the sprinklers into multiple zones. This will allow you to group modules in valve boxes located along the main line where they can be more easily serviced without disrupting the field of play. The example above shows five valve box locations.

- The amount of critical 2-wire communication cable can be reduced by up to 75%
  - Modules can be placed in valve boxes out of the field of play for easier maintenance

    ✓Higher reliability ✓Lower maintenance costs
    ✓Ease of maintenance
- The amount of critical wire splices on the 2-wire communication cable can be reduced by up to 80%
  - Use lower cost DTS wire and non-critical wire splices to connect modules to heads for a lower installed cost

    ✓Higher reliability ✓Lower maintenance costs
    ✓Ease of maintenance
- The amount of surge ground points can be decreased by up to 85% and moved completely off the playing areas
  - Place surge protection points outside the field of play

    ✓Lower cost ✓Lower maintenance costs ✓Ease of maintenance
- Fewer wire splices (critical wire splices) along the main communication line
  - Modules & all critical splices are in easy service valve boxes, off the field of play (this cannot be done with Rain Bird® IC System)

    ✓Ease of maintenance ✓Playability
- Maintain individual head control with multi-station modules
  - Offer the flexibility of individual station control, or the cost savings of multiple heads per stations and multiple station modules.

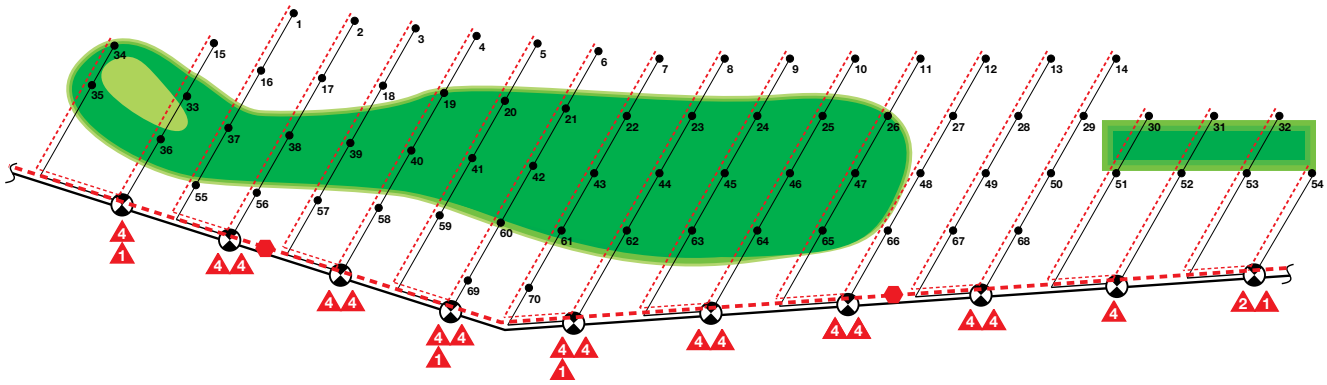
    ✓Flexibility ✓Cost savings
- Modules can be replaced without removing the solenoid

  ✓Lower maintenance costs ✓No digging required
- The Toro GDC System offers higher surge protection than the Rain Bird IC System

✓Better reliability ✓Lower maintenance costs

1.5 Toro GDC Off-Fairway Design Herringbone Lateral Piping Systems

Figure 3 Control system layout grouping modules at every other lateral valve box



FEATURES

Herringbone lateral piping designs consist of lateral pipes placed across the fairway which each feed a smaller quantity of sprinklers across the fairway. This is especially common for designs with three or more rows of sprinklers. This design style allows you to use smaller pipe sizes and requires more mainline taps, but can operate more sprinklers at one time. Sometimes every lateral has a mainline tap, other times a tap is placed on every other lateral.

TORO GDC ADVANTAGES

Although it is possible to use integrated modules with herringbone laterals (the way the Rain Bird IC System has to), a field based 2-wire irrigation system gives you many advantages, including placing modules off the field of play for easier maintenance.

- The amount of critical 2-wire decoder communication cable can be reduced by up to 75%
  - Modules can be placed in valve boxes out of the field of play for easier maintenance

    ✓Higher reliability ✓Lower maintenance costs
    ✓Ease of maintenance
- The amount of critical wire splices on the 2-wire decoder communication cable can be reduced by up to 80%
  - Use lower cost DTS wire and non-critical wire splices to connect decoders to heads for a lower installed cost

    ✓Higher reliability ✓Lower maintenance costs
    ✓Ease of maintenance
- The amount of surge ground points can be decreased by up to 85% and moved completely off the playing areas
  - Place surge protection points outside the field of play

    ✓Lower cost ✓Lower maintenance costs ✓Ease of maintenance
- Fewer wire splices (critical wire splices) along the main communication line
  - Modules & all splices are in easy service valve boxes, off the field of play (this cannot be done with Rain Bird IC System)

    ✓Ease of maintenance ✓Playability
- Maintain individual head control with multi-station modules
  - Offer the flexibility of individual station control, or the cost savings of multiple heads per stations and multiple station modules.

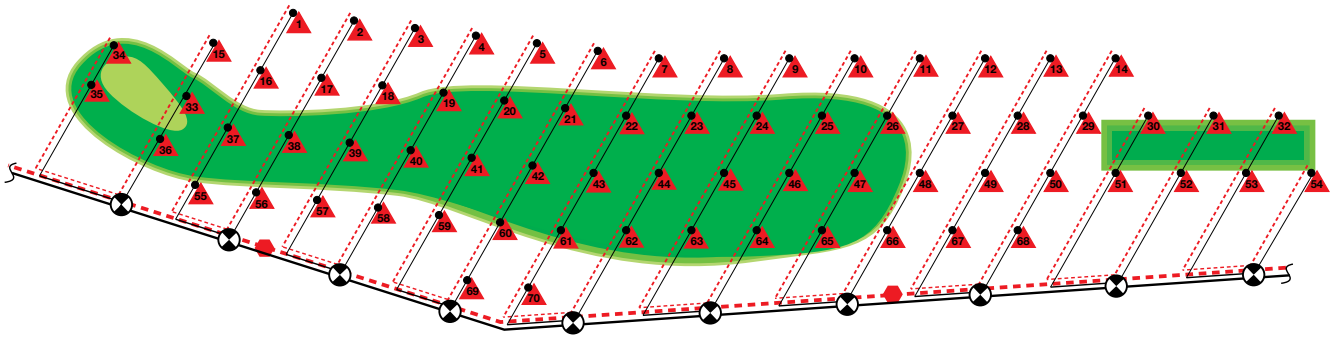
    ✓Flexibility ✓Cost savings
- Module can be replaced without removing the solenoid

  ✓Lower maintenance costs ✓No digging required
- The Toro GDC System offers higher surge protection than the Rain Bird IC System

  ✓Better reliability ✓Lower maintenance costs

1.6 Toro GDC Integrated Design Herringbone Lateral Piping Systems

Figure 4 Control system layout with one integrated module at each sprinkler



FEATURES

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TORO GDC ADVANTAGES

For herringbone lateral designs, you can use an integrated module like the DTi series at each sprinkler. This is the preferred style for some designers. The GDC System has several advantages with this design style.

- The amount of surge ground points can be decreased by up to 85% and moved completely off the playing areas
  - Place surge protection points outside the field of play

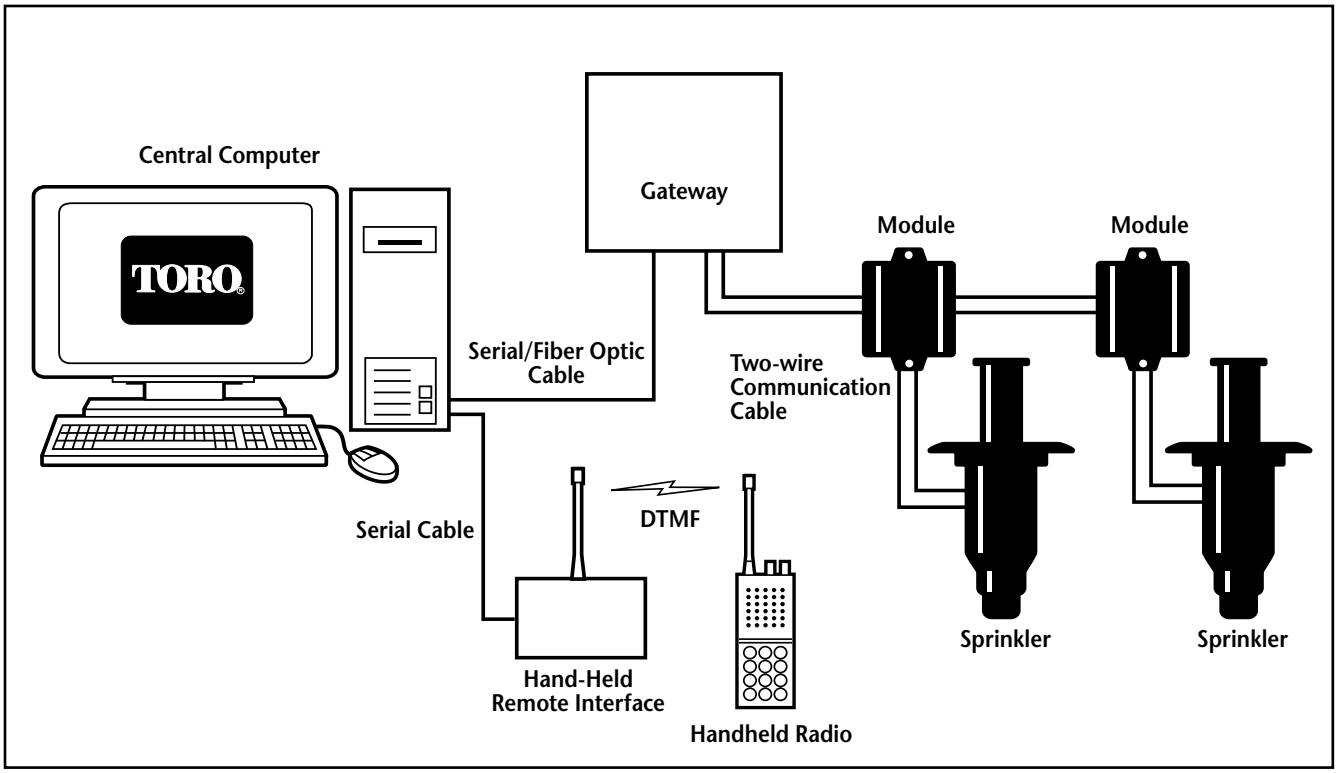
    ✓Lower cost ✓Lower maintenance costs ✓Ease of maintenance
- Module can be replaced without removing the solenoid

  ✓Lower maintenance costs ✓No digging required
- The Toro GDC System offers higher surge protection than the Rain Bird IC System

  ✓Better reliability ✓Lower maintenance costs

2 System Components

In addition to a Gateway and the modules, a 2-wire system may also include a central computer, hand-held remote interface, a weather station interface, and a pump station interface. Installation of all of these components is outlined in the following section.



2.1 Power & Grounding

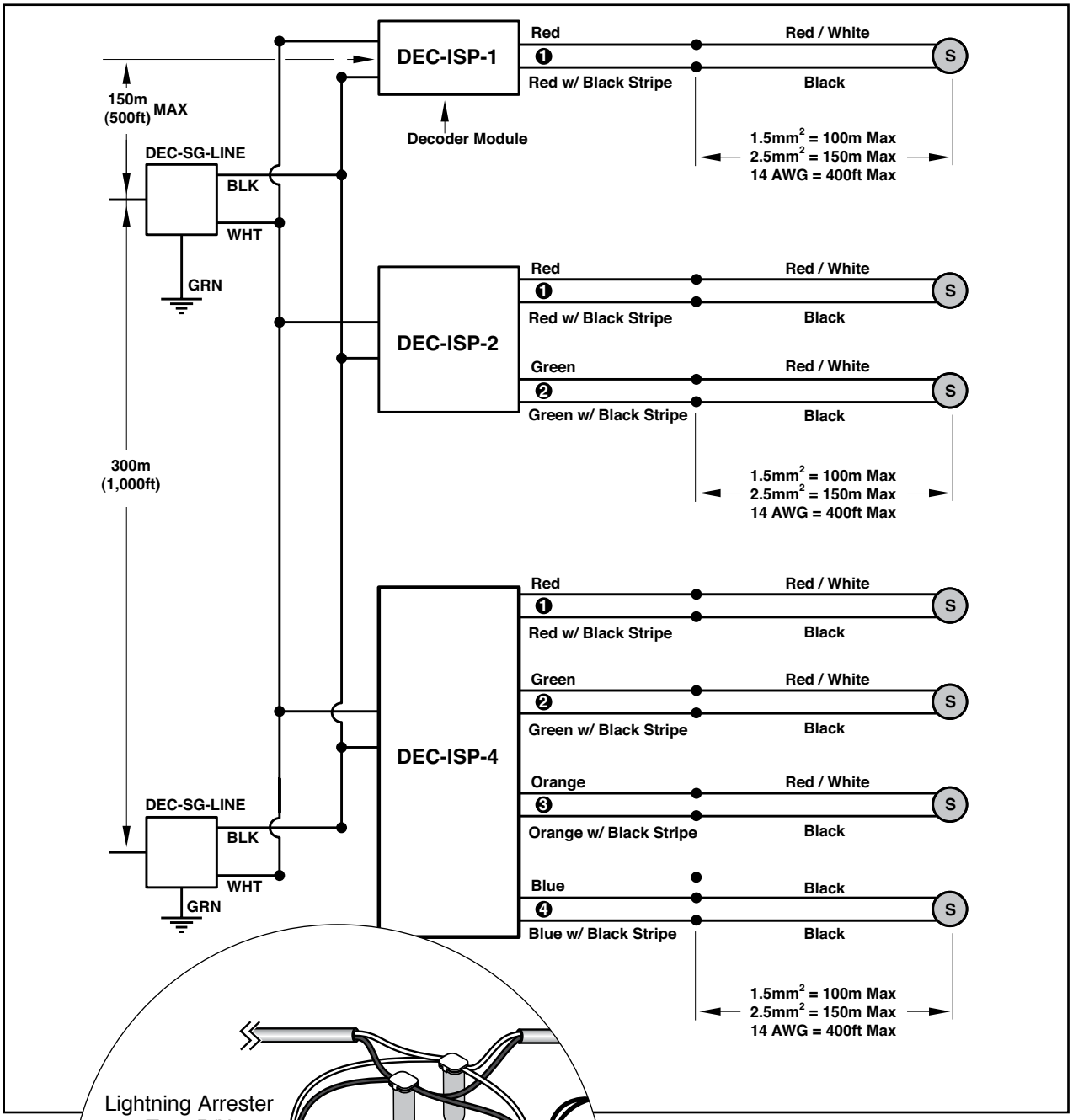
Suitable Power supply.

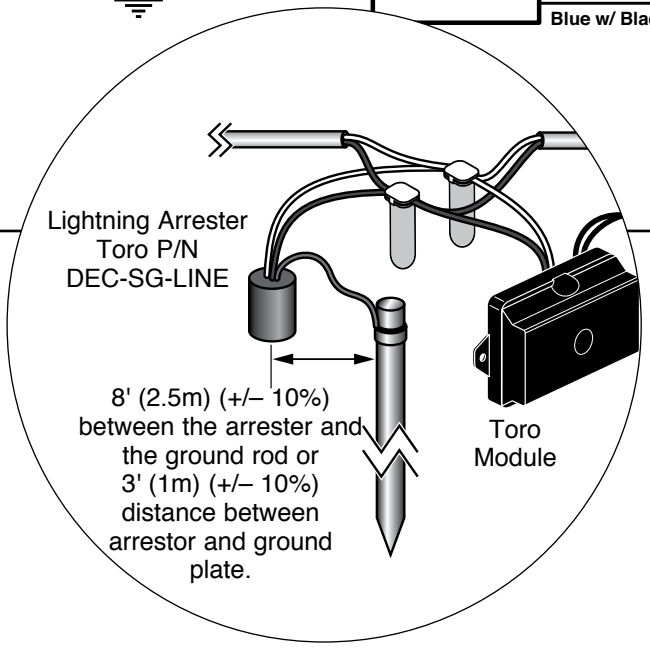
The PC and Gateway are designed to run on a clean, properly earth-grounded main power supply.

Great care should be taken on construction sites where generators may be used to provide power. Prior to operating the 2-wire system, the suitability of the main power supply should be verified by a qualified electrician.

2.3 Surge Arrestors and Grounding

Toro offers two types of surge protection: communication wire and module . The module input and output surge protection is integrated into every module. A communication wire surge unit is properly earth-grounded and spliced into the communication cable every 1000' (300m). Additional wire, moisture-proof splice kits, earth-ground conductors, and Cadweld® connectors are required for the surge unit addition.





2.4 DC Latching Solenoid

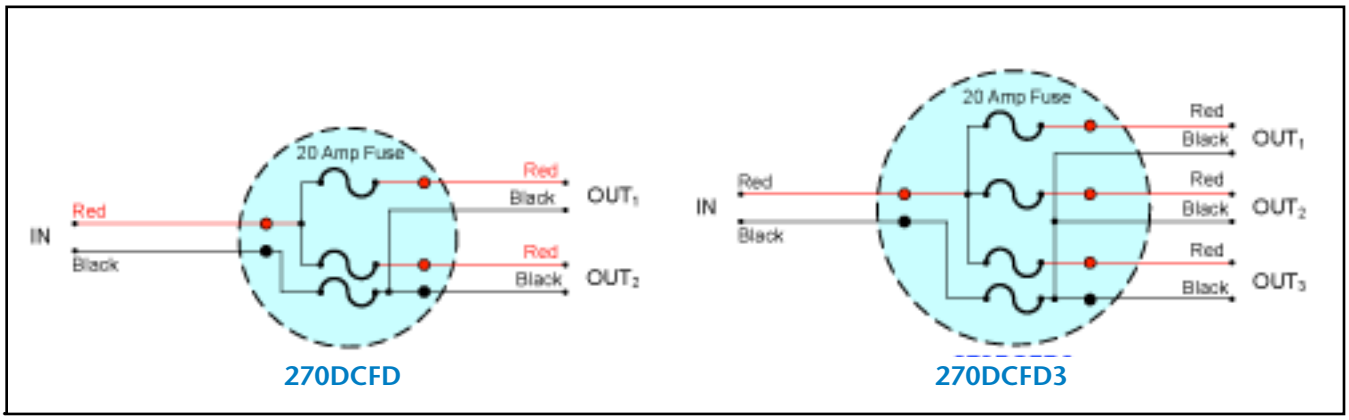
DC Latching solenoids use changing polarity to open and close. They do not require any voltage/current to remain open or closed. The module can operate up to two solenoids per output simultaneously.

Because the latching solenoid operates on DC power, it must be properly connected to the module in order to function. Red or white solenoid wires connect to the solid-color wire from the module for that station while the striped wire connects to the black wire on the solenoid for that station.

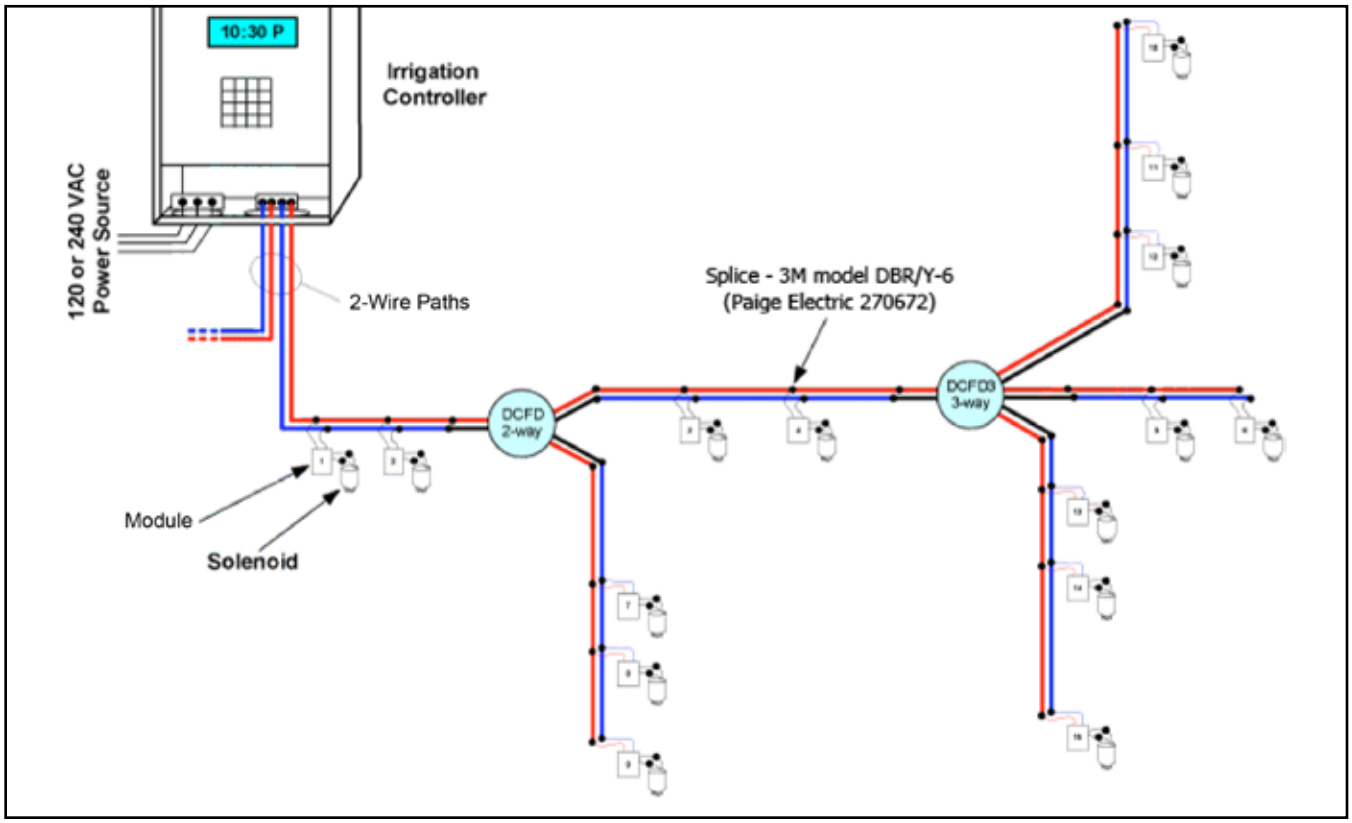
2.5 Communication Wire Path Isolation Devices

An isolation switch can be installed to direct the incoming signal from the Gateway into two or three directions, by simply flipping a switch.

The Paige® DCFD™ (Decoder Cable Fuse Device, part# 270DCFD, 2-way splitter, and 270DCFD3, 3-way splitter) should be installed at strategic locations throughout the 2-wire system such that it can isolate certain sections of cables for purposes of troubleshooting.



It is advisable to install DCFD's where the 2-wire paths split, as illustrated below. It also helps to install them about half way along very long cable paths. For herringbone designs, install one DCFD per hole. By doing so, cable sections can be isolated by removing a fuse. At all fuse device locations, a sufficient amount of 2-wire comm cable should be provided to allow the splice connection to be raised a minimum of 24" (60cm) above grade (the comm path wiring should be buried at least 24" (60cm) below grade).



3 System Wiring

There are two basic wire types in a 2-wire system: the communication wire that runs from the Gateway to the modules in the field, and the station wire (also referred to as the station output wire), which runs from the module to the solenoid.

3.1 Communication Wire

GDC communication is based around the use of two-core PE insulated solid conductor cable run in **spur or branch** configuration throughout. The communication wire can be no longer than 2.6 miles (14 AWG) or 4.2Km (2.1 mm^2) running from the gateway to the module.

3.1.1 Specification

Two-core 2.1mm^2 or 14 AWG, Solid copper conductor, Polyethylene (PE) insulated.
Color code – Outer sheath: Red, Red/Black, Red/Yellow, Red/Green
Inner sheaths: White, Black

Approved Cables:
Toro 14 AWG cable

Please see Section 6 for approved specification sheets

3.2 Configuration & Placement

Each comm cable path may have a maximum length of 13,717 feet (4,181m). Modules should be evenly distributed along that length. For layouts which have multiple branches (or spurs) in the design, standard voltage drop calculations should be used to determine the maximum length of the wire path.

The maximum permissible voltage drop, measured from the Gateway to the furthest module on the wire path is 6 volts.

- Total voltage drop = the total current x the total resistance.
- Amperage per module = 0.0007 Amps.
- Cable resistance = or 8.2 ohms per 3,280 feet (1000m) or 2.52 ohms per 1,000 feet (304,8m) of Paige 7350D 14 AWG.

Example:

250 modules x 0.0007 amps x 13,717 feet (4,181m) / 2 (average distance) x 2 (return path) x 8,2 ohms / 3,280 feet (1000m) = 6 volts.

For conditions where there is a substantial length of cable from the central before the first module and subsequent modules are installed, the following tables can be used to quickly determine allowable distances.

Length of 14 AWG cable starting from central with NO modules (ft)		Length of 14 AWG cable with 250 modules evenly distributed (ft)		Maximum Length from central to furthest module (ft)
6,800	+	0	=	6,800
6,000	+	1,600	=	7,600
5,000	+	3,600	=	8,600
4,000	+	5,600	=	9,600
3,000	+	7,600	=	10,600
2,000	+	9,600	=	11,600
1,000	+	11,600	=	12,600
0	+	13,500	=	13,500

3.4 Communication Cable Layout and Connections

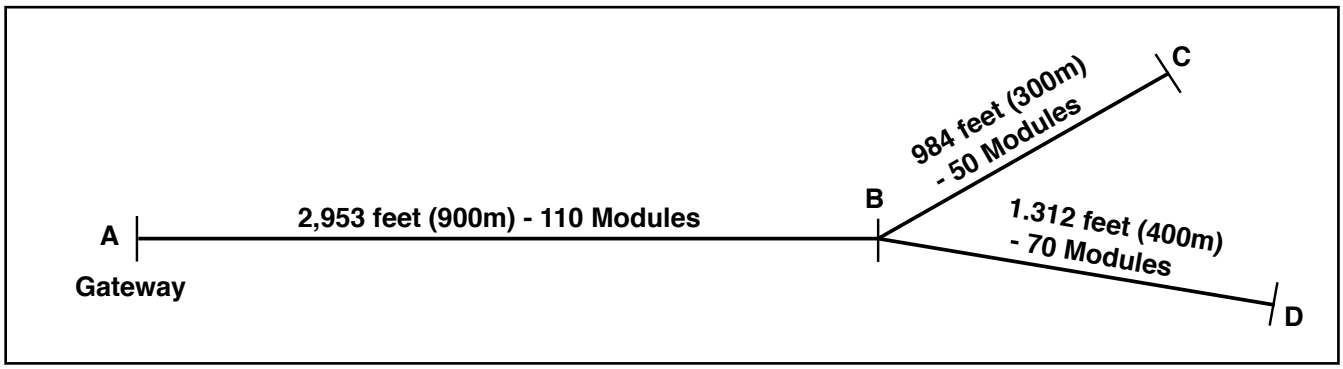
GDC field cable architecture requires that all communication & solenoid cable runs are SPURS.

In conventional AC systems it is a common industry practice to loop the field circuits to help reduce voltage drop. It is critical that this does not happen on GDC systems. Every cable run is a spur – NO RINGS or LOOPS.

The more wire paths that are used, the less vulnerable the system is to a wire cut. It's important to remember to never connect both ends of a wire path to the controller!

3.5 Voltage Drop Calculation

The following example illustrates a basic GDC communication path with a spur configuration, and the calculations used to determine the total voltage drop.



Step 1 - For each wire path, identify the start point and each significant point along the path.
- Sections with no modules (more than 300 ft)
- Sections with modules evenly distributed
- Points where the cable splits in two or more directions
- End points

Step 2 - Calculate the voltage drop for each section.
a) For modules beyond the section endpoint
b) For modules between the section start and end points

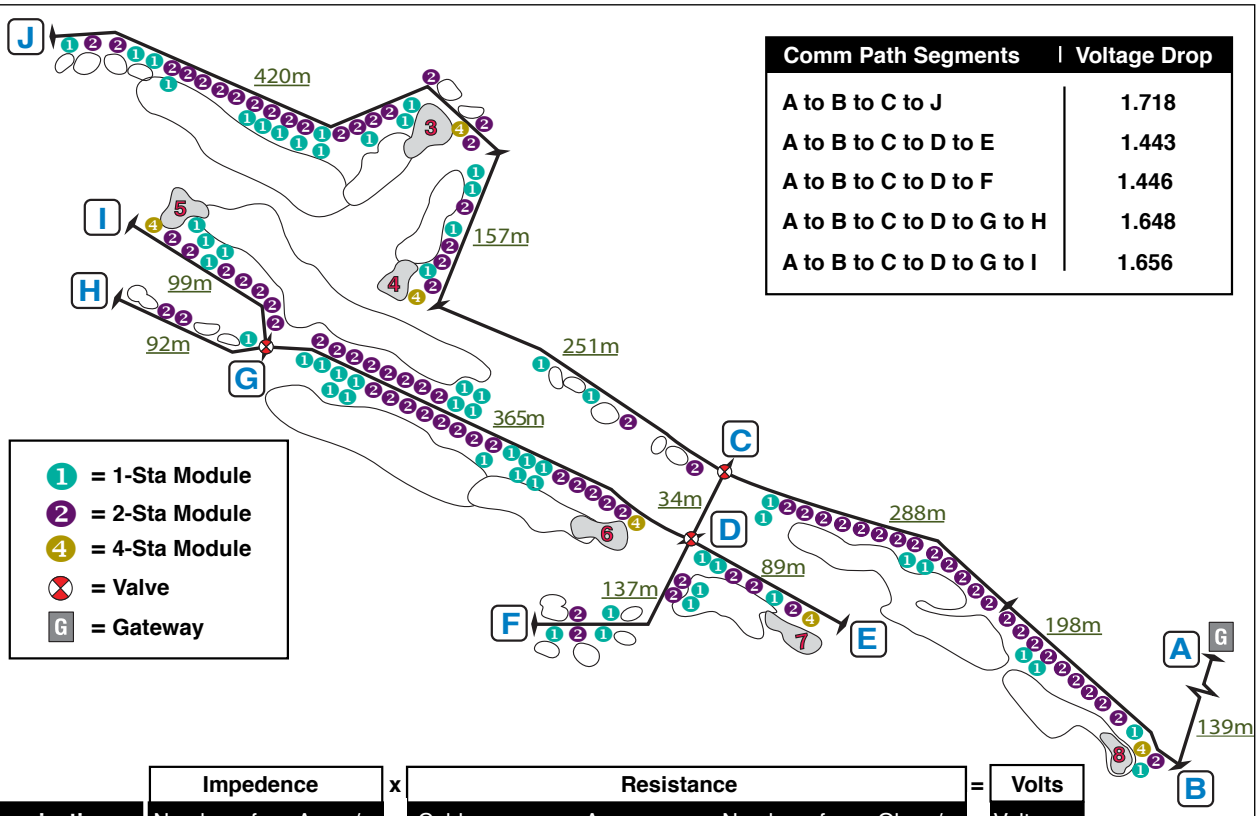
Step 3 - Calculate the total voltage drop from the gateway to each cable endpoint by adding up the subtotals for each section.

Step 4 - If the voltage drop from the gateway to any cable endpoint exceeds 6 volts:
- reduce the quantity of modules on the cable
- reduce the distance
- increase the wire size for some portion (or all) of the cable

	Current			x	Resistance							=	Volts
Communication Path Section	Number of Decoders	x	Amps/ Decoder		Cable Length	x	Average Distance	x	Number of Conductors	x	Ohms/ meter		Voltage Drop
Beyond End Point B	120	x	0.0007	x	2,953 feet (900m)	x			2	x	0.0082	= 1.240	
A to B	110	x	0.0007	x	2,953 feet (900m)	x	0.5	x	2	x	0.0082	= 0.568	
											Total	= 1.808	
Beyond End Point C	0	x	0.0007	x	984 feet (300m)	x			2	x	0.0082	= 0	
B to C	50	x	0.0007	x	984 feet (300m)	x	0.5	x	2	x	0.0082	= 0.076	
											Total	= 0.076	
Beyond End Point D	0	x	0.0007	x	1,312 feet (400m)	x			2	x	0.0082	= 0	
B to D	70	x	0.0007	x	1,312 feet (400m)	x	0.5	x	2	x	0.0082	= 0.161	
											Total	= 0.161	

Example case is as follows: A to B = 1.808 voltage drop
B to D = 0.161 voltage drop
Total = 1.969 voltage drop - Less than 6 volts is acceptable.

The following example illustrates a GDC system communication path and module placement on six holes of a typical golf course application, and the calculations used to determine the total voltage drop for various path segments.



Comm Path Segments	Voltage Drop
A to B to C to J	1.718
A to B to C to D to E	1.443
A to B to C to D to F	1.446
A to B to C to D to G to H	1.648
A to B to C to D to G to I	1.656

	Impedence			x	Resistance							=	Volts
Communication Path Section	Number of Decoders	x	Amps/ Decoder		Cable Length	x	Average Distance	x	Number of Conductor	x	Ohms/ Meter		Voltage Drop
Beyond Endpoint **B**	245	x	0.0007	x	456' (139m)	x	-		2	x	0.0082	=	0.391
A to B	0	x	0.0007	x	456' (139m)	x	0.5	x	2	x	0.0082	=	0.000
											Total	=	**0.391**
Beyond Endpoint **C**	187	x	0.0007	x	1591' (485m)	x	-		2	x	0.0082	=	1.043
B to C	58	x	0.0007	x	1591' (485m)	x	0.5	x	2	x	0.0082	=	0.162
											Total	=	**1.205**
Beyond Endpoint **D**	111	x	0.0007	x	112' (34m)	x	-		2	x	0.0082	=	0.043
C to D	0	x	0.0007	x	112' (34m)	x	0.5	x	2	x	0.0082	=	0.000
											Total	=	**0.043**
Beyond Endpoint **E**	0	x	0.0007	x	292' (89m)	x	-		2	x	0.0082	=	0.000
D to E	13	x	0.0007	x	292' (89m)	x	0.5	x	2	x	0.0072	=	0.007
											Total	=	**0.007**
Beyond Endpoint **F**	0	x	0.0007	x	449' (137m)	x	-		2	x	0.0072	=	0.000
D to F	13	x	0.0007	x	449' (137m)	x	0.5	x	2	x	0.0072	=	0.010
											Total	=	**0.010**
Beyond Endpoint **G**	27	x	0.0007	x	1198' (365m)	x	-		2	x	0.0082	=	0.113
D to G	58	x	0.0007	x	1198' (365m)	x	0.5	x	2	x	0.0082	=	0.122
											Total	=	**0.235**
Beyond Endpoint **H**	0	x	0.0007	x	302' (92m)	x	-		2	x	0.0082	=	0.000
G to H	5	x	0.0007	x	302' (92m)	x	0.5	x	2	x	0.0072	=	0.003
											Total	=	**0.003**
Beyond Endpoint **I**	0	x	0.0007	x	325' (99m)	x	-		2	x	0.0082	=	0.000
G to I	22	x	0.0007	x	325' (99m)	x	0.5	x	2	x	0.0082	=	0.013
											Total	=	**0.013**
Beyond Endpoint **J**	0	x	0.0007	x	2717' (828m)	x	-		2	x	0.0082	=	0.000
C to J	76	x	0.0007	x	2717' (828m)	x	0.5	x	2	x	0.0082	=	0.362
											Total	=	**0.362**

3.6 Solenoid Connections

The wire colors are important for determining the station number and polarity on the module:

Station 1 = Red/Red-Black

Station 2 = Green/Green-Black

Station 3 = Orange/Orange-Black

Station 4 = Blue/Blue-Black

So for example, with a one station module, the red wire on the module must be connected to the red wire on the solenoid. The red/black striped wire is connected to the black solenoid lead.

Remember, wiring must maintain correct polarity for proper operation. If two solenoids are being used on the output wire, wiring must maintain correct polarity for both solenoids.

3.6.1 Splicing

Station output wire connections require waterproof splices, such as 3M DBR/Y connector kits.

3.7 Main Power Interference

Burial Depth

Toro recommends that the Controller to Module and Module to Solenoid cables should have a minimum cover of 6" (150mm). The irrigation plan may specify additional depth to be consistent with the depth of mainline or lateral pipe work and /or soil conditioning procedure such as aeration. Installation procedures must comply with all applicable local and national electrical codes.

Cable Slack

Wherever the cable is installed it should be done so leaving sufficient slack to prevent damage to either the conductors, the insulation or any termination or joints.

Cable Testing

Cable testing should be carried out to ensure the cable has not become damaged due to storage, handling or installation. The following tests may be carried out –

Continuity Test

Paige Cable - Max 2.525 Ω @ 20° per 1000 feet or 8.2 ohms per 1,000m.

Insulation resistance and earth-leakage resistance are measurements that determine whether the cable insulation has been damaged during storage or installation – either conductor-to-conductor (insulation resistance) or conductor-to earth (earth-leakage resistance).

Both of these tests involve a voltage being "injected" into the conductors and the measurement of resistance (should be high value or infinity) should hold for a number of seconds. If the insulation is damaged, either between conductors or between conductors and earth, then the resistance reading will fall rapidly away.

Toro recommends 1 megohm per 1000 feet (305m) @ 250 volts – test time -1 minute.

Cable should be tested in defined sections & lengths, and all test readings should be recorded on the as-built drawing.

Cable Joints.

It is inevitable during installation that there will be a need for cable joints in the field at a place other than a designated valve box position. Cable joints on the communication cable are acceptable, providing they use the recommended jointing method (stated below), and that the joint is housed in a suitable box. The cable and joint should be tested for integrity (as described previously). The joint position should be marked on the electrical as-built drawing.

Main Power Interference

Toro recommends that all communication cables be kept separate from mains power cabling.

Power cables which have a higher voltage than communication/mains control cabling will induce a voltage into that communication line through transformer effect. This will be detrimental to the module communications and reliability.

All cables must be separated from high voltage power lines by at least 12 inch (30cm) per these guidelines:

Power Cable Circuit Rating (max KVA*)	Recommended Minimum Spacing**
0–5 KVA	**12** inch (30 cm)
5–10 KVA	**24** inches (60 cm)
10–20 KVA	**48** inches (120 cm)
>20 KVA	10 feet (3 m)

**** Maximum Voltage x Current ratings of circuit.***

***** These are minimum spacing recommendations to minimize noise coupling. There may be greater separation required by safety agencies or local codes.***

Communication cables should be routed away from potential building and road construction as much as possible. Toro recommends that comm cables are routed in plastic ducting, 0.08 to 0.12 inch wall thickness (2 to 3mm), in areas with ongoing construction expected in order to prevent stretching, crushing or cuts to the cables.

GDC System Product Guide

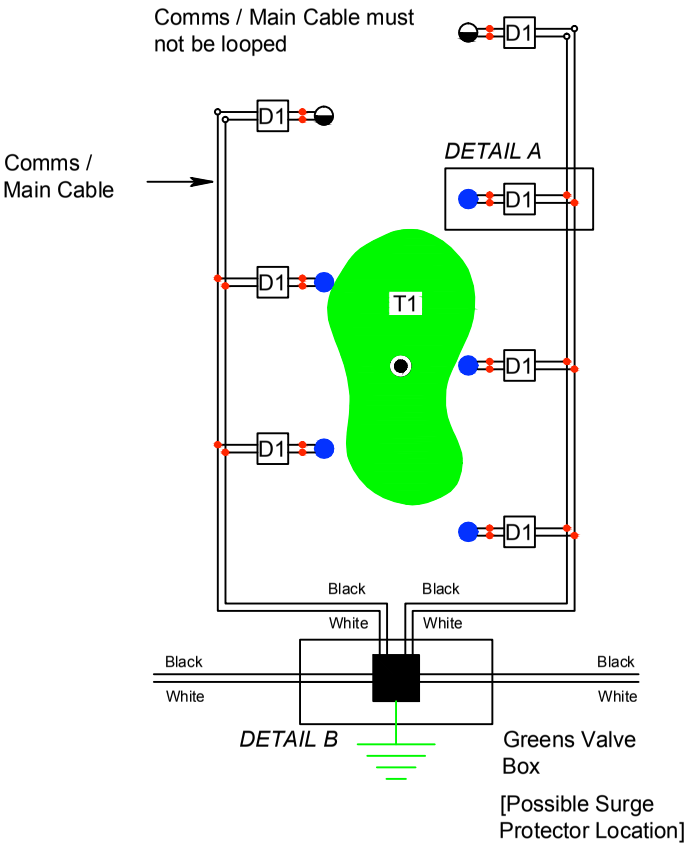
Section 2

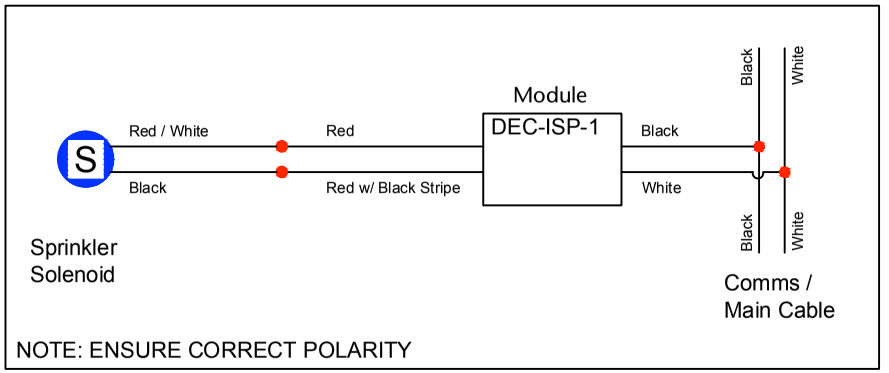
Sample Layouts

SINGLE GREENS & APPROACHES WIRING DIAGRAM

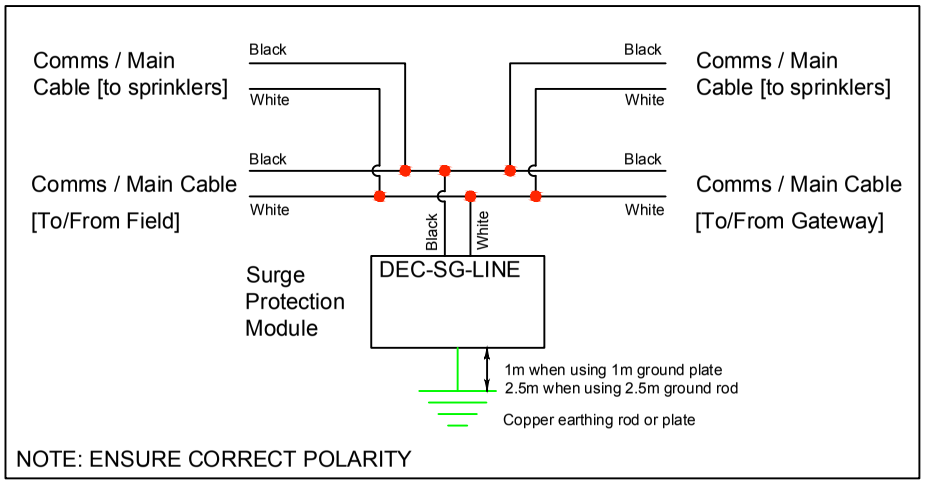
Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)

- TORO 800S or DT SERIES SPRINKLER [GREEN]
- TORO 800S or DT SERIES SPRINKLER [APPROACH]
- 3M DBR/Y-6 CONNECTION
- 3M DBR/Y-6 END CONNECTION
- D1 1 WAY MODULE





DETAIL A



DETAIL B

NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

TYPICAL WIRING DIAGRAM FOR GOLF COURSE GREEN
[SINGLE SPRINKLER HEAD WITH MODULES BURIED AT SPRINKLER HEAD]

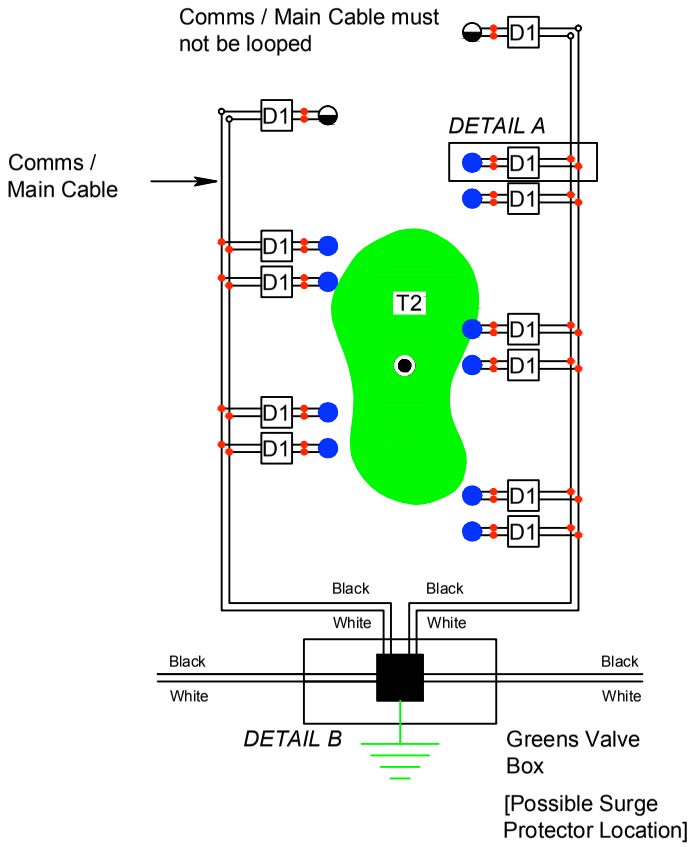
CAST9\Toro_red_tag_blk2.jpg

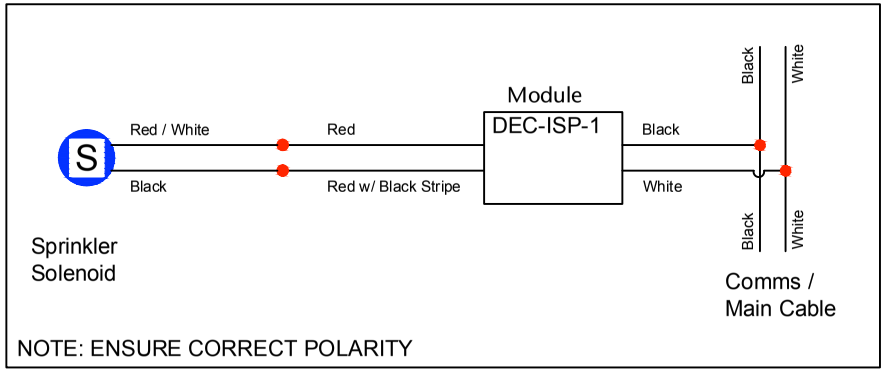
Scale:	+	Date Of Issue:	JAN 2012
Drawn By:	TORO	Checked By:	
Drawing No:	TGDC - 01 GREENS	Amendment:	A

BACK TO BACK GREENS & APPROACHES WIRING DIAGRAM [1 WAY MODULES]

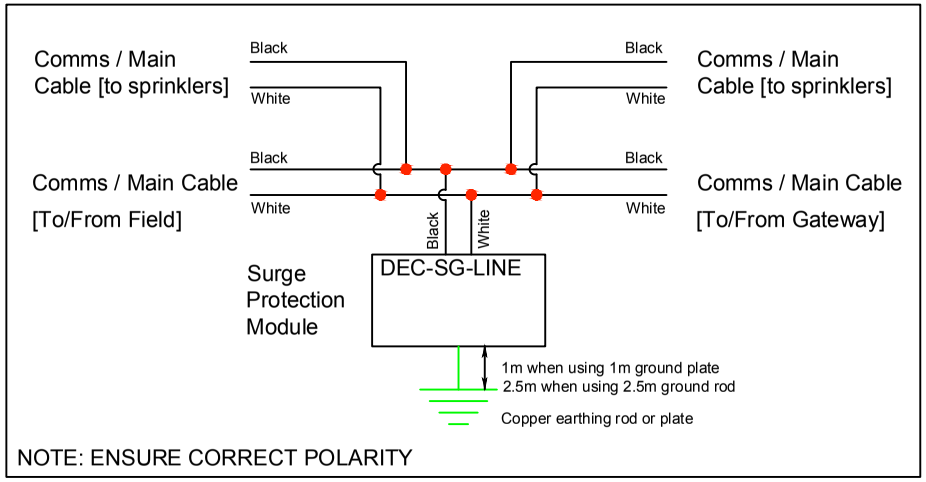
Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)

- TORO 800S or DT SERIES SPRINKLER [GREEN]
- TORO 800S or DT SERIES SPRINKLER [APPROACH]
- 3M DBR/Y-6 CONNECTION
- 3M DBR/Y-6 END CONNECTION
- D1 1 WAY MODULE





DETAIL A



DETAIL B

NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

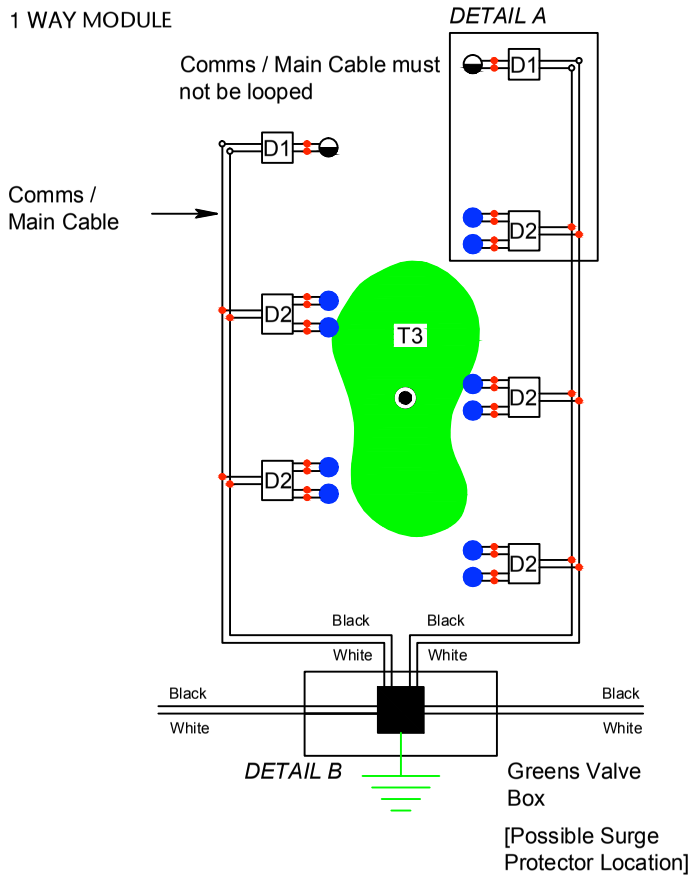
TYPICAL WIRING DIAGRAM FOR GOLF COURSE GREEN
[BACK TO BACK SPRINKLER HEADS WITH 1 WAY MODULES BURIED AT SPRINKLER HEADS]

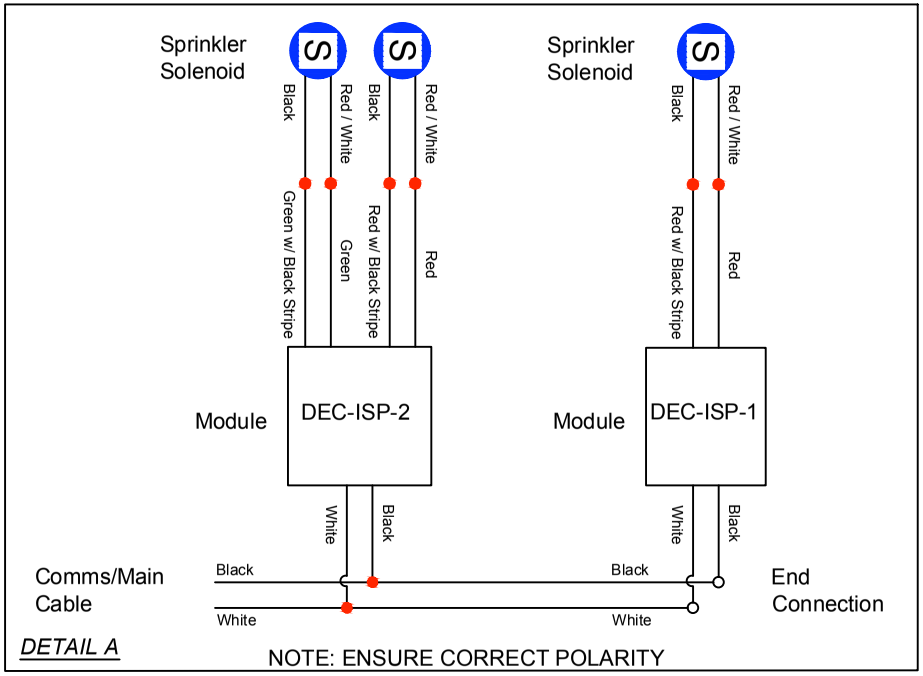
Scale:	+	Date Of Issue:	JAN 2012
Drawn By:	TORO	Checked By:	
Drawing No:	TGDC - 02 GREENS	Amendment:	A

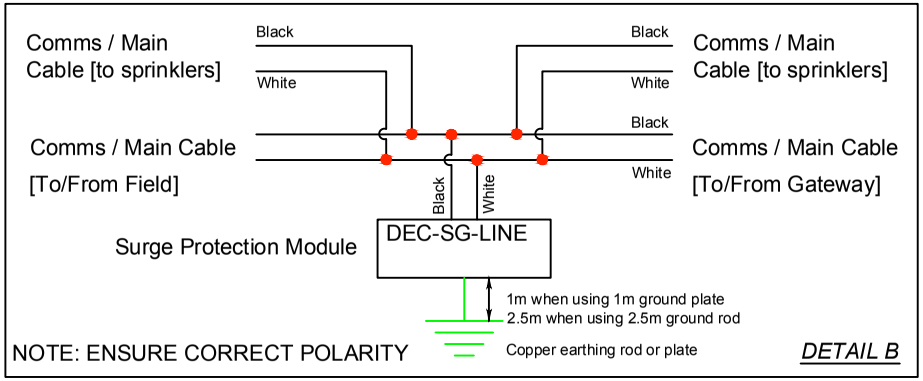
BACK TO BACK GREENS & APPROACHES WIRING DIAGRAM [2 WAY MODULES]

Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)

- TORO 800S or DT SERIES SPRINKLER [GREEN]
- TORO 800S or DT SERIES SPRINKLER [APPROACH]
- 3M DBR/Y-6 CONNECTION
- 3M DBR/Y-6 END CONNECTION
- D2 2 WAY MODULE
- D1 1 WAY MODULE







NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

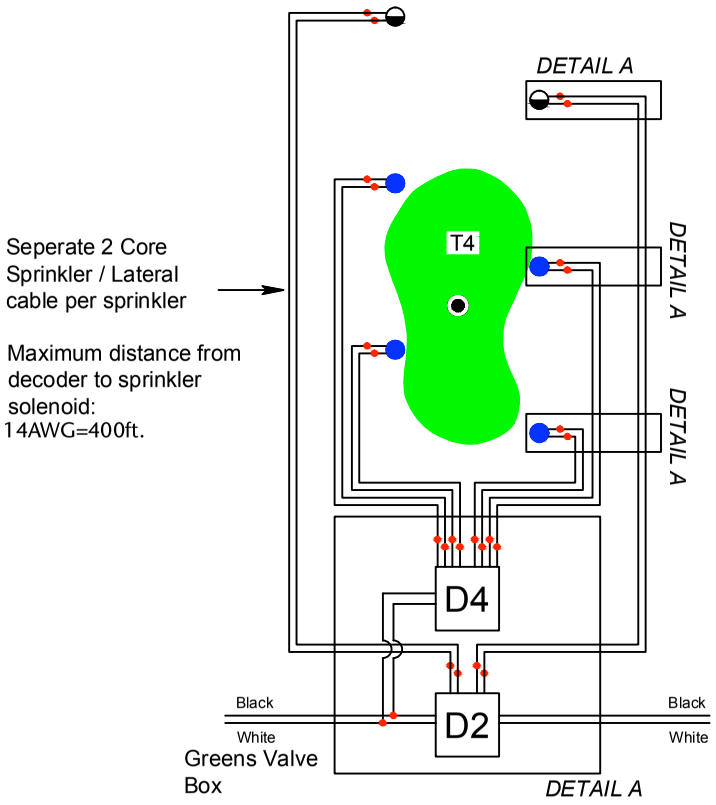
TYPICAL WIRING DIAGRAM FOR GOLF COURSE GREEN
[BACK TO BACK SPRINKLER HEADS WITH 2 WAY MODULES BURRIED AT SPRINKLER HEAD]

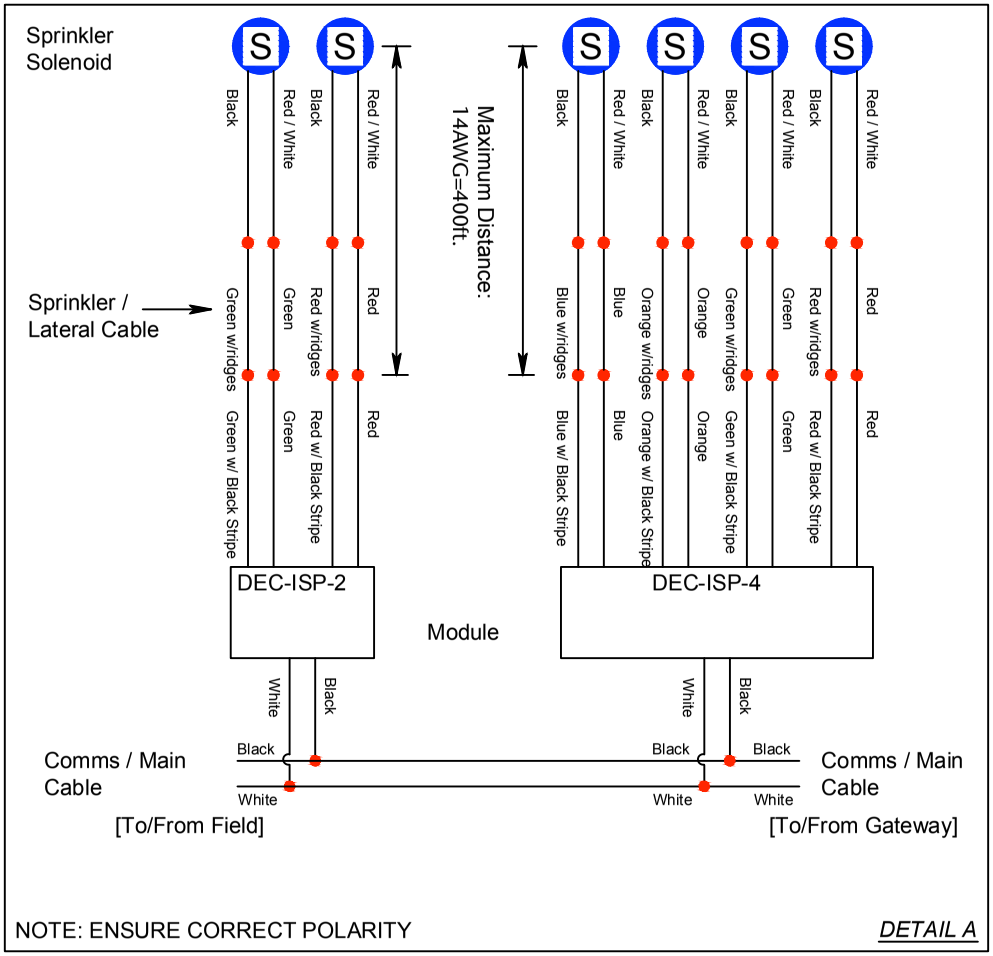
Scale:	+
Date Of Issue:	JAN 2012
Drawn By:	TORO
Checked By:	
Drawing No:	TGDC - 03 GREENS
Amendment:	A

GREENS & APPROACHES WIRING DIAGRAM [MODULES IN GREENS VALE BOX]

Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)
Sprinkler/lateral cable 2 core 2.1mm², Paige P7351D (14AWG)

- TORO 800S or DT SERIES SPRINKLER [GREEN]
- TORO 800S or DT SERIES SPRINKLER [APPROACH]
- 3M DBR/Y-6 CONNECTION
- D2 2 WAY MODULE
- D4 4 WAY MODULE





NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

TYPICAL WIRING DIAGRAM FOR GOLF COURSE GREEN
[SINGLE SPRINKLER HEAD WITH MODULES IN GREENS VALVE BOX]

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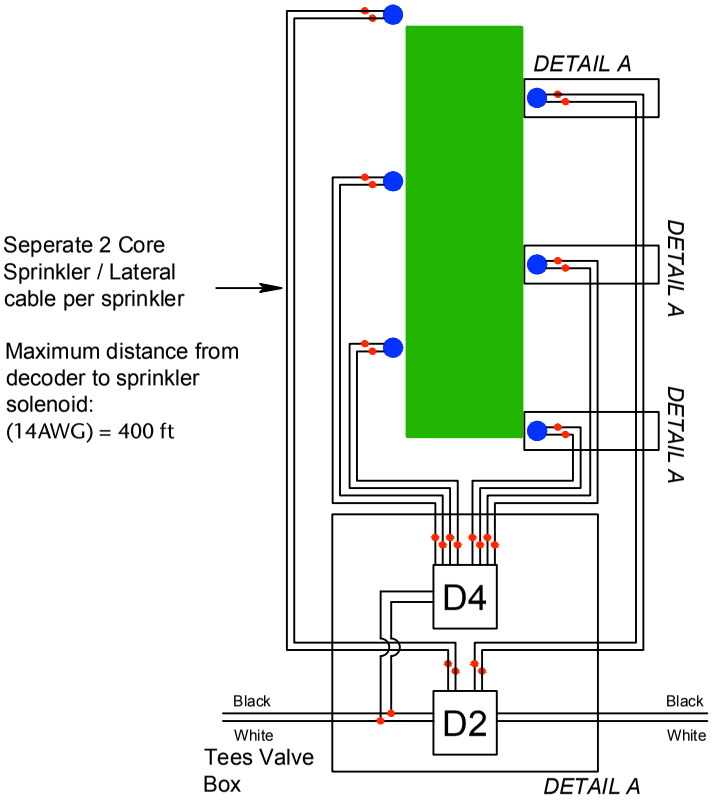
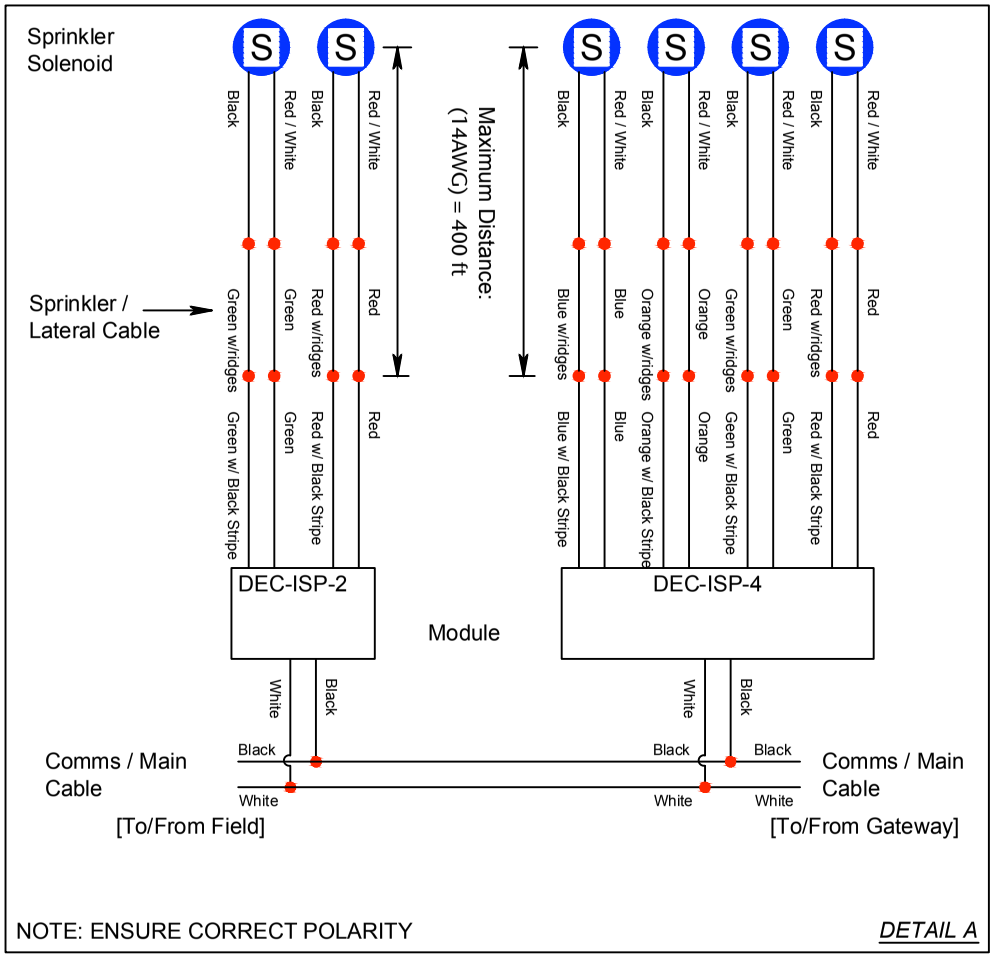
Scale:	Date Of Issue:
+	JAN 2012
Drawn By: TORO	Checked By:
Drawing No: TGDC - 04 GREENS	Amendment: +

TEES WIRING DIAGRAM [MODULES IN TEES VALVE BOX]

Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)
Sprinkler/lateral cable 2 core 2.1mm², Paige P7351D (14AWG)

- TORO 800S or DT SERIES SPRINKLER [TEE]
- 3M DBR/Y-6 CONNECTION
- D2 2 WAY MODULE
- D4 4 WAY MODULE





NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

TYPICAL WIRING DIAGRAM FOR GOLF COURSE TEE
[SINGLE SPRINKLER HEAD WITH MODULES IN TEES VALVE BOX]

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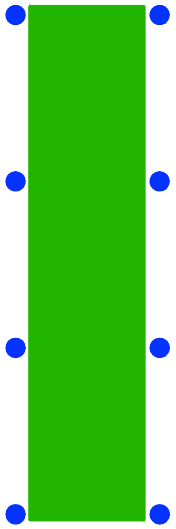
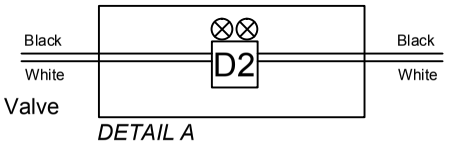
Scale:	+	Date Of Issue:	JAN 2012
Drawn By:	TORO	Checked By:	
Drawing No:	TGDC - 05 TEES	Amendment:	+

TEES WIRING DIAGRAM [MODULES IN FAIRWAY VALVE BOX]

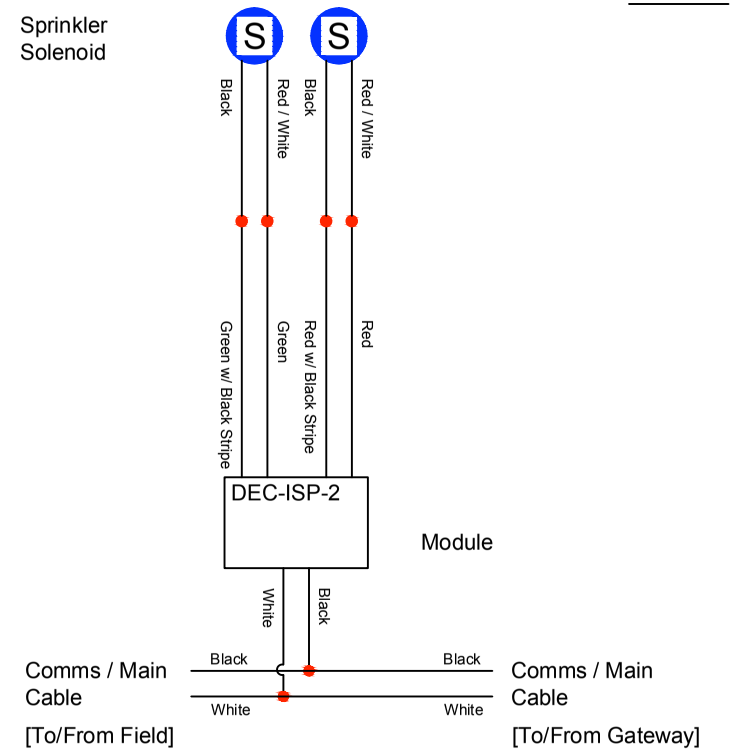
Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)

- TORO 810G SERIES SPRINKLER [TEE]
- 3M DBR/Y-6 CONNECTION
- TORO P220 SOLENOID VALVE
- D2 2 WAY MODULE





DETAIL A



NOTE: ENSURE CORRECT POLARITY

Where a Tee connection is at the end of a wire path the communication/main cable terminates at the module in an end connection.

NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

TYPICAL WIRING DIAGRAM FOR GOLF COURSE TEE
[CHECK-O-MATIC SPRINKLERS WITH MODULES IN TEES VALVE BOX]

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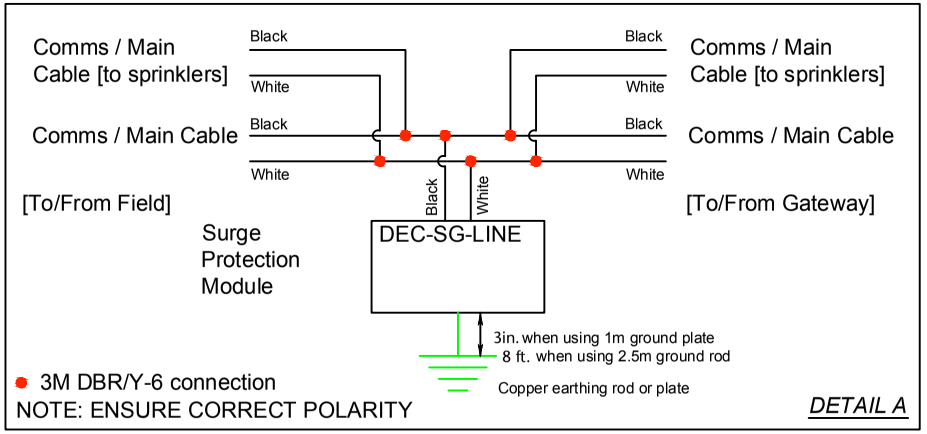
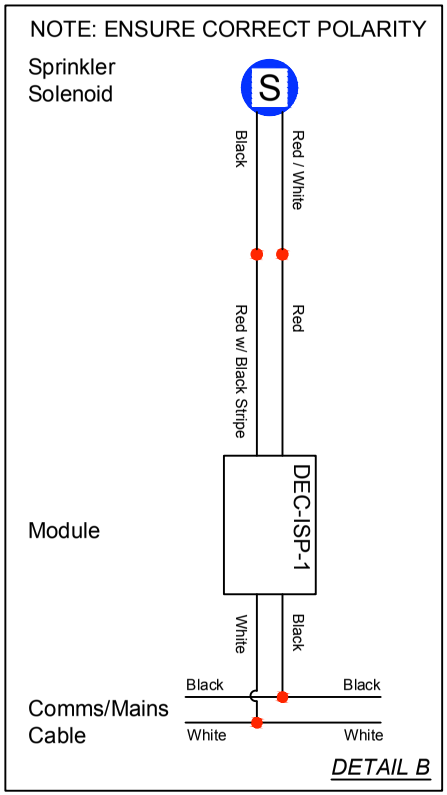
Scale:	Date Of Issue:
+	JAN 2012
Drawn By: TORO	Checked By:
Drawing No: TGDC - 06 TEES	Amendment: +

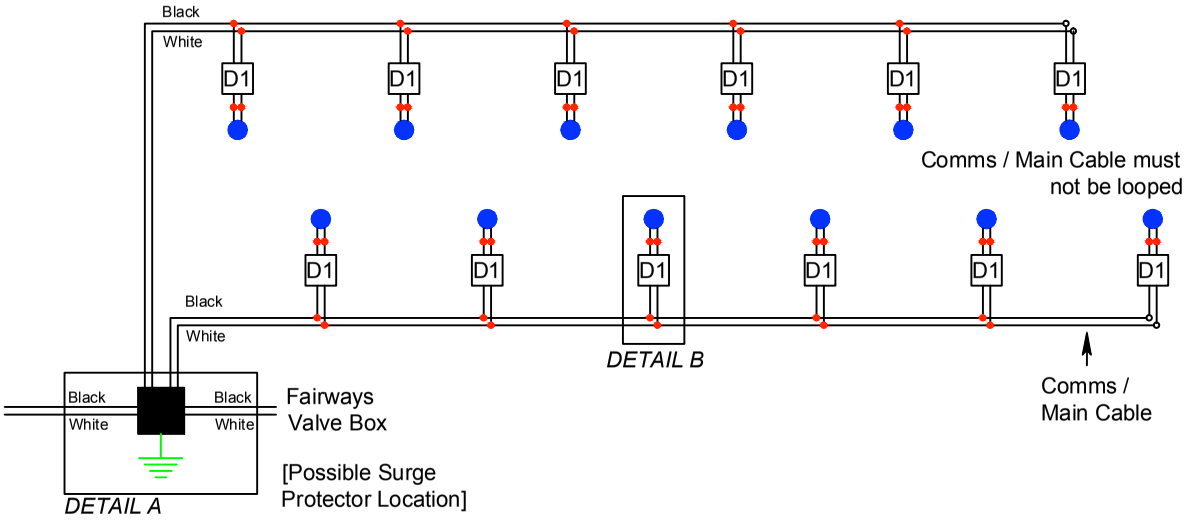
FAIRWAY WIRING DIAGRAM

- TORO 800S or DT SERIES SPRINKLER [FAIRWAY]
- 3M DBR/Y-6 CONNECTION
- 3M DBR/Y-6 END CONNECTION
- D1 1 WAY MODULE

Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)







NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

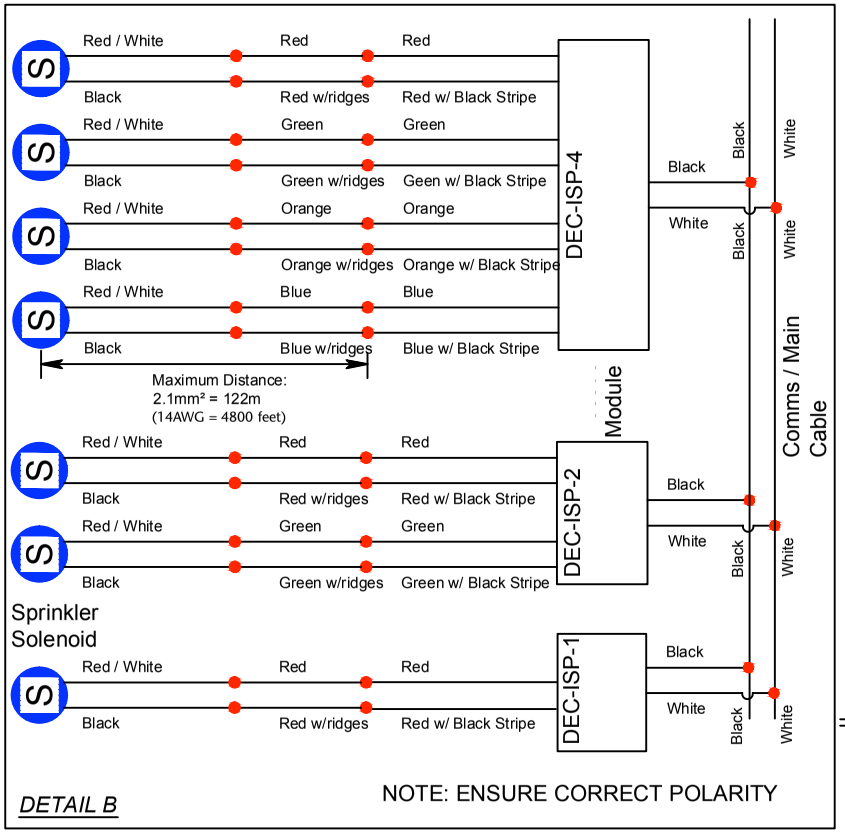
TYPICAL WIRING DIAGRAM FOR GOLF COURSE FAIRWAY
[SINGLE SPRINKLER HEAD WITH MODULES BURIED AT SPRINKLER HEADS]

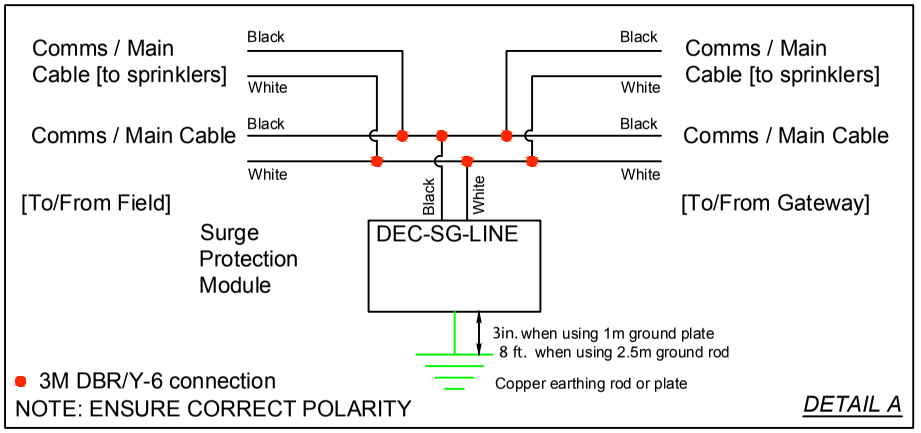
Scale: +	Date Of Issue: JUNE 2009
Drawn By: TORO	Checked By:
Drawing No: TGDC - 07 FAIRWAY	Amendment: A

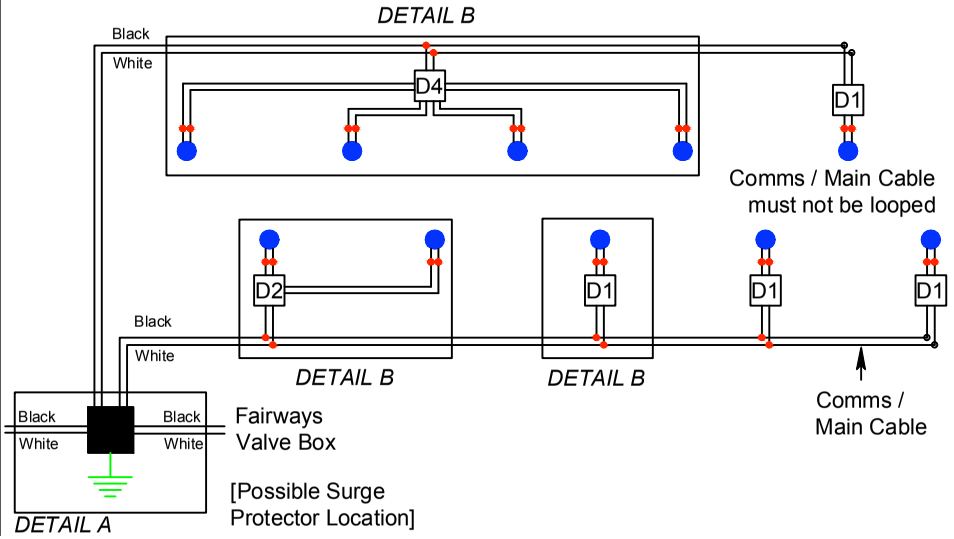
FAIRWAY WIRING DIAGRAM

Communication/main cable 2 core 2.1mm², Paige P7350D (14AWG)

- TORO 800S or DT SERIES SPRINKLER [FAIRWAY]
- 3M DBR/Y-6 CONNECTION
- 3M DBR/Y-6 END CONNECTION
- D1 1 WAY MODULE
- D2 2 WAY MODULE
- D4 4 WAY MODULE







NOTE: PLEASE READ IN CONJUNCTION WITH PART No: 373-0385 & 373-0449

Project

TYPICAL WIRING DIAGRAM FOR GOLF COURSE FAIRWAY
[SINGLE SPRINKLER HEAD WITH MODULES IN FAIRWAY VALVE BOX]

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Scale:	+	Date Of Issue:	JAN 2012
Drawn By:	TORO	Checked By:	
Drawing No:	TGDC - 08 FAIRWAY	Amendment:	A

Notes

GDC System Product Guide

Section 3

Installation

1 Overview

Two-wire is an alternative to traditional controller systems – they work just like conventional controllers but are installed below grade in a valve box with the irrigation valve or alongside a valve-in-head sprinkler. What makes a 2-wire system unique is that both power and data are transmited simultaneously on one two-wire cable. The Toro GDC module comes in 3 basic configurations: one-, two-, and four-station. The GDC has 20,000 volt surge protection at the controller with proper grounding.

2 Recording of As-Built Information

The installation of an irrigation system constitutes a significant investment for a client and it is vital that the installation is recorded accurately to allow for future maintenance of the system. Accurate as-built information will provide the basis for logical troubleshooting of the installation at the commission stage, and in the future if required.

Toro recommends that the installer obtains 'blank' base plans from the designer and on a daily basis throughout the construction/installation phase traces on to those plans the following information for eventual inclusion on the site GPS plan:

Hydraulic drawing:

- Mains pipe routes/ sizes, significant junctions, isolation, drain & air valves
- Lateral pipe routes/ sizes, significant junctions, all sprinklers & valves

Electrical drawing:

- Communication cable routes/ sizes, junctions & joints
- Solenoid cable routes/ sizes, junctions & joints
- Location of DEC-SG-LINE along with earth resistance readings
- Location of any isolation devices
- Module locations & addresses

Toro Lynx® GDC Set Up Information

Lynx is a sophisticated and powerful irrigation software operating system. For Lynx to operate correctly and to its specification, it needs to be configured with accurate and comprehensive design and as-built field information.

The creation of the system database is intricate, but once completed will give the Golf Course Superintendent the specified level of control over the irrigation system. Future changes in the database will only be required when something in the field changes.

Cable Path Information Sheets

The information which is required is that which is installed in the golf course. The following as-installed information is required.

General

Station Number	01
Module Address	91171
Module Output	01/04 (station 1 on a 4 way module)
Location (Head Position)	Front Left
Type Area	Green
Hole No	01

Heads

No. Heads	01
Sprinkler Make & Type	835S
Nozzle	#34
Arc	180°
Single Sprinkler Flow-lpm	114
Formation Type Spacing	Square
Distance Heads/Laterals	74 feet/74 feet (22,6m/22,6m)

This is how Toro recommends the data required to load the Lynx® database is to be collected from the site for eventual entry on to the PC. We would recommend this information also be collected daily during construction.

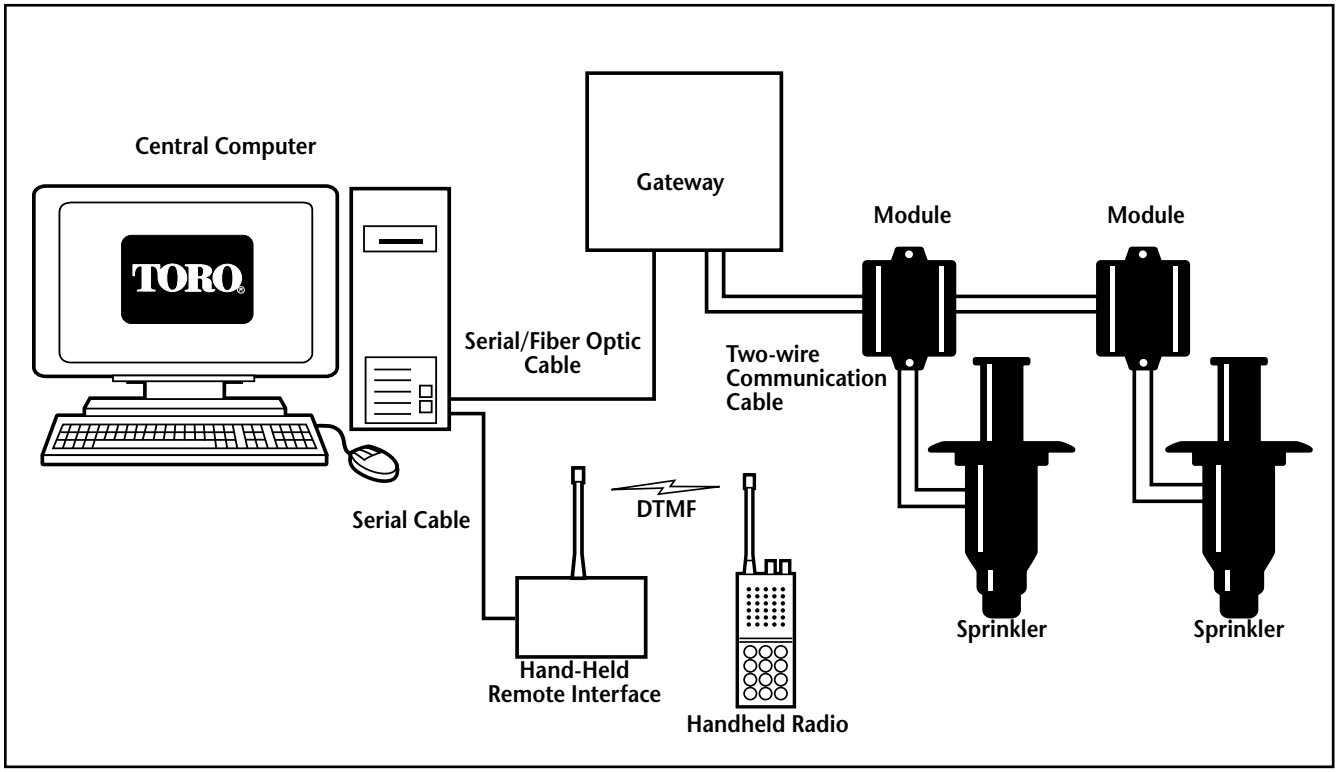
Toro recommends that separate test of sheets are maintained for each cable path.

This information must reflect what is actually in the ground only. Lynx can only be effective for the customer and golf course if it is operating on real parameters and information. Any differences between as-built and design should be agreed with the designer for him or her to make the appropriate allowances within the design specification.

Without the hydraulic drawing, electrical drawing or the site configurations sheets it will not be possible to program Lynx® correctly.

3 Computer Hardware

In addition to a gateway and the modules themselves, a 2-wire system may also include a central computer, hand held remote interfaces, a weather station interface, and a pump station interface. Installation of all of these components is outlined in the following section.



PC & Peripheral Equipment Location

The PC and peripheral equipment represent an expensive part of the system investment, and care should be taken with this sensitive equipment during the construction phase. The equipment should be placed and set to work in a suitable secure, clean & dust free environment.

Suitable Power supply

The PC and Gateway are designed to run on a clean and suitably earthed mains power supply. Great care should be taken on construction sites where generators may be used to provide power.

The condition and suitability of the mains supply should be verified by a qualified electrician.

Commencement of NSN® coverage

Please be aware that NSN coverage begins at the time when NSN releases the unlock codes for the system. If this is likely to be an issue for your contractor/client, then you should discuss the matter with NSN prior to unlock and seek to make alternative arrangements.

Extensions to NSN coverage will not automatically be given, and can only be sanctioned by NSN.

Telephone line connection

NSN can only provide your customer with the support they have purchased as part of their Lynx package if there is a suitable telephone/internet connection at the central computer location.

3.1 Lynx® Central

Installation of the Lynx central control system involves two different components: computer hardware and computer software.

3.1.1 Computer Hardware

In order for the computer to be able to communicate with the gateway, it will first need to be connected to the PC interface. Installing the interface can be done in 7 steps, outlined below.

Step 1 – Place the gateway's power switch to OFF.

Step 2 – Install the fiber optic modem to the gateway mother board (See Figure 1).

Step 3 – Ensure that the FIBER/WIRE switch is in the FIBER position.

Step 3 – Remove the protective cover from the modem's socket and fiber optic cable. Secure the cable to the Transmit (TX) and receive (RX) ports. Ensure that both cables are locked into place. Record the TX and RX cable color for reference.

Step 4 – Route the fiber optic cable to the central computer.

Step 5 – Install the remaining fiber optic modem to the central computer's COM port.

Step 6 – Remove protective cover from the modem's socket and fiber optic cable. Connect the gateway modem's TX to the computer modem's RX input. Connect the gateway modem's RX to the computer modem's TX input.

Step 7 – Place the gateway's power switch back to ON. Restart the central computer and test the system for proper operation.

Figure 6

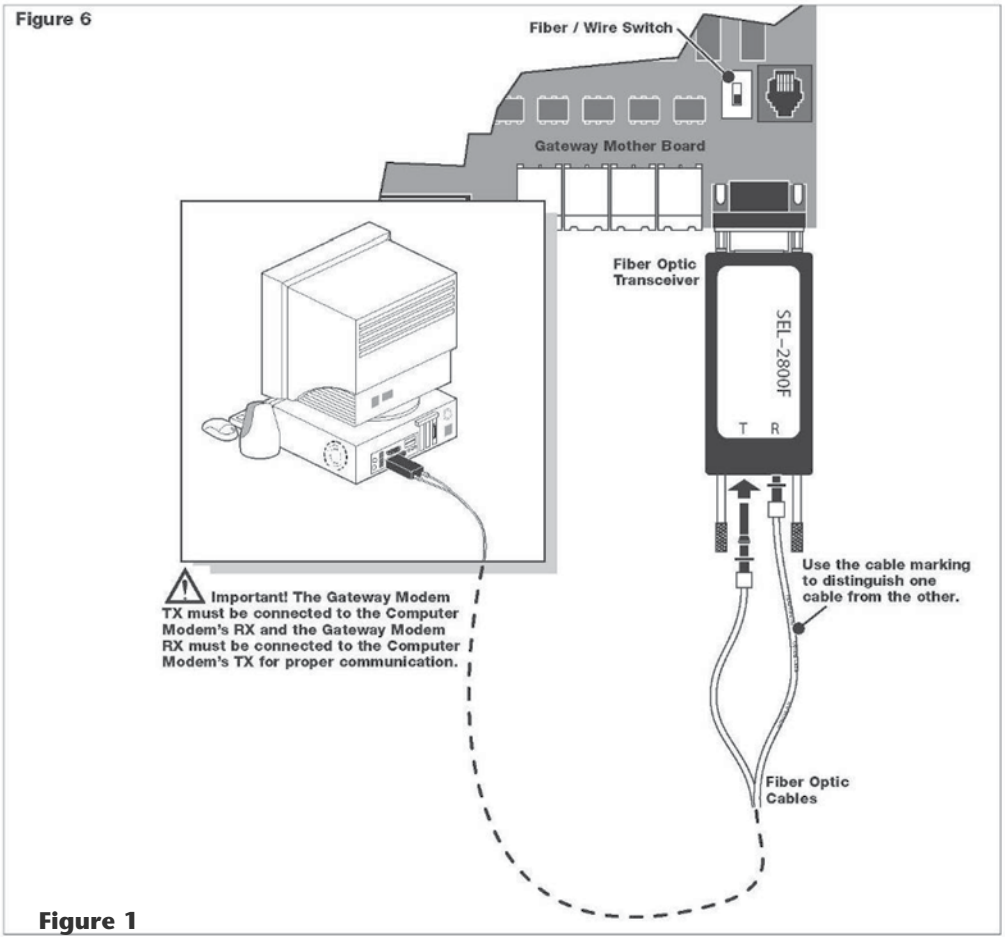


Figure 1

3.1.2 Lynx® Software

If your Toro central computer does not have Lynx pre-installed, you'll need to install the Lynx software. Insert the Lynx CD into your computer's CD-ROM drive, then follow the self-prompting step by step software setup and select the proper options as instructed. After the installation is complete, contact Toro NSN® to obtain an unlock code for the software.

3.1.3 Handheld Remote Interface

The Hand-Held Radio Interface (HHRI) system is designed to operate Toro computerized central irrigation control systems to provide remote manual control operation. The HHRI unit enables most central controlled and 2-wire manual operations to be accessed remotely from the field through a hand-held two-way radio with numeric DTMF keypad or a touch-tone telephone.

Before installation of the HHRI can begin, the following services must be performed by an authorized Toro representative:

Procurement of the radio frequency license.

Selection of the antenna location for proper operation.

Locating the Hand-Held Radio Interface (HHRI)

The HHRI unit is designed for an indoor office environment. Choose a location where the ambient air temperature is between 14° to 104°F(-10° to 40°C), and relative humidity in the 20-80% range.
CAUTION: Operation outside the temperature and humidity range may cause severe damage to the HHRI unit.

Power Connection

The HHRI unit is provided with an external power transformer with DIN plug and wall plug cord for use with a 120 VAC or 220 VAC power source (model specific) (See Figure 2 for connection diagrams).

Antenna Connection

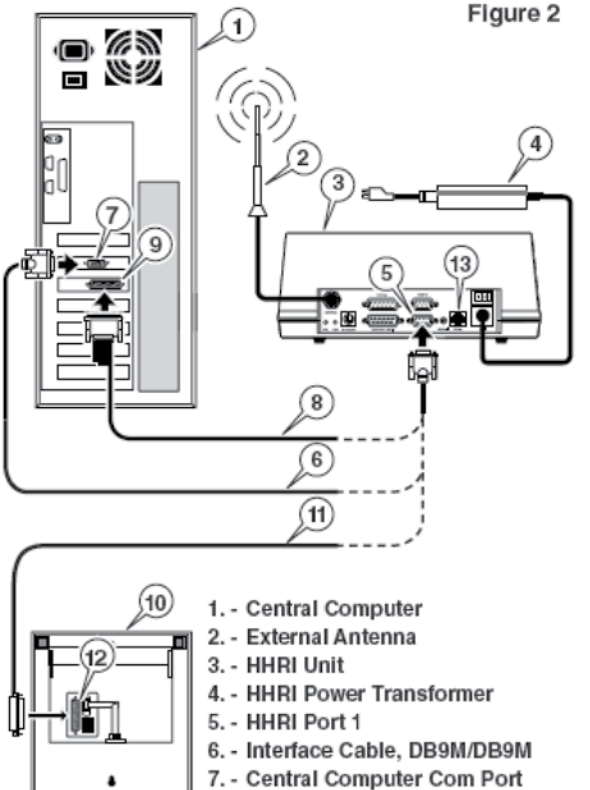
For most installations, it is recommended that the antenna is located away from the HHRI unit and raised high enough to provide good coverage. A roof-mounted antenna will provide much better coverage than the small "rubber duck" type antenna. This is particularly helpful when using an external keyboard (central computer) since many keyboards malfunction in the presence of a strong radio frequency fields.

Setup with Lynx® Central

The HHRI unit can be interfaced with the Lynx Central computer through HHRI Port 1 and a designated COM port.

If assistance is needed in configuring either the Lynx Central or the HHRI unit during installation, please contact your Toro distributor or field service representative.

Figure 2



1. - Central Computer
2. - External Antenna
3. - HHRI Unit
4. - HHRI Power Transformer
5. - HHRI Port 1
6. - Interface Cable, DB9M/DB9M
7. - Central Computer Com Port
8. - Rocket Port Cable Assembly
9. - Rocket Port 25-Pin Female Socket
10. - TouchNet Unit
11. - Interface Cable, DB9M/DB25M
12. - TouchNet 25-Pin Female Socket
13. - HHRI Telephone Socket

After installing the hardware, you'll need to install the HHRI software on your PC. For proper installation, follow the seven steps outlined below.

Step 1 –Ensure that all HHRI unit hardware components are properly installed.

Note: ***The following steps 2 and 5 are required for PC-based central systems only.***

Step 2 –After the software set-up has concluded, switch ON the HHRI unit.

Step 3 –The HHRI unit should show in its LCD display "PC ONLINE AWAKE" . If the message does not appear, re-initialize Lynx. If the problem persists, see "Troubleshooting" section for additional solutions.

Step 4 –Ensure that the central irrigation control program is operational.

Note: ***The Hand-held radio and the HHRI unit must be programmed to the same frequency to enable the system communications.***

Step 5 –Set the hand-held radio frequency to the same frequency of the HHRI unit. Verify that voice communication is working properly. Set the speaker volume on the HHRI unit to the desired level.

Step 6 –Test the HHRI unit operation by transmitting from the hand-held radio as follows:

Note: ***Audible signals called "response tones" are transmitted to the hand-held radio which enable you to easily determine how the system is functioning during set-up and remote command operation.***

Two distinct tones are transmitted in various combinations: A high pitch, short duration tone called a "dit", and a lower pitch longer duration tone called a "**dah.**"

- Press and hold the Push-To-Transmit (PTT) switch in the left side of the hand-held radio.
- Press the # then press * then release the PTT switch. You should hear one of the following response tones:

  Dit-dit which indicates the system is ready for remote operation.

  Dit-dah which indicates the system is inoperable and not ready for remote operation because the HHRI unit is in "sleep mode."

  Dah-dah which indicates the system is not available for remote operation because the HHRI unit is not connected properly to the central and/or the central software is not operating properly. If this response tone occurs, check all previous installation steps, then retry the system test. This response tone will also be automatically sent to the hand-held radio if the HHRI unit becomes inoperable.

Now that both the HHRI hardware and software have been installed, we can configure the system. This process involves programming the security code and time-out duration.

Security Code

To help safeguard against unauthorized hand-held radio operation, the HHRI unit utilizes a three-digit security code which must be entered prior to issuing any irrigation system operating commands.

The factory default security code is 1 2 3 and can be used if desired; however, we recommend selecting your own security code. If you do not wish to change the security code, you can skip the following procedure and continue to "Time-Out Duration" section.

Step 1 –While pressing the PTT switch on the hand-held radio, press the radio keys in the sequence shown in **Figure 3.**

Step 2 –Release the PTT switch and listen for the response tone. A dit-dit-dit response tone indicates that the entry was accepted.

A **dit-dah-dit-dah** response tone indicates that the entry was not accepted and must be tried again.

Figure 3

Select Security Code						
Operation	Begin	Command Code	Current Security Code (Three Digits) Default Code = 123	New Security Code (Three Digits)	New Security Code (Three Digits) Confirmation	End
Select Security Code	* 8	9 9	X X X	X X X	X X X	#

Example: Set security code to 444						
	* 8	9 9	1 2 3	4 4 4	4 4 4	#

Note: ***The above procedure is typical of the way all commands are entered on the hand-held radio keypad. The correct sequence and number of keys pressed is essential for successful operation. A response tone will always be generated after the key sequence to indicate an acceptable or unacceptable command entry.***

Time-Out Duration

The HHRI unit can be taken off-line manually or automatically and placed in a "sleep mode" when not in use. A time-out duration can be set which enables the HHRI unit to remain awake indefinitely or for a period of time from 15 to 255 minutes before automatically returning to the "sleep mode."

The time-out period starts as soon as the wake-up command has been responded to. One minute prior to returning to the "sleep mode", a warning response tone (dit-dit-dit-dit-dit) will be automatically sent letting you know the remote system is about to go off line. You will also hear this response tone whenever an operation command is issued with one minute or less remaining in the time-out period.

Step 1 –While pressing the PTT switch on the hand-held radio, press the radio keys in the sequence shown in Figure 4.

Step 2 –Release the PTT switch and listen for the response tone. A dit-dit-dit response tone indicates that the entry was accepted. A dit-dah-dit-dah response tone indicates that the entry was not accepted and must be tried again.

Note: ***To keep the HHRI unit on line indefinitely, enter 000 for the time-out duration.***

Figure 4

Time-Out Duration

Operation	Begin	Command Code	Security Code (Three Digits)	Time-out Duration (Three Digits: 015–255 Minutes 000 = No Time Out)	End
Set Time-Out Duration	✱ 8	9 2	X X X	X X X	#

Example: Set time-out to 60 Minutes using the default Security Code.

	✱ 8	9 2	1 2 3	0 6 0	#

3.1.4 Weather Station Interface

Lynx includes software to communicate with the weather station. No special set up is required for the Toro GDC System.

3.1.5 Pump Station Interface

The pump station interface and it's installation manual will be provided by the pump station manufacturer. **Please consult the materials they provide to ensure proper installation.**

3.1.6 PC/Gateway

The gateway should be installed on a vertical wall or other sturdy structure near a grounded power source. If the gateway is being installed outdoors, select a location that shades it during the hottest hours of the day and provides as much protection from direct sunlight, rain, wind and snow as possible. DO NOT mount the gateway where it is exposed to direct spray from the irrigation system.

If installing a stand-alone gateway, for easy operation and better view of the display, install the gateway so that the display is at or slightly below eye level.

Step 1 –Drill two pilot holes 6" (16.25cm)apart for the top keyholes of the gateway cabinet.

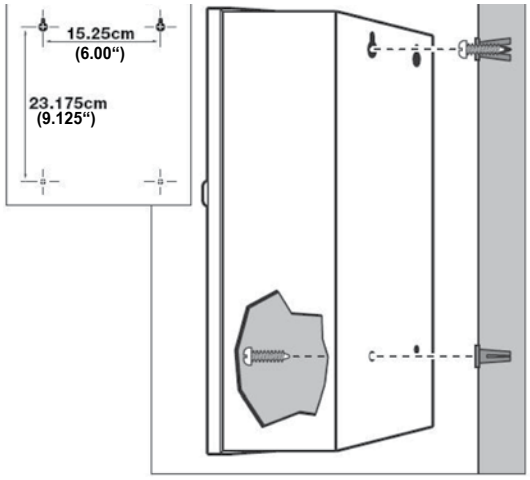
Step 2 –Install the top screws leaving approximately ¼" (5-6cm) of exposed screw to accommodate the cabinet.

Note: ***If mounting the cabinet on dry wall or masonry, install the appropriate type of screw anchors or fasteners to ensure secure installation.***

Step 3 –Hang the cabinet using the top keyhole slots (See **Figure 5**).

Step 4 –Open the cabinet door and install the bottom two screws to secure the cabinet.

Figure 5



3.1.7 Power and Grounding

WARNING! AC POWER WIRING MUST BE INSTALLED AND CONNECTED BY QUALIFIED PERSONNEL ONLY.

ALL ELECTRICAL COMPONENTS AND INSTALLATION PROCEDURES MUST COMPLY WITH ALL APPLICABLE LOCAL AND NATIONAL ELECTRICAL CODES. SOME CODES MAY REQUIRE A MEANS OF DISCONNECTION FROM THE AC POWER SOURCE, INSTALLED IN THE FIXED WIRING, HAVING A CONTACT SEPARATION OF AT LEAST 3mm IN THE LINE AND NEUTRAL POLES.

ENSURE THE AC POWER SOURCE IS OFF PRIOR TO SERVICING. FAILURE TO COMPLY MAY RESULT IN SERIOUS INJURY DUE TO ELECTRICAL SHOCK HAZARD.

Step 1 –Turn off the power to the power source location and place the gateway's power switch to OFF. Connect and route the appropriate size three-conductor cable (10 AWG [2.5 mm2] maximum) from the power source to the gateway cabinet. The provided power cable access hole can accommodate a 1" (25.4mm) conduit fitting. If conduit is required, install a section of flexible 1" (25mm) electrical conduit from the power source conduit box to the cabinet's access hole.

Step 2 –Open the cabinet door and remove the two retaining screws from the power supply cover.

Step 3 –Strip the power cables and secure them to the terminal block. Reference **Table 1** for the appropriate type of power connection.

Step 4 –Reinstall the power supply cover.

Step 5 –Apply power to the controller.

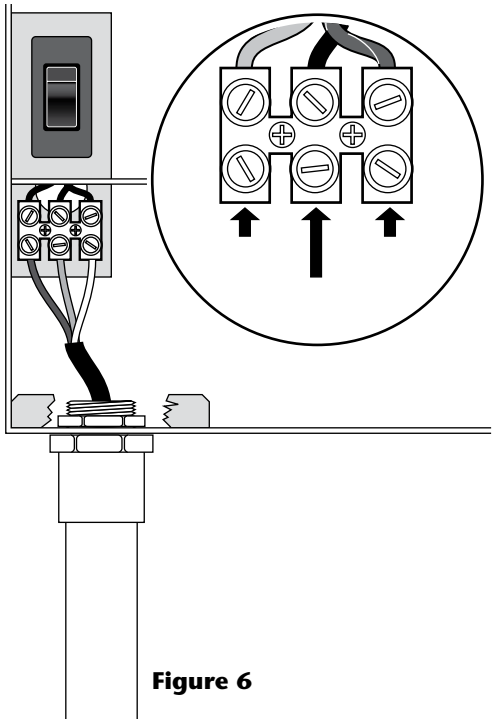


Figure 6

Table 1			
AC Service Type	**Line**	**Equipment Ground**	**Neutral**
100 – 120 VAC (U.S.)	Hot (Black)	Green	Neutral (White)
200 – 240 VAC (3-Phase)	Hot (Black)	Green / Yellow	Hot (Blue or Red)
200 – 240 VAC (International)	Hot (Brown)	Green / Yellow	Neutral (Blue)

Now that the gateway power supply is connected, we'll need to make sure it's properly grounded.

⚠ IMPORTANT! The gateway surge protection components cannot properly function unless an efficient pathway to earth ground is provided. The ground path must be as direct as possible, without sharp bends and must not exceed 30 Ohm resistance (when measured with an earth ground resistance device). All electrical components throughout the irrigation system should be grounded in a manner which provides the same ground potential.

The following instructions depict one of several acceptable earth grounding methods. Due to variables in soil composition and terrain, the method shown may not be suitable for your installation site. Contact your local Toro distributor for assistance and availability of the required earth ground resistance test instrument.

Step 1 –Drive a 5/8 inch x 8 feet (17mm x 2.4m) copper-clad steel rod into well moistened soil not less than 8 feet (2.5m) or not more than 12 feet (3.7m) from the gateway cabinet. The top of the ground rod should be 12" (30.5cm) below grade level (See Figure 7).

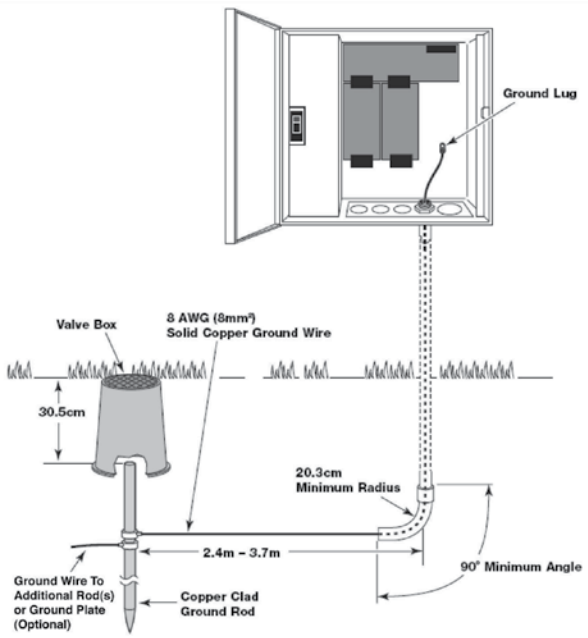
Step 2 –Using a 5/8 inch (17mm) clamp or **Cadweld® fastener**, attach an 8 AWG (8mm^2) solid copper wire near the top of the ground rod. Avoiding wire bends of less than 8 inches (20.3cm) radius and more than 90°, route the wire through conduit and into the cabinet. Secure the wire to the copper ground lug.

Note: ***Make sure the soil surrounding the ground rod(s) remains well moistened at all times. The addition of some form of irrigation may be required if the cabinet is installed in a non-irrigated location.***

Step 3 –Measure the ground resistance per the instructions provided with the ground test instrument. A reading of 0.0 Ohm is optimum, up to 10 Ohm is good and 11–30 Ohm is acceptable in most cases. If the resistance exceeds the acceptable limit, additional ground rod(s) can be installed at a distance equal to twice the buried depth of the first rod; i.e., 16 feet (4.9m). Interconnect the ground rods using 8 AWG (8mm^2) solid copper wire and test again. If the measured ground resistance continues to read above the acceptable limit, contact your local Toro distributor for further assistance and recommendations.

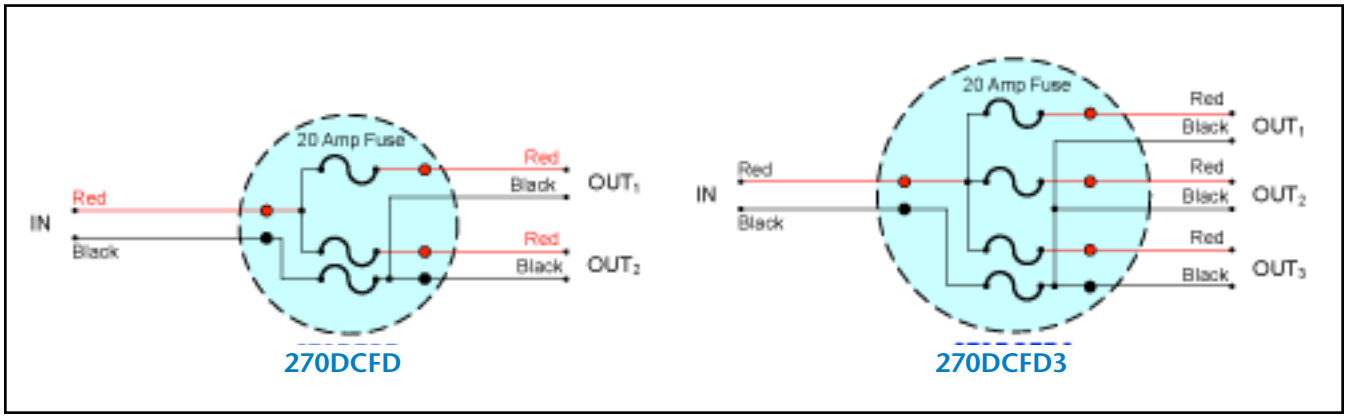
Note: ***Installing a round valve box over the ground rod enables the ground rod to be easily located as well as providing access to the ground wire connection(s).***

Figure 7



3.2 Optional Wire Path Isolation Devices

The Quick-Disconnect Splitter splits the incoming signal from the central computer into two or three directions. See wiring schematics below. By removing a fuse, the decoder cables can be disconnected in order to isolate sections of the system while troubleshooting. There's no need to cut and re-splice wires.



The Paige electric DCFD (Part# 270DCFD for 2-way split and 270DCFD3 for 3-way split) should be installed at strategic locations of a 2-wire system such that it can isolate certain sections of cables for purposes of troubleshooting. It should be installed inside an irrigation valve box as per installation detail in **Figure 8**. The splices for all connections should be made using a 3M model DBR/Y.

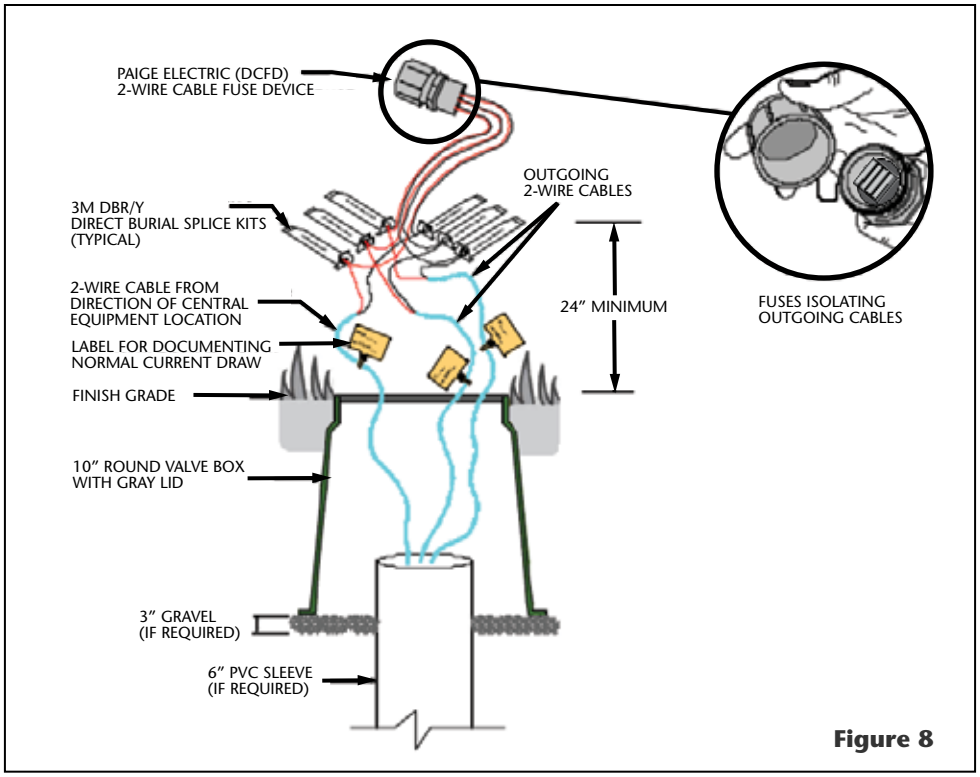


Figure 8

It is advisable to install DCFD's in strategic locations where the two-wire paths split (see **Figure 9**). It also helps to install them half way along very long cable paths. For herringbone designs, install one DCFD per hole. By doing so, cable sections can be connected and disconnected by removing a fuse. At all splice locations, provide sufficient slack to allow the splice to be raised a minimum of 24" (60cm) above grade (the communication path wiring should be buried at least 20 inches (50cm) below grade)

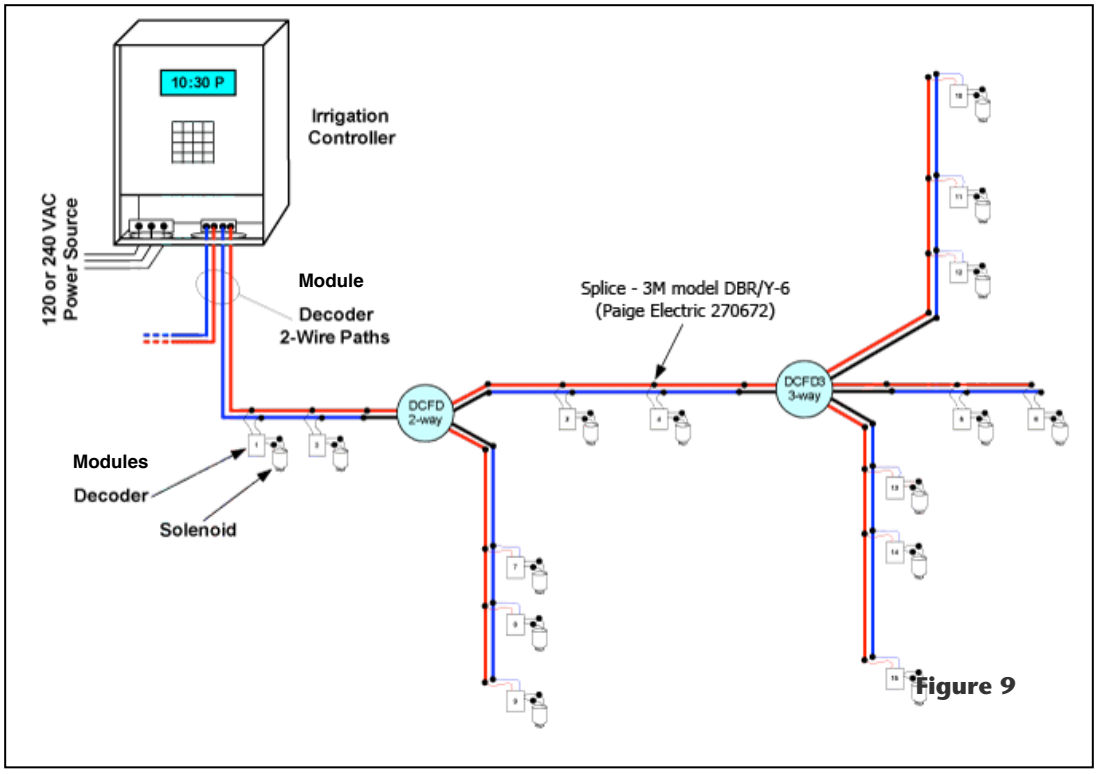


Figure 9

Clearly mark on the tag where the supply cable originates (e.g., from 8th hole) and each outgoing cable goes to (e.g., to 10th green) in an outward bound direction from the central equipment location. Clearly mark the milliamp draw for each leg of cable based on the number of modules "downstream" from that point.

4 System Wiring

There are two basic wire types in a 2-wire system; the communication wire, which runs from the gateway to the modules in the field, and the station wire (also referred to as the station output wire), which runs from the module to the solenoid.

4.1 Communication Wire

GDC communication is based around the use of two-core PE insulated solid conductor cable run in **spur or branch** configuration throughout. The communication wire can be no longer than 2.6 miles (14 AWG) or 4.2Km (2.1 mm^2) running from the gateway to the module.

4.1.1 Specification

Two-core 2.1mm^2 or 14 AWG, Solid copper conductor, Polyethylene (PE) insulated.
Color code – Outer sheath: Red, Red/Black, Red/Yellow, Red/Green
Inner sheaths: White, Black

Approved Cables:
Toro 14 AWG cable

Please see Section 6 for approved specification sheets

4.2 Configuration and Placement

4.2.1 Cable Installation

Recommended cable depths are as follows -

- Communications/Mains Cable 20" (500mm) cover
- Sprinkler/lateral cable 16" (400mm) cover
- DEC-SG-LINE earth cable 16" (400mm) cover

Burial Depth

Toro recommends that the Controller-to-Module and Module-to-Solenoid cables should have a minimum cover of 6" (150mm). The irrigation plan may specify additional depth to be consistent with the depth of mainline or lateral pipe work and/or soil conditioning procedures suche as aeration. Installation procedures must comply with all applicable local and national electrical codes.

Cable slack

Wherever the cable is installed it should be done so leaving sufficient slack to prevent damage to either the conductors, the insulation or any terminations or joints.

Cable testing

Cable testing should be carried out to ensure the cable has not become damaged due to storage, handling or installation. The following tests may be carried out –

Continuity test

Toro Cable - Max 2.525 Ω @ 20º per 1000 feet (305m) or 8.2 ohms per 3,281 feet (1,000m)

Insulation Resistance & Earth Leakage Resistance -

Insulation and Earth Leakage Resistance are measurements which determine whether the cable insulation had been damaged during storage or installation – either conductor to conductor (insulation resistance) or conductor to earth (earth leakage resistance).

Both of these tests involve a voltage being 'injected' into the conductors and the measurement of resistance (should be a high value or infinity) should hold for a number of seconds. If the insulation is damaged either between conductors or between conductors and earth, then the resistance reading will fall rapidly away.

Toro recommends 1 MegOhm per 1000 feet (300m) @ 250 volts – test time 1 minute, use Megger MIT200 or equivalent.

Cable should be tested in defined sections and lengths, and all test readings should be recorded on the as-built drawing.

Modules must be disconnected during this test. Failure to disconnect may result in damage to the modules and will cause the test to fail.

Cable joints

It is inevitable during installation that there will be a need for cable joints in the field at a place other than a designated valve box position. Cable joints on the communication cable are acceptable providing they use the recommended jointing method (stated below), and that the joint is housed in a suitable box. The cable and joint should be tested for integrity (as described above). The joint position should be marked on the electrical as-built drawing.

Mains Power Interference

Toro recommends that all communication cables be kept separate from runs of mains power cabling.

Power cables which have a higher voltage than communication/mains control cabling will induce a voltage into that communication line through transformer effect. This will be detrimental to the decoder communications & reliability.

All cables must be separated from high voltage power lines by at least 12" (30cm) per these guidelines:

Power cable circuit rating(max KVA*)	Recommended minimum spacing**
0 – 5 KVA	12 inches (30 cm)
5 - 10 KVA	24 inches (60 cm)
10 – 20 KVA	48 inches (120 cm)
> 20 KVA	10 feet (3 m)

* Maximum Voltage x Current ratings of circuit.

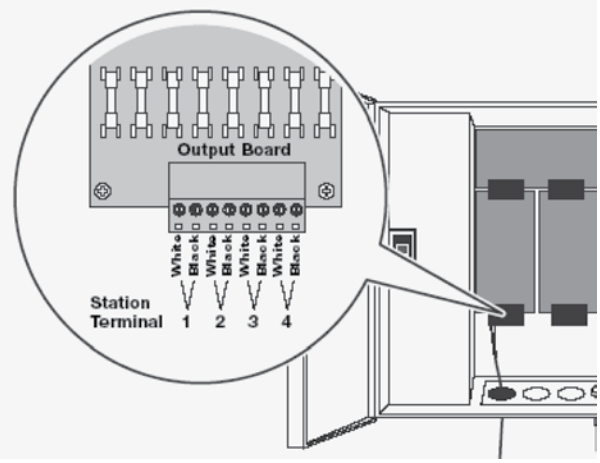
** These are minimum spacing recommendations to minimize noise coupling. There may be greater separation required by safety agencies or local codes.

Communication cables should be routed away from potential building and road construction as much as possible. Toro recommends that comms cables are routed in plastic ducting 0.08 to 0.12 inches (2 to 3mm wall thickness) in areas with ongoing construction expected in order to prevent stretching, crushing or cuts to the cables.

4.2.2 Gateway Output - Field Wiring Details

Gateway Connections

A single GDC Gateway has a 1600 Station Capacity provided from 2 output boards.
Output board 1 - 800 Station Capacity, 4 pairs connection terminals, **1/1, 1/2, 1/3, 1/4**
Output board 2 - 800 Station Capacity, 4 pairs connection terminals, **2/1, 2/2, 2/3, 2/4**



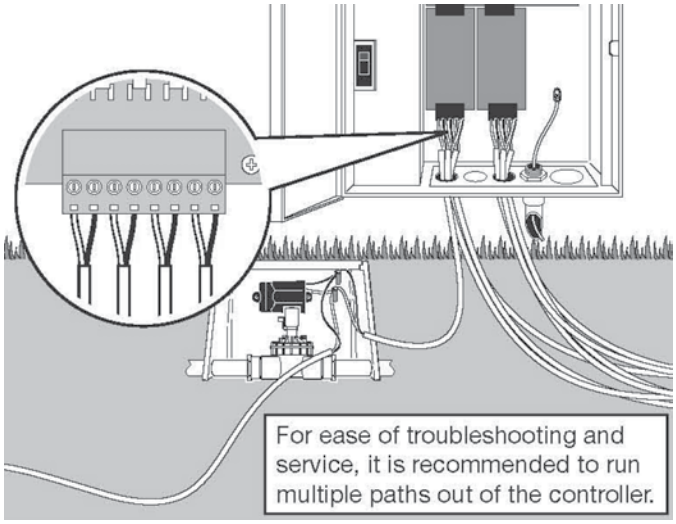
Maximum 250 modules per wire path, 500 per output board, 1000 per gateway.

Maximum 800 stations per wire path, 800 per output board, 1600 per gateway.

All 800 stations may be run off a single wire path, however Toro recommends as a guideline where practical that stations be distributed evenly over the available cable paths.

For Example - 1/1 (max 250 modules), 1/2 (max 250 modules), Output Board 1 max 800 stations.
2/1 (max 250 modules), 2/2 (max 250 modules), Output Board 2 max 800 stations.

Distributing a number of cable paths off each output board will promote system integrity and assist in any future trouble shooting and servicing.



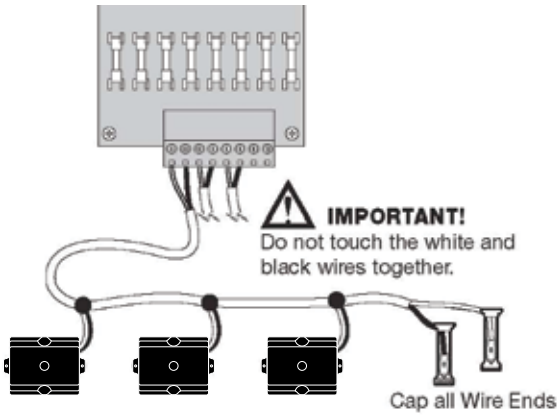
Care should be taken not to place strain on the Output board connection terminals, Toro recommends that the communication cables are supported where they run up the wall to enter the GDC cabinet by cable tray or similar. In addition, the cables should be glanded into the unit, unused cut-outs should be blanked or sealed.

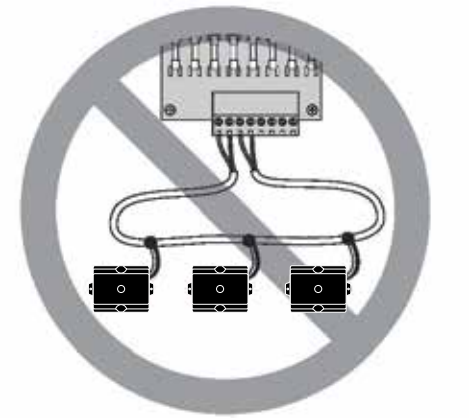
Communication Cable Layout & Connections.

GDC field cable architecture requires that all communication & solenoid cable runs are **SPURS.**

In conventional AC systems it has been common industry practice to loop the field circuits to help mitigate voltage drop. **It is critical that this does not happen on GDC systems.** Every cable run is a spur – **NO RINGS or LOOPS.**

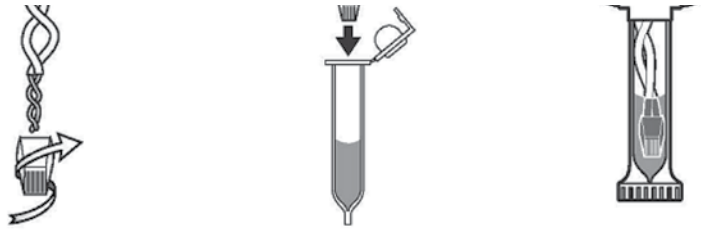
The Gateway output board terminals are marked **White** and **Black.** It is critical that this polarity is maintained between the Gateway and the module. The module communication connection cables are marked **White** and **Black.**





Communication & Lateral Cable Jointing.

The output of the Gateway is 40 VAC, therefore it is essential that the appropriate method of cable jointing is selected to comply with local electrical codes. Toro recommends the use of Scotch 3M® DBR/Y .



Waterproof all communication cable splices using DBR/Y by 3M®. If using another waterproofing method, verify that it is rated at 40VDC minimum

White and Black communication lines should not be mixed in either the same wire nut or in the same grease filled shroud.

Toro recommends that should it prove necessary to break open a DB cable joint for any form of troubleshooting or maintenance, then the grease filled shroud or pod should either be re-filled with a 3M approved grease, or be replaced.

Communication Cable – Surge Protection.

The ISP modules have surge protection built into the circuitry of the module, however, like other module installations it is necessary to install surge protection on the line or communication side of the system.

The surge protection module is Toro DEC-SG-LINE, these are recommended to be fitted in accordance with the separate wiring diagram. As a guideline, depending on mainline routing, Toro recommends approximately 36 DEC-SG-LINE per 18 holes.

All ISP modules are to be within 500 feet or 150m (cable distance) of a DEC-SG-LINE surge arrestor.

Grounding Communication Cable

The lightning arrester (Toro P/N DEC-SG-LINE) is required to protect the decoder module from lightning. Without lightning arresters, the modules are vulnerable to lightning damage. In order for these arresters to discharge lightning energy efficiently, they must be properly grounded. Figure 5 illustrates the proper grounding and wiring of the arrester.

Step 1 –Locate module's power/communication wires (black and white wires).

Step 2 –Strip the insulation from lightning arrester's white wire and connect it to the white wires from the module and controller-to-module cable. Use 3M DBR/Y or similar products to properly water-proof all wire connections. (See Figure 5.)

Step 3 –Strip the insulation from lightning arrester's black wire and connect it to the black wires from the module and controller-to-module cable. Use 3M DBR/Y to properly water-proof all wire connections. (See Figure 5.)

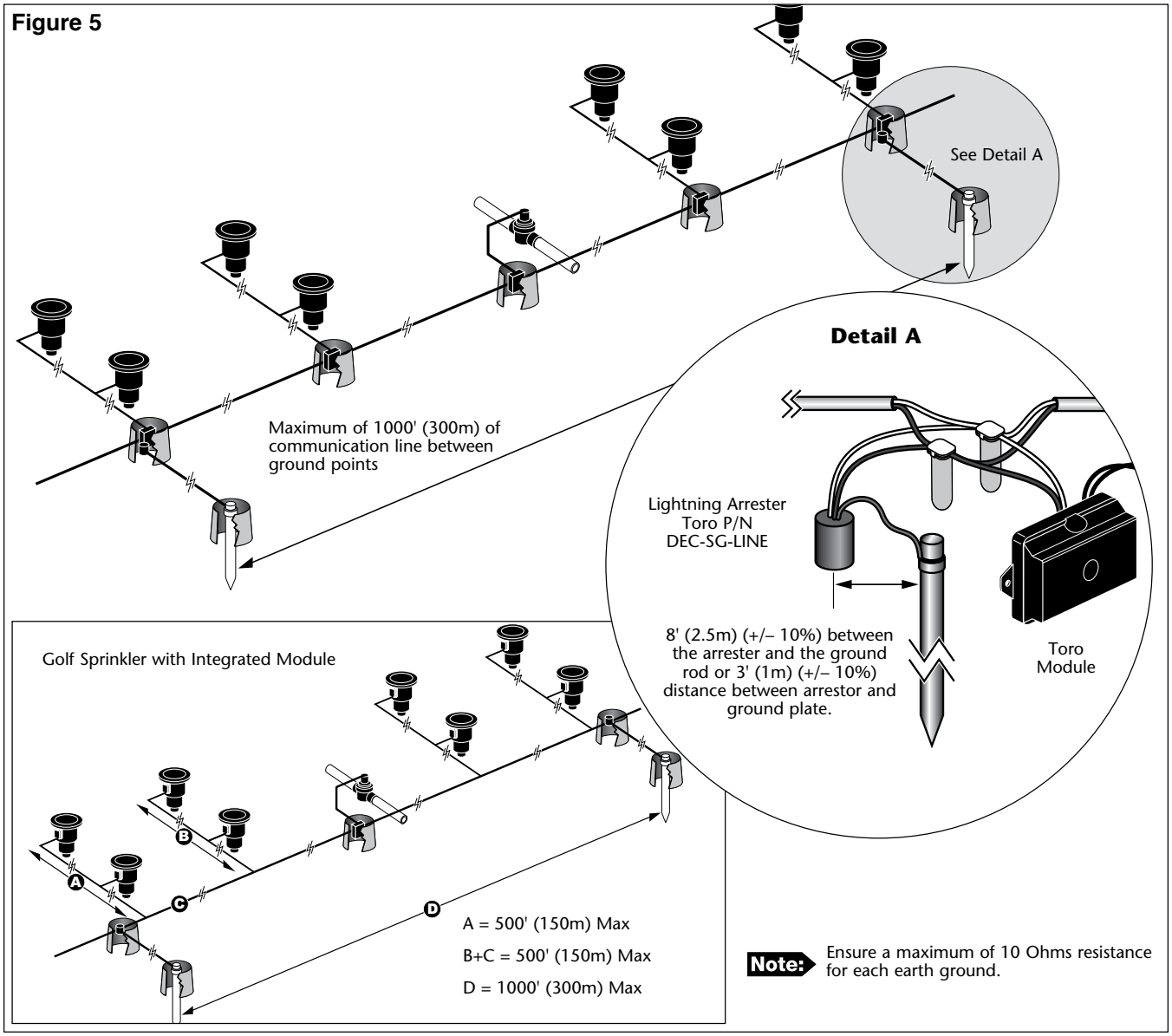
Step 4 –Connect the lightning arrester's ground wire to the ground rod or plate's wire. If the ground rod or plate is not pre-wired, use a 10 AWG bare copper wire. (See Figure 5.)

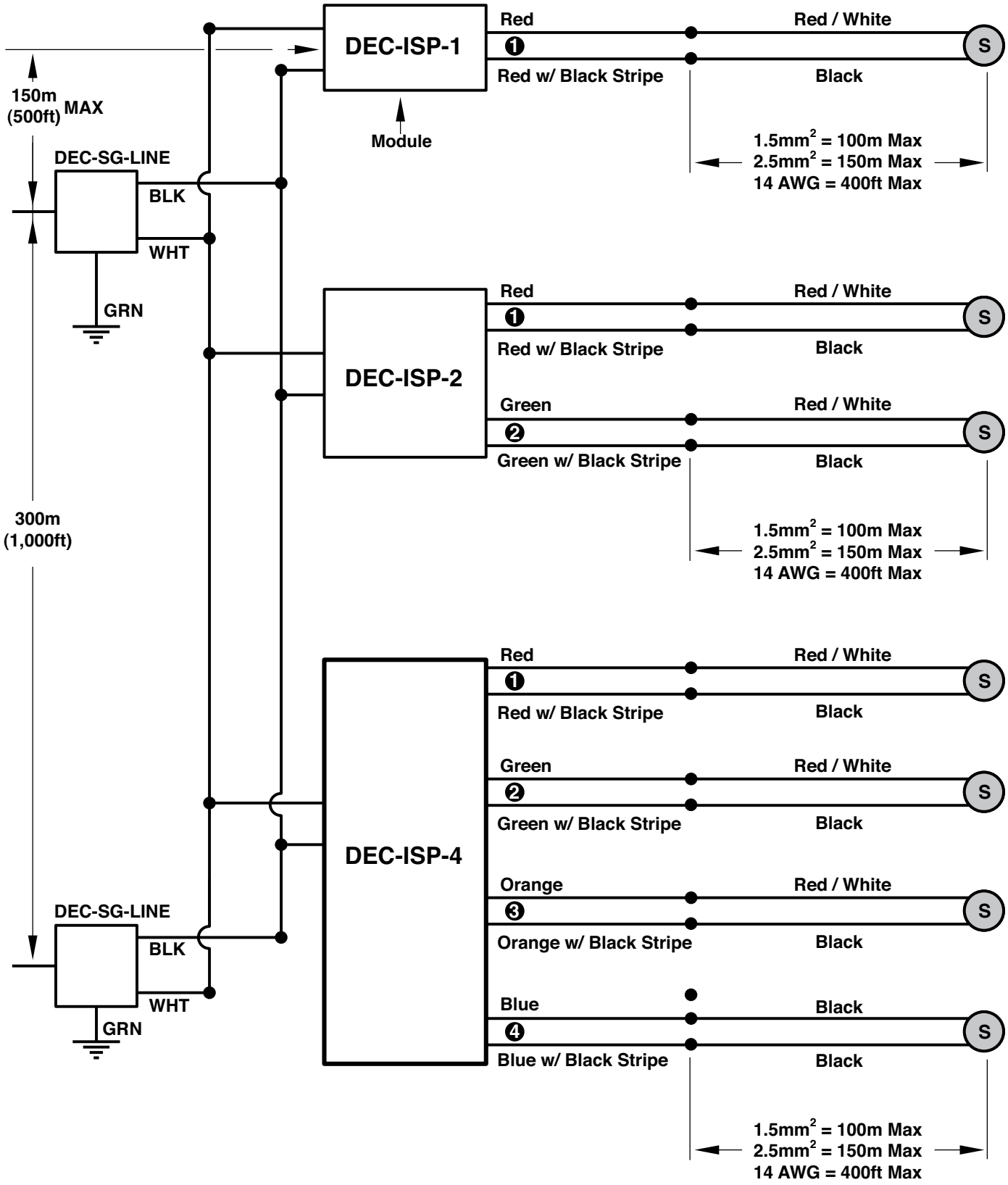
⚠ IMPORTANT! If using a ground rod, verify that the straight line distance between the lightning arrester/modules and the ground rod is 8' (2.5m) +/– 10%. If using a 3' (1m) ground plate, the straight line distance should be 3' (1m) +/– 10%.

Step 5 –If necessary, use ground enhancement material (GEM) to attain a resistance of 10 Ohms or less.

Step 6 –Check the system for proper operation.

Figure 5




DEC-ISP-1
Module
Red
❶
Red w/ Black Stripe
Red / White
Black
S
1.5mm² = 100m Max
2.5mm² = 150m Max
14 AWG = 400ft Max
150m
(500ft) MAX
DEC-SG-LINE
BLK
WHT
GRN
DEC-ISP-2
Red
❶
Red w/ Black Stripe
Red / White
Black
S
Green
❷
Green w/ Black Stripe
Red / White
Black
S
1.5mm² = 100m Max
2.5mm² = 150m Max
14 AWG = 400ft Max
300m
(1,000ft)
DEC-ISP-4
Red
❶
Red w/ Black Stripe
Red / White
Black
S
Green
❷
Green w/ Black Stripe
Red / White
Black
S
Orange
❸
Orange w/ Black Stripe
Red / White
Black
S
Blue
❹
Blue w/ Black Stripe
Black
Black
S
DEC-SG-LINE
BLK
WHT
GRN
1.5mm² = 100m Max
2.5mm² = 150m Max
14 AWG = 400ft Max

Measure the earth resistance per the instructions provided with the earth test instrument. A reading of 0.0 Ohm is optimum, up to 10 Ohm is good and 11-30 Ohm is acceptable in most cases. If resistance exceeds the acceptable limit, additional earth rod(s) can be installed at a distance equal to twice the buried depth of the first rod; i.e., 16 feet (4.9m). Interconnect the earth rods using 8AWG (8mm$^{2)}$ solid copper wire and test again.

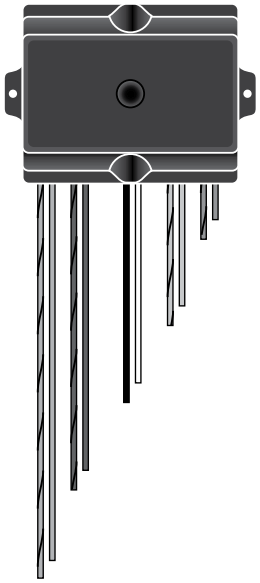
If the 16 feet (4.9m) ground rod resistance is greater than 30 ohms, use a 4 x 40 inch (10cm x 100cm) copper clad grounding plate, buried 3 feet (1m) from the surge arrestor, 2-4 feet (70-100cm) deep. Even if the ground resistance of the installed plate is greater than 30 ohms, it will provide better lightning protection than very long ground rods.

Earthing positions should be recorded on the as-built electrical drawing, along with dated resistance readings recorded.

Communication Cable Polarity

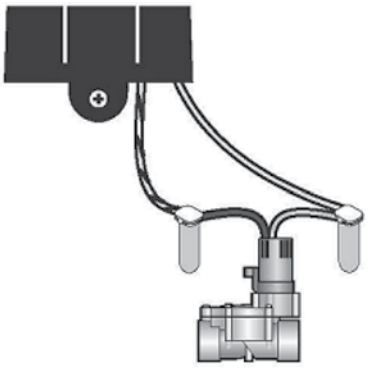
GDC will not work correctly unless the communication/mains cable polarity is maintained throughout the installation.

The Gateway output board terminals are marked **White** and Black. It is critical that this polarity is maintained between the Gateway and the module. The module communication connection cables are marked **White** and Black.



Sprinkler/Lateral Cable Polarity.

GDC will not work correctly unless the sprinkler/lateral cable polarity is maintained throughout the installation.



All module to solenoid wires must be connected with the correct polarity to properly operate the solenoid.

The module's SOLID output wire is connected to the RED solenoid wire.
The module's output wire with BLACK STRIPE is connected to the BLACK solenoid wire.

A single GDC station will operate up to two Valve-in-Head solenoids, or two P220 valve solenoids.

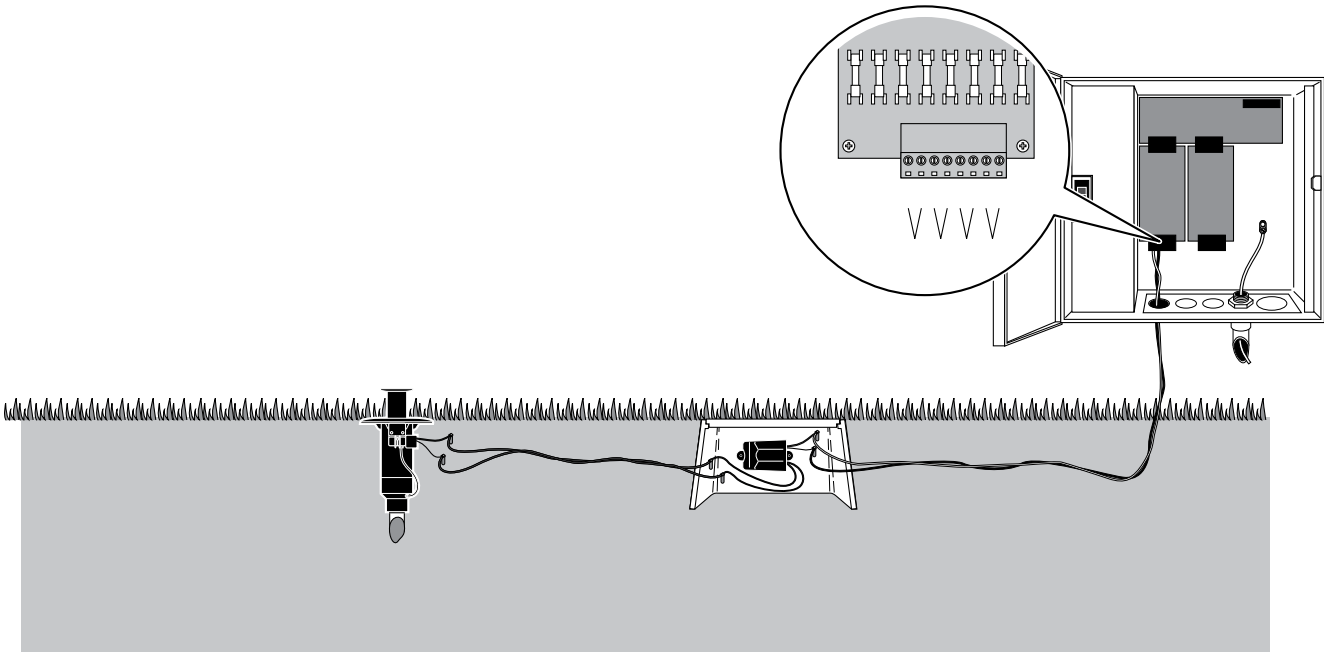
GDC 2-wire Output Polarity Details

Station/Output 1.
Solid Red Station Wire – Connects to Red/White solenoid wire.
Red with Black Stripe Station Wire – Connects to Black Solenoid Wire.

Station/Output 2.
Solid Green Station Wire – Connects to Red/White solenoid wire.
Green with Black Stripe Station Wire – Connects to Black Solenoid Wire.

Station/Output 3.
Solid Orange Station Wire – Connects to Red/White solenoid wire.
Orange with Black Stripe Station Wire – Connects to Black Solenoid Wire.

Station/Output 4.
Solid Blue Station Wire – Connects to Red/White solenoid wire.
Blue with Black Stripe Station Wire – Connects to Black Solenoid Wire.

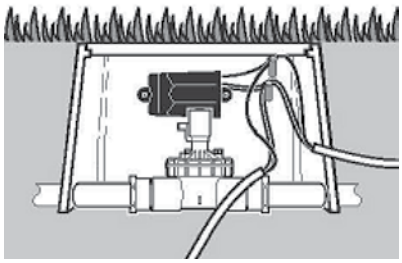


Module Installation - VIH Applications

Where modules are located with the VIH sprinkler head, Toro recommends that the module be secured to the sprinkler body by either plastic cable tie, or electricians tape. The module should be orientated so the wires point downwards, thus protecting the cables in the event of a head being excavated in the future.

Module Installation - COM/Block applications

Where a module is mounted in a valve box, Toro recommends that the module be secured to the box rim by a plastic cable tie or a self tapping stainless steel screw. There is a specifically designed lug on the module for this purpose.



Toro®GDC system operates with latching solenoids only. The following valves are approved to be used with Toro (model # DCLS-P) and Irritrol®(model # DCL) latching solenoids:

9 VDC
Latching Solenoid

Toro – EZF, P220 and 220 Brass Series
Irritrol – 2400/2600, 2500, 200B and 700

Toro 600, 700, DT and 800S sprinklers must have the selectable-pressure pilot valve with the **red** selector cam for proper operation.

Module to solenoid connections

GDC operates DC solenoids only – please ensure you have the correct sprinkler and valve specifications. GDC will not operate conventional AC solenoids.

VIH Sprinklers	Part Number
Solenoid	102-2709
Red Cam Pilot Valve	102-6533 (includes 102-2709)

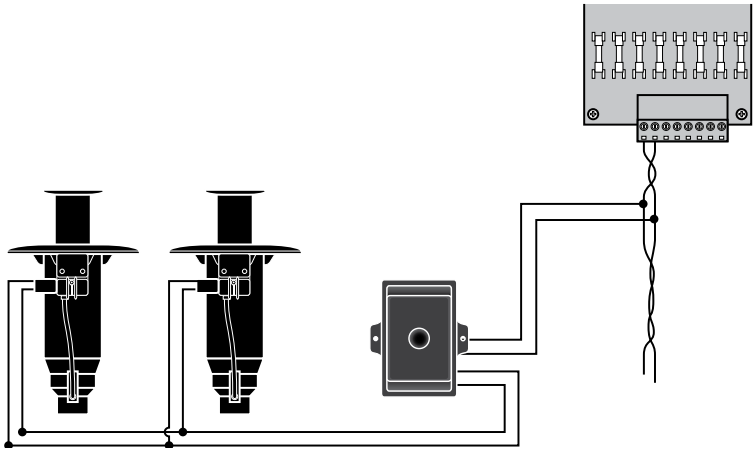
P-220 Valves	Part Number
Solenoid	DCLS-P (date code G08 on).
P220 Plunger	89-9562

IMPORTANT NOTE – Maximum pressure for the P220 with GDC is 150 psi (10 bar), maximum distance from the decoder to the valve is 300 ft (90m) (with 2.1mm^2 or 14 AWG cable). The decoder output voltage setting should be 20 volts for P220 valves.

4.2.2 Gateway Output - Field Wiring Details

Adding stations to a GDC system is simple – you can attach the module anywhere along the communication wire. Because voltage carried by the GDC communication cable exceeds 30 VAC, a high voltage splice is required by the National Electric Code. The 3M DBR/Y complies as they are rated at 600VAC. Communication cable wire connections require waterproof splices (the 3M DBR/Y connector kits comply here as well).

It is recommended that the module be located in a valve box to provide easy access to wire connections.



A few things to keep in mind:

- If one cable path is used for all module connections, the system is more vulnerable to the effects of cable cuts than if multiple wire paths are used for different areas.
- The integrity of the communication cable is critical to operation of the system. As it is being installed, before the modules are connected, loop the communication cable up out the valve box leaving a 3 ft (1m) loop.
- At the end of each wire path, the wire should be tested with a volt-ohm meter to check for damage that may have occurred during installation.

Making a proper splice:

When stripping the wire, strip roughly 6 inches (150mm) of the outer jacket of the cable (it may be easier to remove it in multiple sections). Take care not to pierce the inner insulation while removing the outer insulation.

Set the blade to the lowest position possible. Score the outside of the jacket, then very gently bend the cable back and forth to crack the jacket. Take great care not to break the inner insulation while doing this. Once you've cracked the outer insulation, it should easily pull off, and the colored insulated conductors should now be exposed. Using a wire stripper, remove roughly 5/8 inch (15mm) of the inner insulation from the two conductors (Make sure you use the correct gauge setting).

Using a linesman's pliers, twist together the matching colors of the two wires you are connecting (e.g. white wire to the other white wire and the black wire to the other black wire). No more than three to four twists should be made. Be sure to make the twist by winding the wires in a clockwise direction to prevent "un-twisting" when screwing on the wire nut (Figure 11). After the wires are twisted together, screw on the wire nut and push it as deep as you can into the DBR/Y connector. In order to avoid damage to the wire, make sure not to over tighten the wire nut.

Figure 11

4.3 Station Wire

If the sprinkler or valve is mounted remotely from the module, an approved cable must be used. The module to solenoid wiring should be sized for a maximum resistance of 2 ohms.

Wire Size	Meters	Feet
14 AWG (2.1mm^2)	122	400

4.3.1 Specification

2 Core, Solid copper conductor, Polyethylene (PE) insulated. Conductors must be marked in order to determine polarity.

Approved Cables:

Paige 7351D 14 AWG cable
Please see Section 6 for approved specification sheets

4.3.2 Configuration and Placement

You can have either one or two solenoids on a station wire. So a one station module can control up to two solenoids, a two station decoder can control up to four solenoids, and a four station module can control up to eight solenoids.

4.3.3 Solenoid Connections

Solenoid Connections

The wire colors are important for determining the station number and polarity on the module:

Station 1 = Red/Red-Black
Station 2 = Green/Green-Black
Station 3 = Orange/Orange-Black
Station 4 = Blue/Blue-Black

So for example, with a one station module, the red wire on the module must be connected to the red wire on the solenoid. The red/black striped wire is connected to the black solenoid lead. If a single station solenoid is used, it is recommended to be placed near the solenoid to reduce the potential for lightning damage on long runs of solenoid wiring back to the module .

Remember, wiring must maintain correct polarity for proper operation. If two solenoids are being used on the output wire, wiring must maintain correct polarity for both solenoids.

4.3.4 Splicing

Station output wire connections require waterproof splices, such as 3M DBR/Y connector kits. See Section 3.1.3. (Communication Wire Splices) for details on making a proper splice.

GDC System Product Guide

Section 4

Set Up Information

Toro® Lynx® GDC - Set Up Information

General Information

Course Name & Address: _____

_____

_____

_____

Postcode: _____

Owner / Representative: _____

Tel: _____

Email: _____

Superintendant: _____

Tel: _____

Email: _____

Architect: _____

Tel: _____

Email: _____

Consultant: _____

Tel: _____

Email: _____

Toro Distributor: _____

Contact: _____

Tel: _____

Email: _____

Contractor/Installer Information

Contractor Name & Address _____

_____

_____

_____

Postcode _____

Contractor Site Contact: _____

Tel: _____

Email: _____

Lynx® Set Up

Lynx is a sophisticated and powerful irrigation software operating system. For Lynx to operate correctly and to its specification, it needs to be configured with accurate and comprehensive design and as-laid field information.

The creation of the system database is involved, but once completed will give the Golf Course Superintendent the specified level of control over the irrigation system. Future changes in the database will only be required when something in the field changes.

The following information fields are those which are mandatory for the correct setting to work of the Lynx Central.

System Design Parameters

Areas to be irrigated & application rates

Greens		**in/wk**		**in/wk**
Surrounds		**in/wk**		**in/wk**
Approaches		**in/wk**		**in/wk**
Tees		**in/wk**		**in/wk**
Fairways		**in/wk**		**in/wk**
Rough		**in/wk**		**in/wk**
Walkways		**in/wk**		**in/wk**
Bunkers		**in/wk**		**in/wk**
Drip		**in/wk**		**in/wk**
Landscape		**in/wk**		**in/wk**
		in/wk		**in/wk**
		in/wk		**in/wk**

Watering Window

Irrigation start time		
Irrigation finish time		
Total available time		**minutes**

Pump Duty & Capacity

Pump 1		**GPM @**		**PSI/head**
Pump 2		**GPM @**		**PSI/head**
Pump 3		**GPM @**		**PSI/head**
Pump 4		**GPM @**		**PSI/head**
Total		**GPM @**		

Pressure Regulation Settings

65psi (4.5 Bar), 80psi (5.5 Bar), 100psi (6.9 Bar)

VIH Sprinklers	
Solenoid Valves	

Central PC Details

Computer Serial No _____

Lynx® Software Version _____

Windows® Version _____

Central Location & comments _____

_____

_____

_____

Gateway & Hardware Details

Gateway Serial No. _____

Communication Cable Specification _____

_____

Gateway Output board 1 **cable path 1/1** stations used _____

Gateway Output board 1 **cable path 1/2** stations used _____

Gateway Output board 2 **cable path 2/1** stations used _____

Gateway Output board 2 **cable path 2/2** stations used _____

HHRI _____

Radio & Base Station type _____

Frequency _____

Weather Station _____

UPS & Power Supply _____

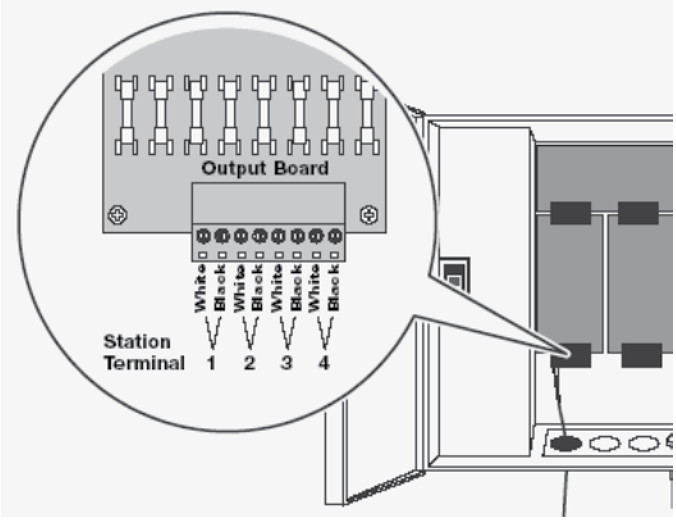
Screen _____

Printer _____

Gateway Wiring Detail.

Gateway Connections.
A single GDC Gateway has a 1600 Station Capacity provided from 2 output boards.
Output board 1 - 800 Station Capacity, 4 pairs connection terminals, **1/1, 1/2, 1/3, 1/4**
Output board 2 - 800 Station Capacity, 4 pairs connection terminals, **2/1, 2/2, 2/3, 2/4**

Toro recommends for standard installations that 4 cable paths are used, 1/1, 1/2 and 2/1, 2/2



Maximum 250 modules per wire path, 500 modules per output board, 1000 modules per gateway.

Maximum 400 stations per wire path, 800 stations per output board, 1600 stations per gateway.

For Example - 1/1 (max 250 modules), 1/2 (max 250 modules), Output Board 1 max 800 stations.
2/1 (max 250 modules), 2/2 (max 250 modules), Output Board 2 max 800 stations.

Distributing a number of cable paths off each output board will promote system integrity and assist in any future trouble shooting and servicing.

Possible station allocations are shown below -

Output Board 1.					Output Board 2.				
Cable Path No.	Method a).	Method b).	Method c).	Method d).	Cable Path No.	Method a).	Method b).	Method c).	Method d).
1/1	200	*300*	*400*	*800*	2/1	200	*300*	*400*	*800*
1/2	200	*300*	*200*	*0*	2/2	200	*300*	*200*	*0*
1/3	200	*100*	*100*	*0*	2/3	200	*100*	*100*	*0*
1/4	200	*100*	*100*	*0*	2/4	200	*100*	*100*	*0*
Total Stns.	800	*800*	*800*	*800*	Total Stns.	800	*800*	*800*	*800*

For future service and trouble-shooting, Toro recommends that full details are recorded to show what the overall configuration of modules is on the project, and that this information be recorded below.

Output Board 1.

Cable Path No.	Total Stations	Total Modules	1 Outlet Modules	2 Outlet Modules	4 Outlet Modules	Unused Outlets*
1/1						
1/2						

Output Board 2.

Cable Path No.	Total Stations	Total Modules	1 Outlet Modules	2 Outlet Modules	4 Outlet Modules	Unused Outlets*
2/1						
2/2						

Unused outlets refer to multi – outlet modules being installed where all stations are not being used.

Cable Path Information Sheets.

Please fully complete a set of cable path sheets for each path used (Separate sheets, example attached).

The information which is required is that which is installed in the golf course. The following as-installed information is required.

General	
Station Number	01
Decoder Address	91171
Decoder Output	01/04 (station 1 on a 4 way module)
Location (Head Position)	Front Left
Type Area	Green
Hole No	01

Heads	
No. Heads	01
Sprinkler Make & Type	835S
Nozzle	#34
Arc	180°
Single Sprinkler Flow-lpm	114
Formation Type Spacing	Square
Distance Heads/Laterals	74 feet/74 feet (22,6m/22,6m)

NSN Coverage – Important Note.

NSN coverage is deemed to commence when the system unlock codes are issued by NSN®.

NSN will only be able to support the customer correctly if the central PC has a suitable internet connection.

Should any deviation in NSN support be required by your client, then the distributor should contact NSN to agree what date deviations are required.

Lynx Set Up / Commissioning Check List.

To set up Lynx correctly, it must be configured with completely accurate information from the design and the field. Without this the hydraulic flow management will not work correctly.

Please find below the check list of information required to set up Lynx.

Item	Tick
As-built Hydraulic Drawing (can be hand sketched)	☐
As-built Electrical Drawing (can be hand sketched)	☐
Toro Lynx Set Up Information (completed)	☐
Toro Lynx Cable Path Information Sheets 1/1 (completed)	☐
Toro Lynx Cable Path Information Sheets 1/2 (completed)	☐
Toro Lynx Cable Path Information Sheets 2/1 (completed)	☐
Toro Lynx Cable Path Information Sheets 2/2 (completed)	☐

			General			*Heads*							
Stat No.	**Module Address**	**Dec Output**	**Location (Head Position).**	**Type. Area.**	**Hole No.**	**No. Heads**	**Sprinkler Make and Type**	**Nozzle**	**Arc**	**Single Sprinkler Flow-GPM**	**Formation Type Spacing.**	**Distance.**	
												Heads	**Lats.**
1	91171	1	Green 22 Front Left	Grn	22	1	835S-56	35	180	115	rectangle	19	17.5
2	93457	1	Green 22 Surr F/L	Surr	22	1	835S-56	35	180	115	rectangle	19	17.5
3	88859	1	Approach 16 Left	App	16	1	835S-56	35	360	115	square	19	19
4	92491	1	Tee 14 Middle	Tee	14	4	835B-52	31	180	49	square	12	12
5	91121	1	F/Way 17 1/24	Fway	17	1	835S-56	35	360	115	triangle	19	-
6	91775	1	Walkway 12 (Tee)	WW	12	6	835B-52	30 (plug)	180	33	in-line	9	9
7	94944	1	Rough 10 Left	Rgh	10	1	835s-56	35	360	115	triangle	18.5	-
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

Stat No.	Module Address	Dec Output	*General* Location (Head Position).	Type. Area.	Hole No.	*Heads* No. Heads	Sprinkler Make and Type	Nozzle	Arc	Single Sprinkler Flow-GPM	Formation Type Spacing.	Distance. Heads	Distance. Lats.
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

			General			*Heads*								
Stat No.	Module Address	Dec Output	Location (Head Position).	Type. Area.	Hole No.	No. Heads	Sprinkler Make and Type	Nozzle	Arc	Single Sprinkler Flow-GPM	Formation Type Spacing.	Distance. Heads	Distance. Lats.

Notes

GDC System Product Guide

Section 5

Troubleshooting

5 Troubleshooting

This section will cover the preventive maintenance and diagnostic tools available for troubleshooting the GDC system. In order to help prevent problems before they occur, Toro recommends the following preventative maintenance procedures:

- Check the ground connections every twelve months
- Clean the gateway cabinet/boards and check wire connections every six months
- Run the Lynx® diagnostic reports every week
- The Toro Field Service team recommends these tools for GDC System maintenance and hardware diagnostics.
- Progressive (Tempo) 521 Locator
- Progressive (Tempo) PE2003 Pulser Fault Locator
- Meterman AC50 Leakage Current Clamp Multimeter

5.1 Central Tests

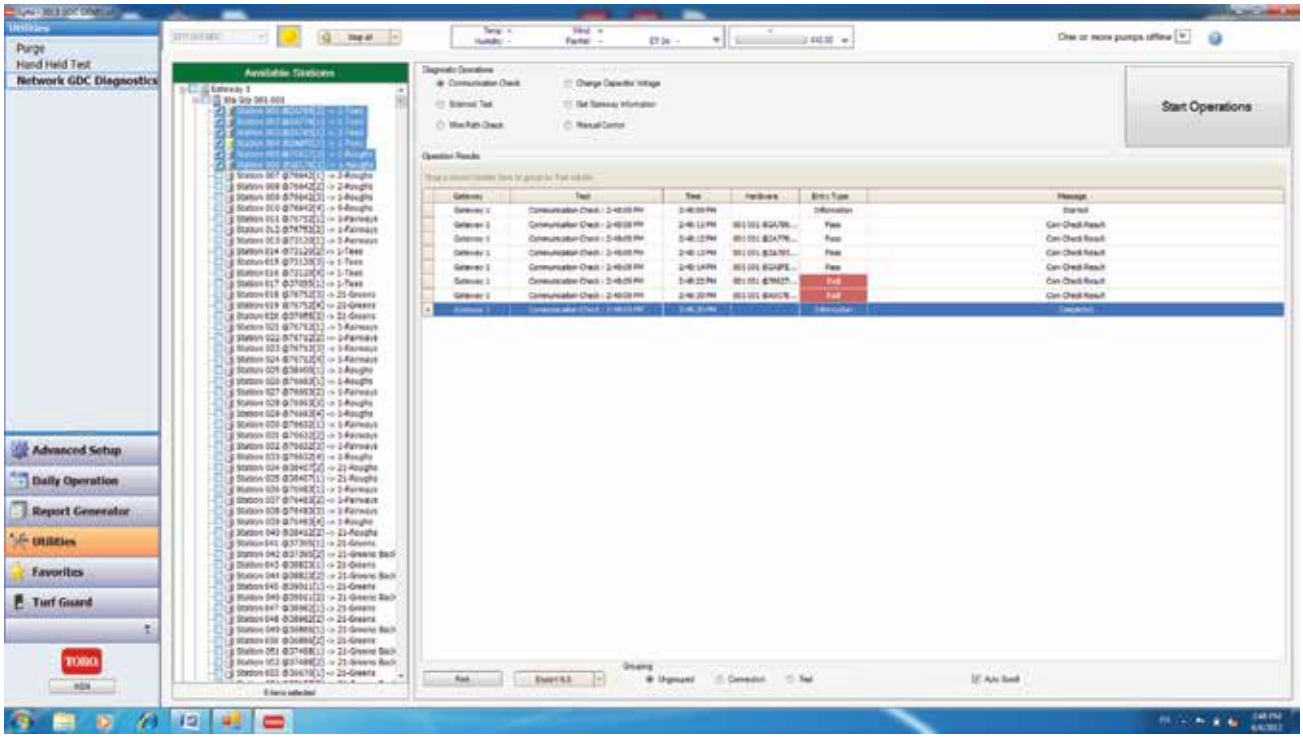
Before we run any diagnostic reports in Lynx, first make sure you check the following:

- Are the correct module addresses entered?
- Is the correct wire path assigned?
- For GDC 100/200, are there any alarms?
- Are the stations disabled?
    - If so, make sure they are enabled so that you can irrigate!
    - Quickest way is to reset disables within the System Settings Screen

5.1.1 Communication Test

If all of the above potential issues are okay, we can move on to review the tools that exist in Lynx® to assist you. In Lynx, the Network GDC Diagnostic Reports will assist you in decoder diagnosis. This report verifies communication with the gateway, communication to the modules and identifies short or open solenoids.

In the ***Utilities*** folder, clicking on the ***Network GDC Diagnostics panel*** will open the screen below. Select ***Communication Check*** and then select the gateway, station group and stations you want to test. To begin the test, click ***Start Operations*** at the top of the page.



The report will begin by identifying the start of the test. Each module serial number and hardware address are then displayed along with communication status Pass or Fail

When a communication error is detected, the communication status for that module will display [in red] “Fail”.

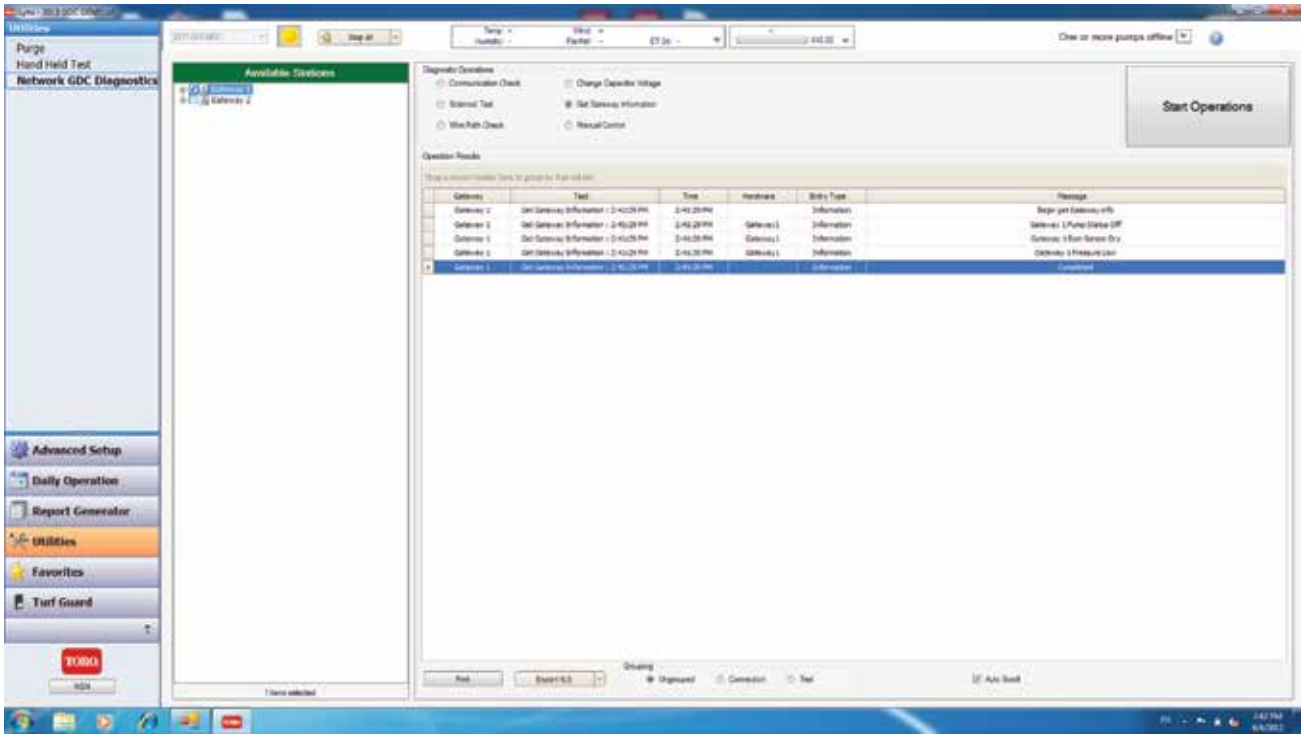
Click ***Print*** to print the reports as selected.

If the communication report displays multiple module communication failures, check the as-built drawings to determine if there is a logical pattern to the outage. If a communication wire is nicked or cut, all modules downstream of the break will experience a communication failure.

5.1.2 Gateway Information Test

You may also run a Get Gateway Information test, which will poll each gateway for the status.

In the ***Utilities*** folder, clicking on the ***Network GDC Diagnostics panel*** will open the screen below. Select ***Get Gateway Information*** and then select the gateway you want to test. To begin the test, click ***Start Operations*** at the top of the page.



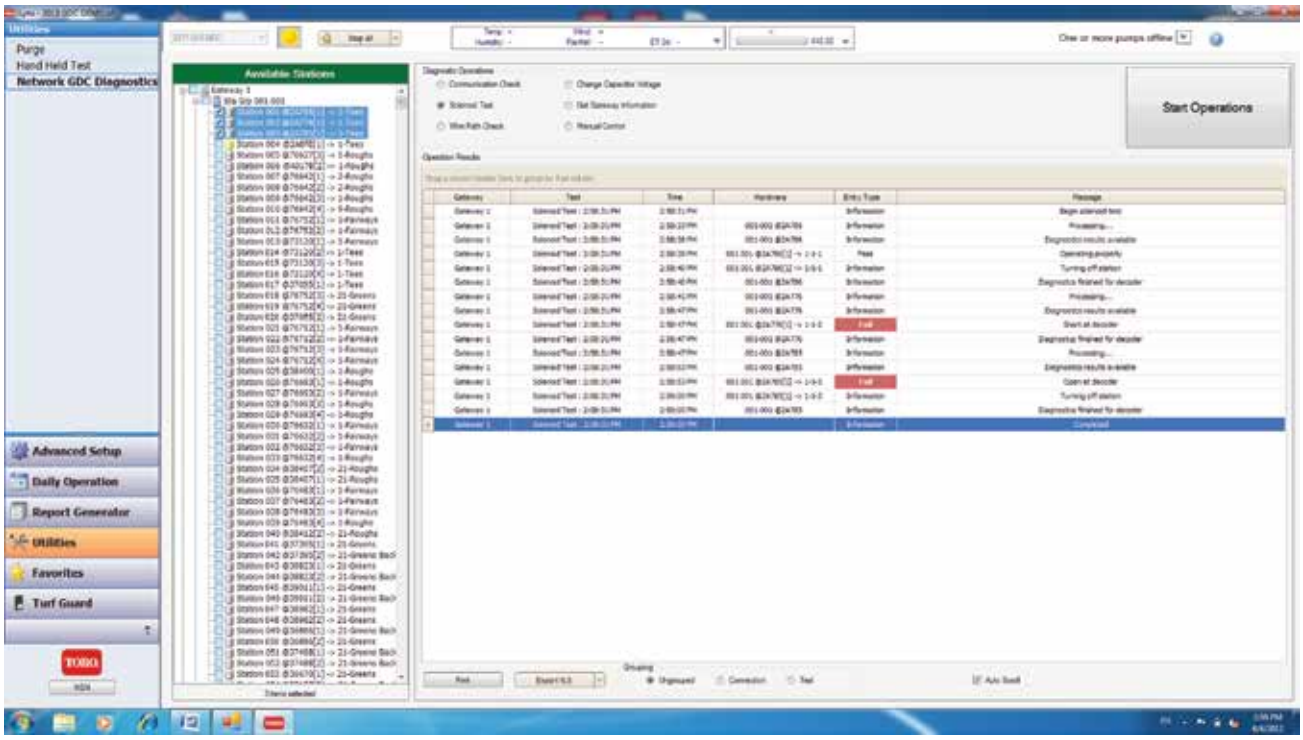
Here's what each of the information messages mean:

Pump Status	*Displays the state of the gateway pump output relay, On or Off.*
Rain Switch Status	*Displays the state of the rain switch input of each gateway, that is connected to the system. The Rain Switch will note whether it is Dry or Wet.*
Pump Pressure Status	*Notes whether the pump pressure is Low or High.*

Click ***Print*** to print the reports as selected.

5.1.3 Solenoid Test

The next report is the Solenoid Test. This will check the status of the solenoids. In the ***Utilities*** folder, clicking on the ***Network GDC Diagnostics panel*** will open the screen below. Select ***Solenoid Test*** and then select the gateway, station group and stations you want to test. To begin the test, click ***Start Operations*** at the top of the page.



The potential test results are:

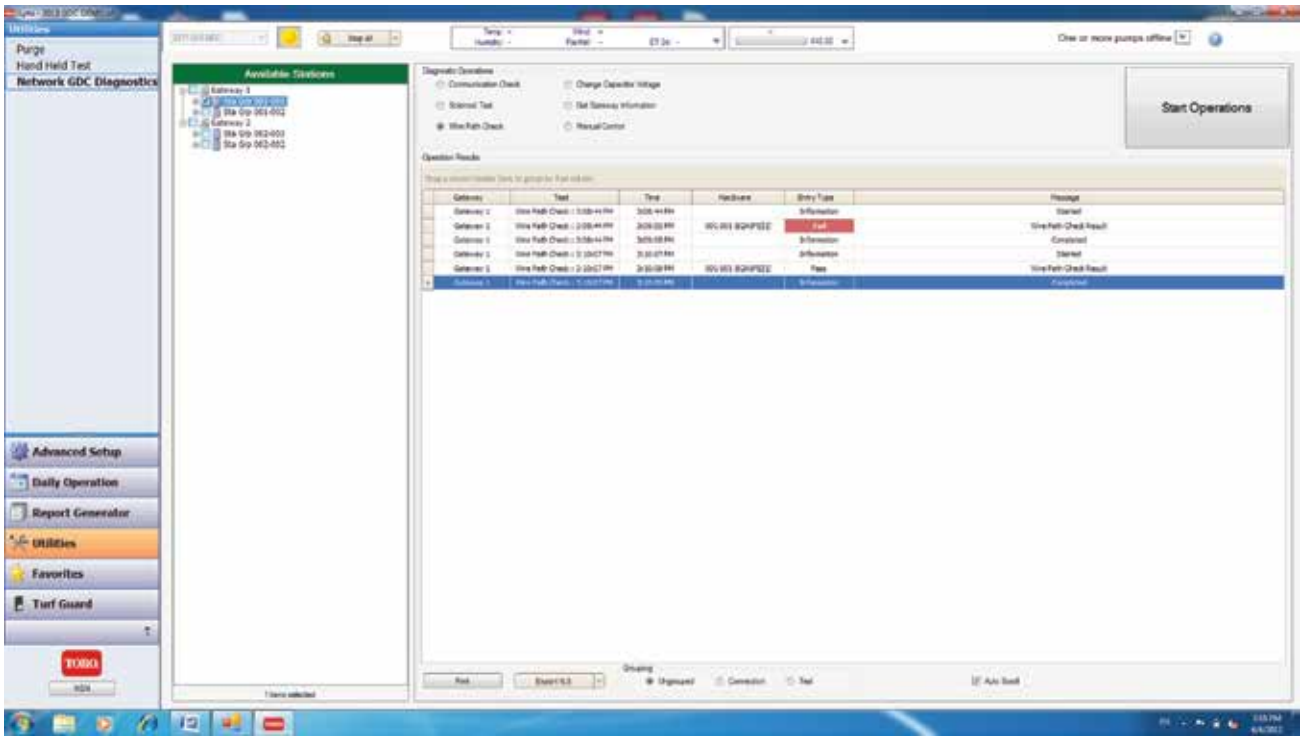
Communication Failed	*No communication from the module.*
Solenoid Fail	*A solenoid is open.*
Solenoid Fail	*A solenoid is shorted.*
Solenoid defined in more than one station	*A module station address has been defined more than once in the control system.*
Solenoid not present on module	*A station-offset number was used higher than the capacity of the module, e.g. station offset 3 was used on a two-station module.*
Module address not defined for station	*A station has an incomplete module address definition.*
Solenoid available on module	*A station offset of a module is available for definition.*

As was the case with the Communication Test, each module and station will be displayed in the Test Results window as it is tested. Failures will be displayed in red.

5.1.4 Wire Path Check

This test allows you to quickly verify the communication cable integrity by checking communication with the last module on each cable. The terminal modules for each Sta Grp are defined in control system.

In the ***Utilities*** folder, clicking on the ***Network GDC Diagnostics panel*** will open the screen below. Select ***Wire Path Check*** and then select the gateway and station group you want to test. To begin the test, click ***Start Operations*** at the top of the page.



If the results are Pass, you quickly know that the whole wire path communication is good. If any of the results are Fail, use the Communication Check to locate specifically where the problem is located.

5.2 Wire Path Amperage Measurements

Verify the nominal amps per cable path (should be quantity of modules multiplied by 0.7mA). This value should be within +/- 10% of nominal. The average should also be compared to a survey of 5-10 modules per cable path as the amps per module will be affected by cable size, cable length, jointing methods, gateway input voltage, etc. High amps are generally caused by damaged modules. Low amps are most likely caused by wiring issues.

To read the amperage draw for the wire path, set the AC50 meter to 40 mA (milliamps) for module wire path readings below 40mA. Place the Meterman AC50 in the 40mA setting. Clamp around ONE of the communication wires going out to the field. If some module s are offline, the new reading will differ from the original reading. If the wire path is cut the reading will also be lower.

Verify that the amp readings for both wires (white and black) of a particular cable are equal (within 5%). Differences of more than 5% are likely caused by damaged insulation (wires touching earth) or bad connections.

Check the communication line grounding devices (Toro DEC-SG-LINE) to verify no leakage to earth.

5.3 Wire Path Voltage Measurements

Check communication line voltages at the gateway and at the end of each cable path. Nominal voltage at the gateway is 40 +/-2 volts. If the voltage is zero at the gateway output, switch off the gateway at the power switch, remove the fuses and check with a meter. You can also test the fuse when it is removed with the Continuity Test Mode that has an audible tone. Use the probes across each fuse to check them. If there's no tone, the fuse is bad.

Check the voltage at the end of each cable path. The acceptable range is 31 to 40 volts. The minimum voltage is 31 volts.

Note: Make sure to use a true RMS meter for these measurements.

5.4 Wire Path Isolation

If you have installed the Paige DCFD (Decoder Cable Fuse Device), you will be able to easily isolate wire paths without cutting a single cable.

Go to the suspected trouble area and take an amperage measurement using the Meterman. For each module downstream of the measuring location, there should be an additional 0.6 mA. If the amp reading is lower than it should be, turn off ONE of the paths by disconnecting the corresponding fuse on the DCFD. If the new measurement is correct for the isolated wire path, replace the fuse in the DCFD and remove other fuse to isolate the other wire path. If there is a malfunctioning module (or modules) on the line, the amperage reading will be 0.7 mA lower for each failed unit.

5.5 Manual Station Activation

In order test the controller-to-module communication, try to activate the offending station from Lynx® (if using a central system), or from the Gateway (if using a stand-alone system). If none of the sprinklers running from that unit turn on, it can be assumed that either the module or the comm. line to the module is bad. If some but not all of the sprinklers turn on, it can be assumed that either there's something wrong with the sprinkler(s) or one of the station wires is bad.

5.6 Manual Program Activation

Similar to the manual station activation, we can test the controller-to-module communication by manually running programs from Lynx or from the stand-alone Gateway. Take note of which stations and sprinklers run to isolate the offending module(s).

5.7 9V Battery Test – Solenoid

 The least costly but perhaps most valuable diagnostic tool is a 9-volt battery. Use the battery to open a latching solenoid manually for test purposes (red wire to the positive charge), and reversing the battery polarity to close the solenoid. You can also use the battery to determine correct polarity and to identify wires for a specific solenoid from a bundle.

Warning! Do not hold the wires onto the battery constantly. It only requires a quick touch to pulse the solenoid "ON" or "OFF".

A normal impedance reading for a latching solenoid is around 10 ohms – if the solenoid is shorted it would read 0 ohms, if it's open the reading would be very high or infinite.

5.8 Wire Integrity

It is also possible that a wire may be the source of the problem. If a wire is damaged, it could potentially disrupt communication to the modules. A visual check of the wires and splices in the area in question may be necessary.

5.9 Individual Decoder Tests

For older (non ISP) modules, symptoms of a defective module would be

- Module does not communicate with the central (just one, not in a group of decoders)
- Does not turn sprinkler on or off (sprinkler verified with 9V battery)
- High amp reading (over 1.0 mA)

For new (ISP) modules, symptoms of a defective module would be

- Module does not communicate with the central (just one, not in a group of decoders)
- Does not turn sprinkler on or off (sprinkler verified with 9V battery)
- Low amps (poly fuse activated)

5.10 Sprinkler Tests

If a sprinkler does not turn on

- Verify that the pilot valve is not defective
- Verify that the PV selector cam is turned all the way to the AUTO position
- Check for debris in the pilot valve or com tube
- Make sure the solenoid is properly tightened and not cross-threaded

If a sprinkler does not turn off

- Check for debris in the main valve or in the body passages connecting the main valve to the pilot valve.
- Try cycling the PV selector cam from AUTO to ON and back to AUTO two times. Although contractors have reported that loosening the solenoid fixes something it is unlikely that changing the solenoid position is necessary – cycling the cam should achieve the same result.
- Make sure the polarity of the wires from the module to the solenoid are not reversed
- Make sure the solenoid is not over tightened and not cross-threaded

5.11 Cable Tests

Complete the following checks at the central to determine if additional cable testing and troubleshooting is necessary.

- Module Communication Test
- Check TxStatus on the Scheduled Activity Report (next 24)
- Check amperage on communication lines (both black and white wires)

If the communication test shows a large number of communication failures AND the amp readings (black and white) are low and close to equal, there is probably a break in the comm cable, close to the last decoder that passes the communication test. Verify the break by checking for expected current and voltage at the suspect location. Use the Pulser to find the break in the cable. This could also be a bad splice in communication cable in the same vicinity. If you don't find a break, open and check all comm cable splices in the area.

If the communication test shows a large number of communication failures or course report shows many communication failures AND the amp readings (black and white) are not close to equal, there is probably one communication wire touching earth. Starting in the location where communication starts to fail, use the clamp meter to find the location where there is the greatest difference between current on the black and white wires of the com cable. Then use the Pulser to find the wire that is touching earth.

If the communication test shows a large number of communication failures or course report shows many communication failures AND the amp readings (black and white) are high and close to equal there is probably a short on the communication line. Use the clamp meter to find the location where the amp readings change from high to low. If the short is not at a module or in a valve box, then use the Pulser or ohm meter to find the short in the buried cable.

Note: 14AWG (2.1mm²) cable has resistance of .0025 Ω/ft, so for example, if you measure 0.5 ohm across the black and white wires, the short circuit would be around 100 feet (30m) away.

GDC System Product Guide

Section 6

Cable and Accessory Specifications

Toro® 2-Wire: Communication Cable

Features
Easy stripping of outer jacket, slides off easily for faster connections

Twisted 2-wire construction for higher inductance. Cable with 2 twisted direct burial wires helps to prevent surge damage

High-density Polyethylene outer jacket for added toughness and additional mechanical strength during installation

Toro® Wire is specialty cable specifically designed to Toro's high standards for quality and reliability required in direct burial projects. Available in 2,1mm²/2C (14 AWG/2C) construction.

Specifications
- **Conductor:** Soft drawn bare copper at ASTM specification B-3 or B-8
- **Insulation:** Low-density high molecular weight polyethylene and a thickness of 0.045" (1,1mm)
- **Outer Sheath:** Red, high density polyethylene with a thickness of 0.035" (0,9mm)

Toro® Direct Burial Decoder Cable Specifications

Model Number	Description
TDW0221T-1000	Toro Wire Direct Burial, 3280', Solid, B+W, Twisted

Accessories

Waterproof Connectors

The 3M™ waterproof connector DBR/Y is a superior connection used to electrically connect two to four pre–stripped copper wires and moisture seal the connection for direct burial. With enough space to accommodate variability in bare end lengths, and wires from 18 to 8 AWG, this is the recommended connector for making connections in Toro GDC systems.

Model No.: DBR/Y-100

Toro® Wire: Module-to-Solenoid (DTS) Cable

Features
Available in colors to match decoder wire connections for added accuracy and time-savings

Two conductor parallel design, easily separated for faster splices.

Ideal for use with Toro's GDC system.

Available in 2,1mm²/2C (14 AWG/2C) construction.

Specifications
- **Conductor:** Soft drawn bare copper at ASTM specification B-3 or B-8
- **Insulation:** Low-density high molecular weight polyethylene and a thickness of 0.045"(1.1mm), One leg has raised ridges and visible printing for polarity identification

Toro® Direct Burial Decoder Cable Specifications

Model Number	Description
TDW0221-500	Toro Decoder Wire, Decoder to Solenoid, 1640', Red
TDW0221-500GRN	Toro Decoder Wire, Decoder to Solenoid, 1640', Green

Toro Stripping Tool

The cable-stripping tool features a spring-loaded cable support arm with a beveled leading edge that assists with insulation and outer jacket removal. The blade swivels to facilitate circular, spiral, and longitudinal cuts making it the ideal tool for fast and efficient stripping of Toro Wire.

Model No.: TDW-STRIP

2-Wire Cable Fuse Device (DCFD)

These products were specifically designed as electrical isolation devices to help with troubleshooting of damaged or non-functioning 2-Wire irrigation systems. Single or multiple sections of the electrical circuit can be disconnected or isolated by simply removing a fuse, without cutting wires or undoing splices/joints. Patent Pending.

Features

- **Quick-disconnect Splitter:** Splits the incoming signal from the central computer into two (270DCFD) or three (270DCFD3) directions. See wiring diagrams.
- **Fuses:** Standard 20-amp Mini Automotive fuses are utilized to act as circuit switches when they are inserted (closed/on) or removed (open/off.) The fuses also provide lightning protection when the electrical surges exceed the capacity of the 20-amp fuse(s.) The isolation of circuit sections eliminates or minimizes electronic component failure.
- **Test Posts:** These posts (red dots in the Wiring diagrams) are accessible when the threaded cap is removed. This allows the measurements of voltage and current flow. It may be necessary to use a "True RMS" multi-meter to perform these tests. Consult with the manufacturer of the 2-wire system.
  - Voltage can be measured by connecting the probes of the meter to the Red/Black posts
  - Current flow can be measured when a fuse is removed and the probes of an in-line amp meter are connected to the posts on each side of the empty fuse holder.
- **Water Tight:** A resin is used to waterproof the wire leads.
- **Wire Leads:** All wires are 14 AWG, Type UF/TWU direct burial, 36" long. This allows the assembly to be brought above grade when troubleshooting and accessing the fuses.
- **O-Ring Seal:** Provides a waterproof capsule. Cap is unscrewed to access the fuses.
- **ACME Threads:** Minimizes binding of threads due to soil.
- **Splices/joints:** All connections of the 14 AWG wire leads onto the 2-wire cables shall be made using a 3M model DBR/Y-6 (Paige Electric 270672.)

Typical Specifications:

- The Paige Electric Decoder Cable Fuse Devices shall be installed at strategic locations of a 2-Wire/2-Core system such that it can isolate certain sections of cables for purposes of troubleshooting. The DCFD shall be installed inside an accessible irrigation valve box. Each location shall be clearly shown on the as built drawings. The splices for all connections shall be made using 3M model DBR/Y-6 (Paige Electric 270672) waterproof connectors.

Accessories

Grounding Plates

- Expanded surface area provides the most reliable grounding protection over ground rods
- Significantly reduces installation time required over ground rods
- A 10-foot (3.05 m) continuous length of 10 AWG, green insulated, with extruded yellow stripe, solid bare copper wire is welded to the plate
- Pre-welded copper wire eliminates need for welding wire in-field to grounding device further reducing installation time

Model No.: 182201PW2-Wire

PowerSet

- Superior conductive material that improves the effectiveness of ground rods/plates and facilitates faster and more effective grounding installations
- Reduces resistance-to-ground, more quickly reducing ohm readings, regardless of soil conditions
- Ideal for use in dry conditions, rocky ground and sandy soils
- 50 lbs (23 Kg) bags

Model No.: 1820058

Warranty

- Using Toro Wire and DBR/Y Wire Connectors from Toro will extend the warranty an additional year for the Toro GDC Central Control System

Decoder Cable Fuse Device Specifications

Models	Diameter	Height	Description
270DCFD	2-3/16"	3-1/16"	2 Way Cable Fuse Device
270DCFD3	2-3/8"	3-1/4"	3 Way Cable Fuse Device

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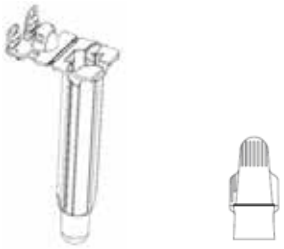
GB Form Number: 200-5106NA

3M™ Direct Bury Splice Kit DBR/Y



Data Sheet **January 2010**

Applications

The 3M™ Direct Bury Splice Kit DBR/Y is used to electrically connect two or more pre–stripped copper wires and moisture seal the connection for direct burial.

The kit includes a 3M™ Performance Plus Wire Connector R/Y+ and a high impact, UV-resistant polypropylene tube prefilled with moisture-resistant grease.

NOTE: Not recommended for submersible applications

Specifications

Maximum Voltage Rating	600 V
Application Temperature	32°F to 120°F (0°C to 49°C)
Operating Temperature	-40°F to 221°F (-40°C to 105°C)
Flammability	UL94 V2

Construction:

Tube	Impact and UV Resistant Polypropylene
Grease	Mineral Oil Base, EG3
R/Y+ Connector	Steel Spring, Flame Retardant Insulator

Wire Combinations Copper wire only Solid or Stranded

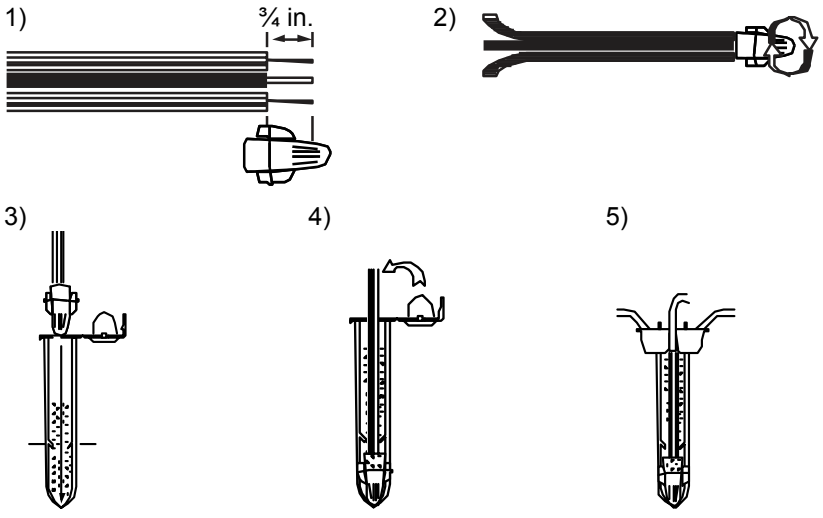
see chart for all combinations

2 - 7 #18	1-3 #12 w/ 1 #18
2 - 6 #16	1-2 #10 w/ 1 #18
2 - 4 #14	1-3 #12 w/ 1 #16
2 - 4 #12	1-2 #10 w/ 1 #12
2 - 3 #10	1-2 #14 w/ 1 #18

Installation Instructions

⚠ Warning

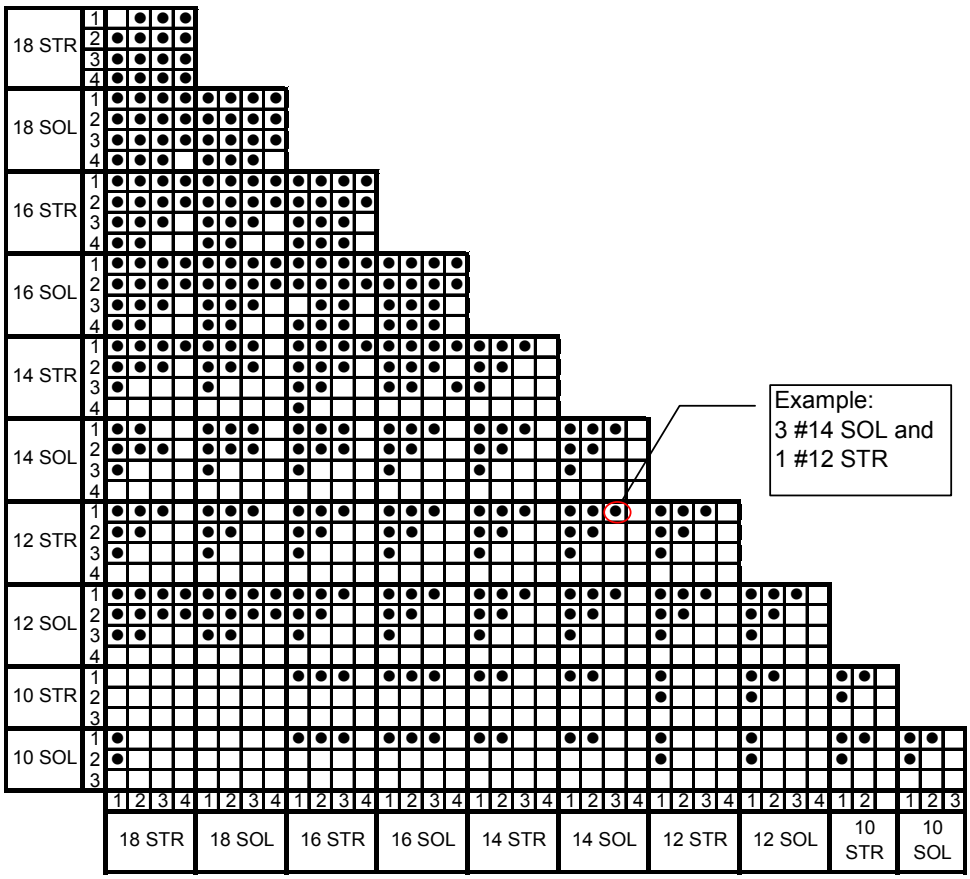
Turn power off before installing or removing connector. All electrical work should be done according to appropriate electrical codes.



1) Strip insulation ¾ in.
2) With wire ends even, insert wires into the connector and tighten until secure.
3) Insert the connector all the way into the tube until the connector rests on the bottom.
4) Fold the wire into the channels.
5) Close the cap.

3M™ Direct Bury Splice Kit DBR/Y

Combination Chart



Shelf Life & Storage	This product has a 5-year shelf life from date of manufacture when stored in a humidity controlled storage (10°C/50°F to 27°C/80°F and <75% relative humidity).
Availability	From your local distributor; or from 3M.com/electrical [Where to Buy] or call 1-800-245-3573.
Important Notice	All statements, technical information, and recommendations related to 3M's products are based on information believed to be reliable, but the accuracy or completeness is not guaranteed. Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. Any statements related to the product, which are not contained in 3M's current publications, or any contrary statements contained on your purchase order, shall have no force or effect unless expressly agreed upon, in writing, by an authorized officer of 3M.
Warranty; Limited Remedy; Limited Liability	This product will be free from defects in material and manufacture at the time of purchase. 3M MAKES NO OTHER WARRANTIES INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. If this product is defective within the warranty period stated above, your exclusive remedy shall be, at 3M's option, to replace or repair the 3M product or refund the purchase price of the 3M product. Except where prohibited by law, 3M will not be liable for any indirect, special, incidental or consequential loss or damage arising from this 3M product, regardless of the legal theory asserted.

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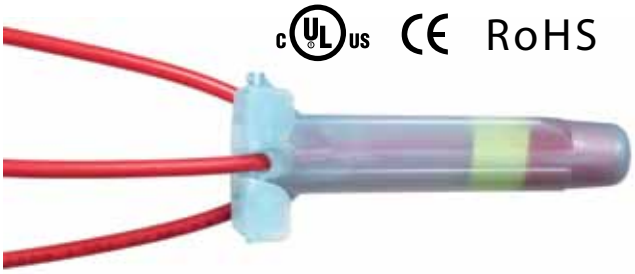
Paige® spec **P7364D - Rev 1**

3M™ Direct Bury Splice Kit DBR/Y-6



1.0 SCOPE:

1.1 The 3M™ Direct Bury Splice Kit DBR/Y-6 is used to electrically connect two or more pre–stripped copper wires and moisture seal the connection for direct burial. It includes the 3M R/Y+ Electrical Spring Connector and a high impact, UV-resistant polypropylene tube prefilled with moisture-resistant gel. It is ideal for splicing wires and cables in irrigation and Low Voltage Lighting systems. For residential, commercial, golf, and other green industry applications.

2.0 PACKAGING DETAILS:

Paige Part Number		270670	270671
3M Part Number		DBR/Y-6 Bulk	DBR/Y-6 Kit
Description		Bulk pack of 100 each gel-filled tubes and twist-on connectors.	25 Kits in a plastic bag. 2 gel-filled tubes and 2 twist-on connectors per bag.
Case Data	Weight	5.1 lbs 2,3 Kg	3.5 lbs 1,6 Kg
	Dimensions	14.25 x 7.625 x 7.5 inches 36 x 19 x 19 cm	13 x 7.6 x 6 inches 33 x 19 x 15 cm
Pallet Data	Quantities	75 cases 7,500 tubes	133 cases 6,650 tubes (3,325 kits-of-2)
	Weights	402 lbs 183 Kg	485 lbs 221 Kg
	Dimensions	48 x 42 x 43 inches 122 x 107 x 109 cm	48 x 42 x 47.5 inches 122 x 107 x 121 cm
	Volume	50.2 ft^3 1,42 m^3	55.4 ft^3 1,57 m^3

3.0 FEATURES:

3.1 ***Reduces inventory and SKUs:*** Replaces the following 3M connectors: DBY, DBR, DBY-6, DBR-6, DBR/Y, DBY-Kit, DBR-Kit, DBY-6-Kit, DBR-6-Kit, DBR/Y-Kit. Reduces the SKUs from 10 to 2 (DBR/Y-6 and DBR/Y-6 Kit.)

3.2 ***Rated for 600 volts:*** One connector for most connections required in irrigation (conventional and decoder types) and landscape lighting systems. Listed under UL486D for USA and Canada, File 102356. Meets Directive 2006/95/EC and IEC standards EN61984:2009, EN60998-1:2004, and EN60998-2-4:2005.

3.3 ***Bulk or Kits-of-two connectors:*** Each waterproof connector includes the R/Y+ twist-on connector (wire nut*), and a gel-filled tube

3.4 ***Water Resistant & Rain Tight:*** The DBR/Y-6 may be installed above or below ground, inside a "valve box" or buried next to a valve-in-head sprinkler or light fixture.

3.5 ***Sunlight resistant:*** Connector can be used above or below ground level.

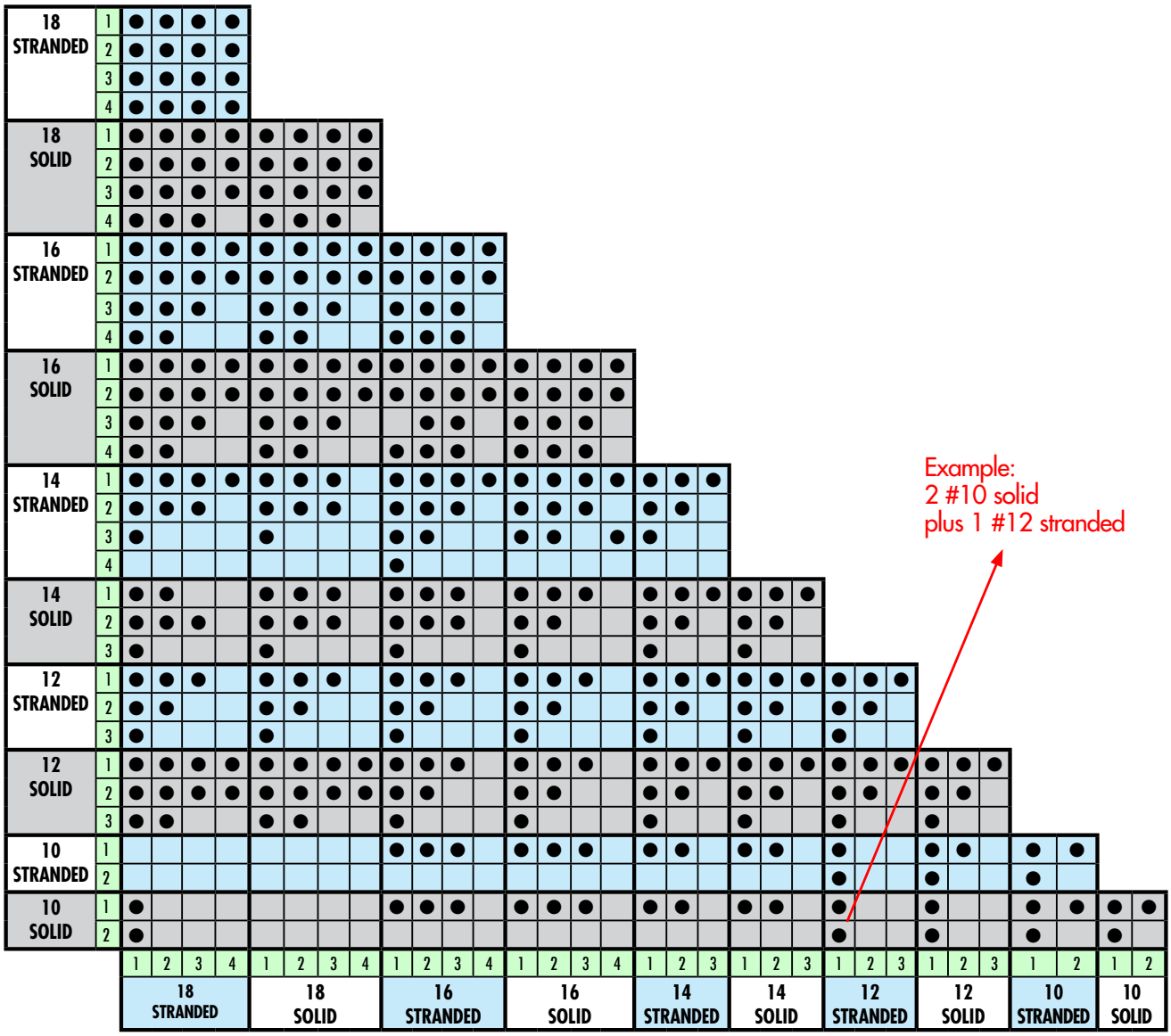
3.6 ***Strain relief:*** The gel-filled tube includes a lid that compresses the wire insulation when closed. This applies a pressure, known as "strain relief" that keeps the connection inside the tube when the wires are pulled-upon. The connector tube includes channels for three sets of wires.

3.7 ***Operating temperature:*** -40°F to 221°F (-40°C to 105°C)

3.8 ***Made in the USA by the 3M Company:*** Unquestioned quality by a name you can trust!

3.9 *The R/Y+ connector has an aggressive quick-bite:*

It makes a fast and reliable mechanical connection over a wide temperature range. The R/Y+ connector locks in place when inserted into the gel-filled tube. It accepts a multitude of direct burial copper wire combinations, as listed in the Table below.



Metric Wire Combination			
Cross section capacity	2,0 mm² through 16,0 mm²		
Conductor combinations	Quantity	Size	Type
	5 - 7	0,5 mm²	sol/str.
	3 - 7	0,75 mm²	sol/str.
	2 - 8	1,0 mm²	sol/str.
	2 - 7	1,5 mm²	sol/str.
	2 - 5	2,5 mm²	sol/str.
	2 - 4	4,0 mm²	sol/str.
	2	6,0 mm²	sol/str.
* Only AWG wire size combinations are UL LISTED or CSA Certified.			

Paige irrigation

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* "Wire nut" is a registered trade mark of Ideal Industries, Inc.

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Paige® irrigation spec **P7350D-Rev 3**

TORO JACKETED DECODER CABLES DIRECT BURIAL

SIZES: 14 & 12 AWG, SOLID COPPER, 2-CONDUCTOR

1.0 SCOPE:

1.1 This specification covers jacketed cables containing two listed Sprinkler Systems Wires, single conductor, suitable for direct burial, for operation up to 600 volts, and temperatures up to 60°C.

2.0 CONSTRUCTION:

2.1 ***Inner Conductors:***
Soft drawn bare copper meeting the requirements of ASTM specification B-3 or B-8. Insulation shall be low density high molecular weight polyethylene and a thickness of 0.045", per Paige Electric specification P7079D. The two conductors (black and white) shall be twisted with a minimum lay of 4".

2.2 ***Overall jacket:***
High density polyethylene with a thickness of 0.035". Available with different color jackets as listed in the table below. The jacket shall be sufficiently round, and loose, to facilitate its removal when being stripped.

PAIGE PART NO.	JACKET STRIPE	OUTSIDE DIAMETER	SHIPPING WEIGHT (Pounds/1000')	SIZE
170800	None	.378 ± .020	65	14 AWG 2C
170800BK	Black			
170800YL	Yellow			
170800GN	Green			
170804	None	.416 ± .020	95	12 AWG 2C
170804BK	Black			
170804YL	Yellow			
170804GN	Green			

2.3 ***Surface Print:***

2.31 Inner Conductors – "Paige Electric P7079D 14 or 12 AWG PE Listing file Number 600V Sprinkler System Wire Direct Burial"

2.32 Outer Jacket – "Paige Electric, P7350D, 14 or 12 AWG PE 600V Sprinkler System Wire Direct Burial Only for Toro Decoder Systems RoHS"

3.0 TEMPERATURE RATING

3.1 -55ºC to +60ºC

4.0 PUT-UPS:

4.1 500' (164m), 1000' (328m), 2500' (762m) and some odd lengths.

5.0 SPLICING RECOMMENDATIONS:

Wire splices are the weak link of any electrical circuit. It is especially important to make proper joints in irrigation systems because the joints are exposed to wet and damp environments that can cause corrosion of the copper conductor, and premature failure. Paige Electric recommends the strict use of Model DBR/Y-6, as manufactured by the 3M Company (Paige specification P7364D)

03/30/11

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Paige® irrigation spec **P7351D - Rev 2**

DECODER-TO-SOLENOID CABLES (DTS Cables™) DIRECT BURIAL

SIZES: 14 AWG, SOLID COPPER, 2-CONDUCTOR

1.0 SCOPE:

1.1 This specification covers a cable containing two wires laid in parallel with a web joining them, listed as Sprinkler System Wire, suitable for direct burial, for operation up to 600 volts and temperatures up to 60ºC. Listed by UL or ETL or CSA.

2.0 CONSTRUCTION:

2.1 ***Conductors:***
Soft drawn bare copper meeting the requirements of ASTM specification B-3 or B-8.

2.2 ***Insulation:***
Low density high molecular weight polyethylene and a thickness of 0.045". One leg has raised ridges for polarity.

2.3 ***Testing:***
After scoring the web between the conductors with a knife, the conductors must be able to be separated without showing copper and must meet the minimum wall thickness of .045" everywhere along the insulation wall.

2.4 ***Colors:***

PAIGE PART NO.	COLOR	DIMENTIONS		PUT-UPS		SHIPPING WEIGHT	
		Inches	mm	Feet	meters	Lbs/2500'	Kg/762m
170803RD	Red	.155 x .325	3,9 x 8,3	2500	762	103	47
170803BL	Blue						
170803BN	Brown						
170803GY	Gray						
170803GN	Green						
170803OG	Orange						
170803BK	Black						
170803YL	Yellow						
170803WT	White						
170803PR	Purple						

2.5 ***Surface Print:***
Paige Electric P7351D 14 AWG PE Number of conductors Listing Number 600V Sprinkler System Wire Direct Burial Decoder-to-Solenoid RoHS"

3.0 TEMPERATURE RATING

3.1 -55°C to +60°C

4.0 SPLICING RECOMMENDATIONS:

Wire splices are the weak link of any electrical circuit. It is especially important to make proper joints in irrigation systems because the joints are exposed to wet and damp environments that can cause corrosion of the copper conductor, and premature failure. Paige Electric recommends the strict use of Model DBR/Y-6, as manufactured by the 3M Company (Paige specification P7364D)

03/29/11

Toro is always there to help you care for your landscapes the way you want, when you want, better than anyone else.

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Phone: (1) 877-345-8676

For more information on the Toro GDC System
Toro Company Website: http://www.toro.com/irrigation
Link to Paige Wire: http://www.paigewire.com

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