Appendices

Appendix – Signal Wiring/Cabling

There are a variety of conductors and cables specifically designed for the traffic signal industry. The type and size of conductors and cables should conform to the National Electrical Code (NEC) and to IMSA cable specifications as a matter of good practice. In some cases, manufacturers may recommend specific types of wire or cable for the proper operation of their equipment. **Table 1** shows information related to wiring typically used by DelDOT Traffic.

Table 1
Wiring Diagram Supplemental Information

Device	Cable Type	Size	Volt. (AC)
HIB, Jumper Wire	4-Conductor Electrical Cable	No. 14 AWG (2)	600
Pedestrian Signal Head and Push Button (1 Way) per direction	5-Conductor Electrical Cable	No. 14 AWG (2)	600
1- & 2-Section Signal Heads, 3-Sect. Head w/Arrows & Jumper Wire (Mast arm)	4-Conductor Electrical Cable (1)	No. 14 AWG (2)	600
4- and 5-Section Signal Heads (mast arm)	9-Conductor Electrical Cable (1)	No. 14 AWG (2)	600
Signal Heads (span wire)	16-Conductor Electric Cable	No. 14 AWG (2)	600
Loop Wire Lead-In Cable	1-Conductor (Aluminum shielded)	No. 14 AWG	600
Loop Detector Home-Run Cable	2-Conductor (Aluminum shielded)	No. 14 AWG	600
Opticom Detector	4-Conductor Detector Cable	No. 18 AWG	300
Grounding	Strand. Bare Cop. Gnd. Wire	No. 6 AWG (2)	----
Power Feed (disconnect to cabinet)	2-Conductor Electrical Cable	No. 8/ 2 UF w/G (2)	110/220
Electrical Service (transformer to disconnect)	1-Conductor Electrical Cable	No. 8 THHN w/G(3) or No. 6 Triplex Service Cable (2)(3)	110/220

(1) – Consideration should be given to increasing the number of conductors needed in mast arm installations for spare and future use.
(2) – For longer runs, a heavier gauge cable may be required to reduce voltage drop.
(3) – Cable determined by power company providing service.

Field Cabling

Signal head wiring originates at the control cabinet and terminates at the signal head. Cables composed of multiple conductors are used for this application. The number of conductors making up the cables is standardized to three or four combinations to reduce inventory requirements. DelDOT Signal Construction uses cables with 1, 2, 4, 5, 9, and 16 conductors per cable. Additional sizes may be used if required but, prior approval from the Signal Construction Manager shall be required.

A separate neutral wire shall be used for signal display returns for each approach to the intersection. One neutral wire shall be used for a maximum of five (5) signal faces, all directed toward the same approach to the intersection. Separate neutral wires shall be used for pedestrian signal displays, and for pedestrian detector returns.

a. Cable Sizing

The number of conductors needed in a cable can be determined by counting the number of indications to be controlled, adding the conductors needed for neutral, and providing at least one spare. After the number of conductors needed is known, the cable size that is appropriate from the normal inventory can be selected. **Table 1** shows the resulting preferred cable type for each device.

The signal cable shall typically be continuous and unbroken between the control cabinet and the first signal head that it services. However, while they should generally be avoided, signal cable splices may be used in the bottom of steel poles or nearest conduit junction well for the following circumstances, such as:

- Mast Arm Designs
- Pre-wired pedestrian poles
- For emergency signal repairs

Cabling may be overhead or underground, depending on the type of signal installation and the availability of pole lines and/or underground conduits.

b. Span Wire Cabling and Splice configurations

Signal head cables for a span wire installation are typically underground from the control cabinet to the nearest steel pole, up the pole, and onto the span through a weather head.

Two (2) 16-conductor cables shall be installed for normal signal span installations. One cable will be used to serve both one major street approach and one side street approach. The other cable will be used for the remaining approaches.

Signal heads facing the same approach that will display identical displays throughout the signal cycle may be jumped together with a 4-conductor cable and be spliced into the appropriate 16-conductor cable, leading back to the control cabinet.

Table 2 illustrates the standard practices of signal wiring and color codes for span wire configuration.

Table 2
Standard Practices of Signal Wiring and Color Codes

Conductor Colors	16/#14 Cable #1 Direction	16/#14 Cable #2 Direction	Signal Color
Typical Installation			
Green	NB or EB Artery	SB or WB Artery	Green
Orange			Yellow
Red			Red
White			Neutral
Green / Black	NB or EB Side Street	SB or WB Side Street	Green
Orange / Black			Yellow
Red / Black			Red
White / Black			Neutral
Green / White	NB or EB Artery Left Turn (If Used)	SB or WB Artery Left Turn (If Used)	Green
Black / White			Yellow
Red / White			Red
Blue / White			Neutral
Blue	NB or EB Side Street Left Turn (If Used)	SB or WB Side Street Left Turn (If Used)	Green
Black			Yellow
Black / Red			Red
Blue / Black			Neutral
Permissive Left Turns (5 section signal head)			
Green	NB or EB Artery Left Turn	SB or WB Artery Left Turn	Green
Yellow			Yellow
Red			Red
Blue			Green ←
Black			Yellow ←
White			Neutral

c. Mast Arm Pole Cabling and Splicing Configurations

Signal head cabling for a mast arm pole typically needs fewer conductors and more cables than a span wire installation. Below is the typical cable layout for mast arm designs.

Signal head cables for a mast arm pole installation are typically underground from the control cabinet to the base of the up-right of the structure. The signal cables connecting the signal cabinet and each mast arm pole should be designed as follows:

- **Single Mast Arm with a Single Phase:** Use one (1) 9-conductor for the signal head, one (1) 5-conductor for each pedestrian indication and buttons, and one (1) 4-conductor for pre-emption devices.
- **Single or Dual Mast Arm with 2 to 3 Phases:** Use one (1) 16-conductor for the signal head, one (1) 5-conductor per each pedestrian indication(s) and push button(s), and one (1) 4- conductor for each pre-emption device installed.
- **Single or Dual Mast Arm with 4 Phases:** Use two (2) 16-conductors for signal head, one (1) 5-conductor for each pedestrian indication(s) and push button(s), and one (1) 4-conductor for each pre-emption device installed.

A single 4-conductor to each three (3)-section indication and a single 9-conductor to each four (4) or five (5)-section indication shall be installed on the mast arm pole to the base of the mast arm up-right, with no splices. At the bottom of the pole, signal head conductors shall be spliced into the proposed conductor from the controller cabinet. The splices shall be twisted and with wire nuts to ensure a good connection. All splices shall be covered and secured with electrical tape or a similar form of protection. All splices should occur in the hand hole at the base of the up-right.

Table 3a – 3d below illustrates the standard practices for wiring various types of signal equipment for a mast arm design.

Table 3a
Four-Conductor Cable Wiring and Color Codes

Conductor Colors	Single Section Signal Head	3 Section Signal Head
Green	Not used	Green lens
Black	Power Feed	Yellow Lens
Red	Not used	Red Lens
White	Neutral	Neutral

Table 3b
Nine-Conductor Signal Wiring and Color Codes

Conductor Colors	Single Ped Signal	2-way Ped Signal	4-section "T" Head	4-section "⊥" Head	5-section Head
Green	Walk	#1 Walk	Green	Green	Green
Orange	Not used	Not used	Yellow	Yellow	Yellow
Red	Don't Walk	#1 Don't Walk	Red	Red	Red
White	Neutral	Neutral	Neutral	Neutral	Neutral
Green / Black	Not used	#2 Walk	Not used	Green Arrow	Not used
Black	P.B. Output	#1 P.B.	Not used	Not used	Yellow Arrow
Red / Black	Not used	#2 Don't Walk	Red Arrow	Not used	Not used
White / Black	P.B. Ground	P.B. Ground	Not used	Not used	Not used
Blue	Not used	#2 P.B.	Not used	Not used	Green Arrow

Table 3c
Left Turn Signal Head Wiring

Option #1 5-Section Signal Head			
Orange / Black	Side Street	Side Street	Yellow
Red / Black	Left Turn	Left Turn	Red
Blue / Black			Green ←
Black / Red			Yellow ←
White / Black			Neutral
Option #2 **Flashing Red Arrow (4-Section "T" Head) Artery Left Turns Only**			
Green / White	N.B. or E.B.	SB or W.B.	Green ←
Black / White	Artery	Artery	Yellow ←
Red / White	Left Turn	Left Turn	Red
Black / Red			FL Red ←
Blue / White			Neutral

Table 3d **16-Conductor of Signal Wiring and Color Codes**			
Conductor Colors	**16/#14 Cable #1 Direction**	**16/#14 Cable #2 Direction**	**Signal Color**
Typical Installation			
Green	NB or EB Artery	SB or WB Artery	Green
Orange			Yellow
Red			Red
White			Neutral
Green / Black	NB or EB Side Street	SB or WB Side Street	Green
Orange / Black			Yellow
Red / Black			Red
White / Black			Neutral
Green / White	NB or EB Artery Left Turn (If Used)	SB or WB Artery Left Turn (If Used)	Green
Black / White			Yellow
Red / White			Red
Blue / White			Neutral
Blue	NB or EB Side Street Left Turn (If Used)	SB or WB Side Street Left Turn (If Used)	Green
Black			Yellow
Black / Red			Red
Blue / Black			Neutral
Permissive Left Turns (5 section signal head)			
Green	NB or EB Artery Left Turn	SB or WB Artery Left Turn	Green
Yellow			Yellow
Red			Red
Blue			Green ←
Black			Yellow ←
White			Neutral

d. Detector Wiring

Detector wiring generally consists of electrically connecting the detector (usually an inductive loop detector) with its electronics in the control cabinet. DelDOT Traffic has specific requirements for loop detectors, optical detectors and video detectors:

Loop Detectors: These loops are formed by saw cutting the roadway and placing a one-conductor encased in flexible tubing in the saw cut which is then sealed. To ensure that the wire is protected in the transition from roadway to the nearest conduit junction well all loop wire lead-in cables should be placed in a 1.5" galvanized rigid metal conduit and weatherproof fitting in this transition area. The detector connection from the conduit junction well to the controller cabinet shall be a 2-conductor (aluminum-shielded) home-run cable for each loop detector and consist of a continuous run, without splices, between the control cabinet and the conduit junction well adjacent to the loop installation.

The loop detector shall be spliced to the "home-run" cable in the conduit junction well adjacent to the loop installation. All connections in the loop splice shall be soldered and individually insulated, with heat shrink tubing. When all connections are completed, the entire splice shall be encased in an epoxy-filled splicing kit (for example, 3M Scotch Cast #82-A1 or approved equal).

These installation procedures will minimize noise in the cable, which could interfere with the proper operation of the detector. Each splice will inevitably add electrical resistance, which would impede the proper operation of the detector. Therefore, only one splice will be allowed between the loop location and the control cabinet.

Optical and Video Detectors: Shall comply with all the recommended manufacture wiring requirements to achieve maximum data output.

e. Grounding

The following guidelines should be followed to ensure proper grounding of all wire:

- A single No. 6 AWG stranded copper ground wire shall run through all pathways between the cabinet and junction wells and the bases of all pole structures to ensure proper grounding of all wires.
- In the control cabinet:
    - The white wire and the ground (bare copper) wire from the service shall be connected directly to the ground rod in the concrete cabinet base. The white wire shall continue, unbroken, to the ground buss on the "Power Panel."
    - The green ground wire in the cabinet shall be connected as directly as possible to the ground rod.

- All individual signal neutral returns shall be connected to the ground buss on the "Power Panel."

f. Calculation of Wiring for Signal Heads

Many applications for signal head wiring use two (2) 16/#14 cables to accommodate all movements. The following is a list of steps taken to determine the cable size:

1. Determine the furthest grouping of heads for one movement
2. Determine all signal heads that will operate together
3. One wire will be used for each of these signal head groups
4. Add one wire for grounding

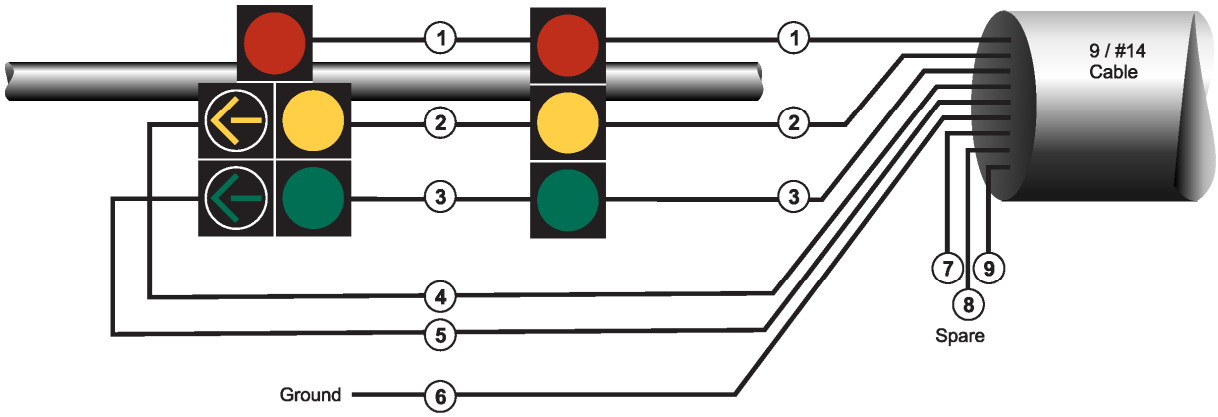

Figure 1. Example Wiring for Signal Heads

The example shown above will need a minimum of 6/#14 to accommodate all heads. However, to allow for wire failures and the addition of signal heads in the future, a 9/#14 should be used for this installation.