ORIGINATOR Director, Bureau of Highway Operations		5-1-4
CHAPTER 5	Signal Plan Format	
SECTION 1	Permanent Signal Plan Format	
SUBJECT 4	Signal Cabling	

GENERAL

For all new or reconstructed state-owned signals installed under contract, a Cable Routing Schedule **shall** be included, and reviewed by the Regional Electrical staff and the Regional Traffic Engineer as part of the signal plan review process.

The Cable Schedule assures the maintaining electrical staff that the standard WisDOT wiring scheme is followed. Electrical staff *should* be contacted prior to preparing the Cable Routing Schedule to discuss proper wiring practices. Additionally, it is important that this plan sheet correctly identifies the wiring scheme as installed at the intersection. A sample of the chart is provided.

The cable routing sheet is also used by the electrical contractor as a blueprint for the routing of the signal feeder cables and field connections. This sheet will also aid the signal designer when determining miscellaneous quantities.

This section presents information, some of which has been previously printed in such documents as the *Standard Specifications for Road and Bridge Construction* (Specification 655), Standard Detail Drawings, and the *Wisconsin Electrical Code*.

COMPLETION OF THE CABLE ROUTING SCHEDULE

At the top left of the cable routing sheet, insert the project identification number followed by the intersection name and signal number.

The color-coding chart provides identification of each conductor within the signal feeder cables. The conductor colors and sequence for cables can be found in the International Municipal Signal Association, Inc. (IMSA) specification No. 20-1. Base colors **shall** consist of colored insulation. Tracers **shall** be colored stripes or bands along the surface of the insulation. The color-coding chart utilizes the use of a three-letter

abbreviation for each conductor color. Examples: RED=red, ORG=orange, GRN=green and for the tracer colors: WHT/BLK=white/black, RED/WHT=red/white, etc.

There are five tables placed in the cable routing sheet, which are:

- SIGNAL FEEDER CABLES
- EQUIPMENT GROUNDING CONDUCTOR
- PULL BOX BONDING JUMPERS
- LIGHTING CABLES
- EMERGENCY VEHICLE PREEMPTION CABLES

To fill in the cable routing sheet from the example in TDSM Subject 5-5-1 Second Revision Plan, the signal feeder cable goes from the cabinet base (i.e. CB1) to each signal base (i.e. SB1). For SB1, the minimum number of conductors needed is 7 and a maximum will typically be 15 conductors. The following concepts apply to the example chart provided: head no. 18 requires 3 conductors, head no. 23 requires 2 conductors, 1 conductor is needed for the pedestrian push button, and 1 conductor is used for the grounded conductor. This example used a 15 conductor as a feeder cable. A 12 conductor could also be used, in either case this will provide some additional spare conductors to meet future needs.

Signal Cable, IMSA-20-1, Ungrounded Conductors

During emergency situations it is imperative that the maintenance staff knows the wiring at the intersection. For this reason, the Signal Cable, IMSA-20-1, Ungrounded Conductors (wiring table) is very important. The wiring table identifies the signal cable path and wiring scheme for all signal and pedestrian indications at the intersection it is important that a copy of this be located inside the controller cabinet for use during maintenance. Wiring color schemes vary among Regions and local jurisdictions. Prior to beginning the wiring table, the maintaining electrician *should* be contacted to determine the proper routing procedure.

Signal Feeder Cables Table

The preferred method for installing signal feeder cable is to run a separate home run cable from the control cabinet base to each individual signal base. When selecting the number of conductors needed in each signal feeder cable, future signal expansion *should* be considered such as adding pedestrian heads, pedestrian push buttons, turn arrows, etc. Consideration *should* also be given to minimize the number of different sized cables to be used as feeder cables. For intersection wiring, it is easier to provide a few standard size cables like a 12 conductor cable instead of providing 7, 9, or 10 conductor cables. This wiring scheme eliminates the need for a separate 10 AWG XLP white grounded conductor. A 14 AWG white-grounded conductor will be provided for in the signal feeder cable.

The next entry on the chart is the signal head number and the phase the head is associated with as shown on the signal plan. In the example, Head 18 is a phase 4

head, head 23 is a phase 6 pedestrian head, and the push button is for the phase 6 ped.

To complete the entries for SB 1, the signal indication wire color section needs to be entered. Across the top of the chart are the signal indications. We start with the circular indications of red, yellow, and green followed by the arrow indications, the pedestrian signal indications, the pedestrian push buttons, and other. For each indication used, a signal feeder conductor is assigned to the signal indication. These colors are entered as shown in the signal wire color-coding section. Head # 18, RED = red, ORG = yellow, and GRN = green. Head #23 the DON'T WALK = BLK and the WALK = BLU. The push button needs 2 conductors. One conductor will be the WHT/BLK and the other side of the button will be connected to the grounded conductor (neutral) in the signal feeder cable.

Cable Routing Schedule Example

CB _ TO	JUMPER	# OF COND	HEAD NO.	PHASE	SIGNAL INDICATION WIRE COLOR								PED BUTTON	OTHER
					RED	YELLOW	GREEN	<RED	<YELLOW>	<GREEN>	D/WALK	WALK		
SB 1		12	18	4	RED	ORG	GRN							
			23	6							BLK	BLU		
			BUTTON	6									WHT/BLK	
SB 2		12	1	6	RED	ORG	GRN							
			11	5				RED/BLK	ORG/BLK	GRN/BLK				
			24	4							BLK	BLU		
			BUTTON	4									WHT/BLK	
SB 3		12	12	5	RED/BLK	ORG/BLK	GRN/BLK							
SB 4		12	4	1				RED	ORG	GRN				
			8	2	RED/BLK	ORG/BLK	GRN/BLK							
SB 7		12	9	2	RED	ORG	GRN							
			25	4							BLK	BLU		
			BUTTON	4									WHT/BLK	
SB 8		12	16	4	RED	ORG	GRN							
			26	2							BLK	BLU		
			BUTTON	2									WHT/BLK	
SB 9		12	31	OL A	RED				ORG	GRN				
SB 10		12	14	8	RED	ORG	GRN							
			19	4 & 7	RED/BLK	ORG/BLK	GRN/BLK		BLK/WHT	BLU/BLK				
SB 11		12	30	OL A	RED				ORG	GRN				
SB 12		12	15	8	RED	ORG	GRN							
			27	2							BLK	BLU		
			BUTTON	2									WHT/BLK	
SB 13		12	5	1				RED	ORG	GRN				
			7	2	RED/BLK	ORG/BLK	GRN/BLK							
			28	8							BLK	BLU		
			BUTTON	8									WHT/BLK	
SB 14		12	2	6	RED	ORG	GRN							
			10	5				RED/BLK	ORG/BLK	GRN/BLK				
			6	1				BLK	BLK/WHT	BLU				
SB 15		12	21	5	RED				ORG	GRN				
SB 16		12	3	6	RED	ORG	GRN							
			29	8							BLK	BLU		
			BUTTON	8									WHT/BLK	
SB 17		12	13	8	RED	ORG	GRN							
			22	6							BLK	BLU		
			BUTTON	6									WHT/BLK	
SB 18		12	20	5	RED				ORG	GRN				
SB 19		12	17	4 & 7	RED/BLK	ORG/BLK	GRN/BLK		BLK/WHT	BLU/BLK				

To complete the wiring chart, an entry is added for each signal base and associated signal heads and pedestrian push buttons. The OTHER column is used for any shadow box signs, time of day signs, etc., fed out of the signal feeder cable.

Equipment Grounding Conductor

The equipment grounding conductors provide grounding for the physical elements at the intersection (i.e. controller cabinet, signal poles, pull boxes, light poles powered from signal cabinet). As with signal cable, the maintaining electrician *should* be contacted to determine the correct routing for the equipment grounding conductors.

Equipment Grounding Conductor Table

The equipment-grounding conductor is a stranded 10 AWG XLP insulated conductor used for grounding purposes. This wire **shall** have an insulation that is green. The conductor starts at the cabinet base and is jumpered in and out of each signal base and returning back to the cabinet base. This creates a loop around the intersection. A stranded 10 AWG conductor is used due to the mechanical strength of the conductor. The use of a spare conductor from the signal feeder cable to be used as permitted. In the example, the equipment-grounding conductor starts at CB1 runs to SB20, to SB1, in and out of the signal bases to SB 19 and from SB 20 terminating back at CB1.

EQUIPMENT GROUNDING CONDUCTOR 10 AWG GRN XLP	
FROM	TO
CB 1	SB 1
SB 1	SB 2
SB 2	SB 3
SB 3	SB 4
SB 4	SB 5
SB 5	SB 6
SB 6	SB 7
SB 7	SB 8
SB 8	SB 9
SB 9	SB 10
SB 10	SB 11
SB 11	SB 12
SB12	SB 13
SB 13	SB 14
SB 14	SB 15
SB 15	SB 18
SB 19	SB 16
SB 16	SB 17
SB 17	SB 19
SB 19	SB 20
SB 20	CB 1

Pull Box Bonding Jumper Table

The pull box bonding jumper **shall** be in accordance with Specification 655.2.5. The purpose of this conductor is to bond all metal pull boxes that are used as a raceway for cables that carry voltages of 50 volts or more to ground. The pull box bonding jumper extends from the pull box to the nearest signal base. This bonding jumper is spliced to the equipment grounding conductor in the signal pole and or.

PULL BOX BONDING JUMPER 10 AWG GRN XLP	
FROM	TO
CB 1	PB 1
SB 2	PB 4
SB 3	PB 2
SB 4	PB 5
SB 6	PB 6
SB 6	PB 7
SB 8	PB 10
SB 10	PB 11
SB 11	PB 12
SB 11	PB 13
SB 13	PB 16
SB 14	PB 17
SB 16	PB 22
SB 18	PB 18
SB 18	PB 19
SB 19	PB 24
SB 20	PB 23
CB 1	PB 25

Lighting

The Lighting Chart identifies the routing for the lighting wire/cable. Since some Regions provide separate conduit for lighting systems, the cable routing *may* have been previously discussed with the maintaining engineer or electrician during the design; nevertheless, the wire/cable routing **shall** be included in the plans. Refer to Specification 655.3.4.

Lighting Table

Lighting is phase-to-ground or phase-to-phase. At a signalized intersection, the lighting is typically 120 volts to ground. Individual lighting feeder cables could be run to each light pole. To minimize the number of home run lighting cables, lighting at the intersection could be split into two circuits. The circuit loads *should* be balanced. Typically, a 12 AWG 2 conductor UF cable with ground feeds the intersection. For higher lighting loads and to maintain minimal voltage drops a larger conductor *may* be required. A maximum 5% voltage drop for a branch circuit is recommended according to the NEC. It is preferred to design up to a 3.5% maximum voltage drop, which would allow for some limited expansion of the lighting system in the future.

LIGHTING UF 12 AWG W/GROUND	
FROM	TO
CB 1	SB 21
SB 21	SB 5
SB 5	SB 6
SB 6	SB 9
CB 1	SB 20
SB 20	SB 18
SB 18	SB 15
SB 15	SB 11

When the number of luminaires exceeds 12, a separate lighting cabinet is required.

When separate traffic signal and street lighting systems are used, the systems **shall** be electrically isolated from each other. Each system would have a separate cabinet and underground conduit system. Examples would include signals and street lighting fed from two different power sources, lighting branch circuit loads exceeding 20 amperes, and/or lighting systems maintained by different governmental agencies.

Emergency Vehicle Preemption Table

The EVP cable **shall** be installed as shown on the plan and in accordance with the manufacturer's specifications. The cable **shall** be installed from the control cabinet to the EVP detector head and be in one continuous non-spliced length. The EVP detector cable **shall** be terminated at the detector head and control cabinet. The cable **shall** be routed through the underground conduit system using the shortest route.

EMERGENCY VEHICLE PREEMPTION	
FROM	TO
CB1	HEAD 'C'
CB1	HEAD 'A'
CB1	HEAD 'D'
CB1	HEAD 'B'

Loop Detector Lead-in Cable & Loop Wire

Although loop detector lead in cables are not shown on the chart, a separate loop detector lead in cable **shall** be provided for each individual loop. This cable **shall** run from the cabinet base (CB) to the loop pull box used as the splice point. The detector lead in cable **shall** be pulled thru each pull box without any additional loops or coils in each pull box. Excessive coils of detector lead in cables *may* affect the loop detector amplifier operation. At the splice point pull box, the detector cable **shall** extend 3 feet above the pull box cover for splicing purposes. At the control cabinet, the detector cable **shall** extend 3 feet above the top of the control cabinet to allow for future landing of the detector cables on the associated loop panel. Splices are made between the loop detector wire and the lead-in cable at the pull box at the side of the road.

PROJECT ID:	
INTERSECTION:	

SIGNAL WIRE COLOR CODING	BLK-BLACK	RED-RED	GRN-GREEN
	WHT-WHITE	BLU-BLUE	ORG-ORANGE

DATE:

CB TO	JUMPER	# OF COND.	HEAD NO.	PHASE	SIGNAL INDICATION WIRE COLOR								PED BUTTON	OTHER
					RED	YELLOW	GREEN	<RED	<YELLOW>	<GREEN>	D/WALK	WALK		

EQUIPMENT GROUNDING CONDUCTOR 10 AWG GRN XLP	
FROM	TO

PULL BOX BONDING JUMPER 10 AWG GRN XLP	
FROM	TO

LIGHTING UF 12 AWG W/GROUND	
FROM	TO

EMERGENCY VEHICLE PREEMPTION	
FROM	TO

NOTES:
1. USE WHITE CONDUCTOR IN THE SIGNAL CABLE AS THE GROUNDED CONDUCTOR FOR ALL TRAFFIC SIGNAL INDICATIONS.
2. ENSURE THE GROUNDED CONDUCTOR IN THE FEEDER CABLE AND THE POLE CABLES ARE BOTH 12" LONGER THAN THE UNGROUNDED CONDUCTORS.
3. AT THE SIGNAL BASES, CONNECT ONE TERMINAL FROM THE PEDESTRIAN PUSH BUTTONS TO THE COLOR INDICATED IN THE CHART. CONNECT THE OTHER TERMINAL TO THE GROUNDED CONDUCTOR.
4. "OTHER" COLUMN MAY INCLUDE SHADOW BOX (BLANK OUT) SIGN.