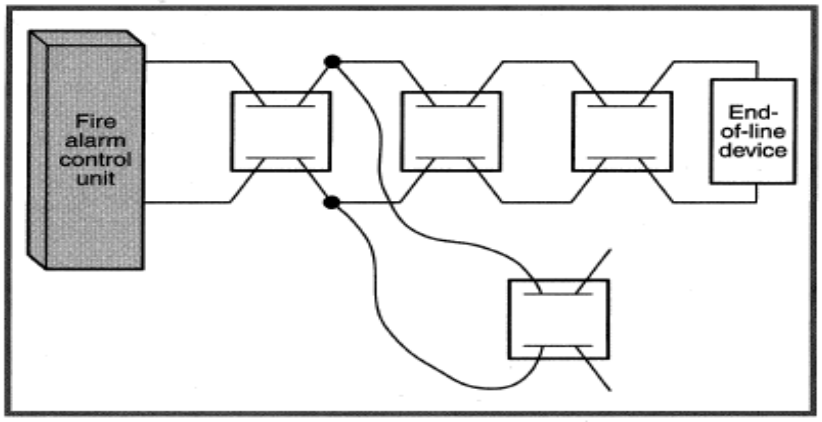
Styles and Performance of Circuits

This class will review the types of circuits typically used in the installation of fire alarm systems. Some of the principles behind the circuit approach and the methods of installation may be consistent with other low voltage systems. The focus of this document will be fire alarm circuits however and include code requirements as they relate to fire alarm systems.

There are a few terms that should be reviewed before proceeding. Many other useful definitions can be found in NFPA and industry manuals such as Fire Alarm Handbook and NICET Review Courses.

- **Ancillary**: A circuit that is intended for a supplementary function outside of the required components of the system circuit(s). This is **not** an auxiliary circuit.
- **Circuit:** A pathway providing connectivity of one device to another. This may include wireless pathways as well as fiber or "wire" (metallic conductors).
- **Fail Safe:** Used to describe a control circuit that upon loss of circuit integrity or connection will activate the item connected. This is typically accomplished by routing power to the coil of the outputs controlling relay in a normal state and eliminating power upon an alarm.
- **Fail Secure:** Used to describe a control circuit that initiates power to activate an output or output control relay. This circuit must be supervised to within three feet of the control item or relay to meet code.
- **T-tapping:** Extending circuit conductors in parallel using a single connection from the existing circuit to the added device. This is acceptable for some signaling line circuits; it is not to be used with initiating device circuits or notification appliance circuits.



Styles of Circuits:

The following tables can be found in NFPA 72 and give an overview of the different classes and styles of circuits. The survivability and related performance criteria determine which classification the circuit falls into. They are separated by the type of circuit as it relates to the category of devices the circuit connects.

Initiating Device Circuits connect devices such as manual stations, automatic detectors, sprinkler switches, and other inputs to the fire alarm system utilizing a “conventional” circuit routed to contacts or electronic connections designed to adjust resistance on the circuit. This approach supervises the wire that connects the devices using an end of line resistor at the furthest point of the circuit.

6.5* Performance of Initiating Device Circuits (IDC).

The assignment of class designations or style designations, or both, to initiating device circuits shall be based on their performance capabilities under abnormal (fault) conditions in accordance with the requirements of Table 6.5.

Table 6.5 Performance of Initiating Device Circuits (IDC)

Class	B			B			B			A			A		
Style	A			B			C			D			Eα		
	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC
Abnormal Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Single open	—	X	—	—	X	—	—	X	—	—	X	R	—	X	R
Single ground	—	X	—	—	X	R	—	X	R	—	X	R	—	X	R
Wire-to-wire short	X	—	—	X	—	—	—	X	—	X	—	—	—	X	—
Loss of carrier (if used)/channel interface	—	—	—	—	—	—	—	X	—	—	—	—	—	X	—

Alm = Alarm.
Trbl = Trouble.
ARC = Alarm receipt capability during abnormal condition.
R = Required capacity.
X = Indication required at protected premises and as required by Chapter 8.
α = Style exceeds minimum requirements of Class A.

Signaling Line Circuits connect intelligent devices to a microprocessor based fire alarm system often referred to as “addressable”. This approach supervises the devices primarily and relies less on the method of routing the circuit to the device often allowing “t-tapping.” This method does not rely on an end of line resistor, the last device on the circuit effectively supervising the circuit.

6.6* Performance of Signaling Line Circuits (SLC).

6.6.1 The assignment of class designations or style designations, or both, to signaling line circuits shall be based on their performance capabilities under abnormal (fault) conditions in accordance with the requirements of Table 6.6.1.

Table 6.6.1 Performance of Signaling Line Circuits (SLC)

Class	B			B			A			B			B		
Style	0.5			1			2α			3			3.5		
	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC
Abnormal Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Single open	—	X	—	—	X	—	—	X	R	—	X	—	—	X	—
Single ground	—	X	—	—	X	R	—	X	R	—	X	R	—	X	—
Wire-to-wire short	—	—	—	—	—	—	—	—	M	—	X	—	—	X	—
Wire-to-wire short & open	—	—	—	—	—	—	—	—	M	—	X	—	—	X	—
Wire-to-wire short & ground	—	—	—	—	—	—	—	X	M	—	X	—	—	X	—
Open and ground	—	—	—	—	—	—	—	X	R	—	X	—	—	X	—
Loss of carrier (if used)/channel interface	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—
Class	**B**			**B**			**A**			**A**			**A**		
Style	4			4.5			5α			6α			7α		
	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC	Alm	Trbl	ARC
Abnormal Condition	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Single open	—	X	—	—	X	R	—	X	R	—	X	R	—	X	R
Single ground	—	X	R	—	X	—	—	X	R	—	X	R	—	X	R
Wire-to-wire short	—	X	—	—	X	—	—	X	—	—	X	—	—	X	R
Wire-to-wire short & open	—	X	—	—	X	—	—	X	—	—	X	—	—	X	—
Wire-to-wire short & ground	—	X	—	—	X	—	—	X	—	—	X	—	—	X	—
Open and ground	—	X	—	—	X	—	—	X	—	—	X	R	—	X	R
Loss of carrier (if used)/ channel interface	—	X	—	—	X	—	—	X	—	—	X	—	—	X	—

Notification Appliance Circuits connect devices such as horns, bells, strobes, speakers and other outputs to the fire alarm system utilizing a “conventional” circuit routed to the device. This approach supervises the wire that connects the devices using an end of line resistor at the furthest point of the circuit. Supervision is accomplished by routing a reverse polarity supervisory current to detect the end of line resistor. Devises have a diode or electronic equivalent to prevent indication when the supervisory current is present.

6.7 Performance of Notification Appliance Circuits (NAC).

The assignment of class designations or style designations, or both, to notification appliance circuits shall be based on their performance capabilities under abnormal (fault) conditions in accordance with the requirements of Table 6.7.

Table 6.7 Notification Appliance Circuits (NAC)

Class	B		B		B		A	
Style	W		X		Y		Z	
	Trouble indication at protected premises	Alarm capability during abnormal conditions	Trouble indication at protected premises	Alarm capability during abnormal conditions	Trouble indication at protected premises	Alarm capability during abnormal conditions	Trouble indication at protected premises	Alarm capability during abnormal conditions
Abnormal Condition	1	2	3	4	5	6	7	8
Single open	X	—	X	R	X	—	X	R
Single ground	X	—	X	—	X	R	X	R
Wire-to-wire short	X	—	X	—	X	—	X	—

X = Indication required at protected premises.
R = Required capability.

Class "A" Circuits:

3-4.2.2.2* All styles of Class A circuits using physical conductors (e.g., metallic, optical fiber) shall be installed such that the outgoing and return conductors, exiting from and returning to the control unit, respectively, are routed separately. The outgoing and return (redundant) circuit conductors shall not be run in the same cable assembly (i.e., multi-conductor cable), enclosure, or raceway.

Exception: The outgoing and return (redundant) circuit conductors shall be permitted to be run in the same cable assembly, enclosure, or raceway under any of the following conditions:

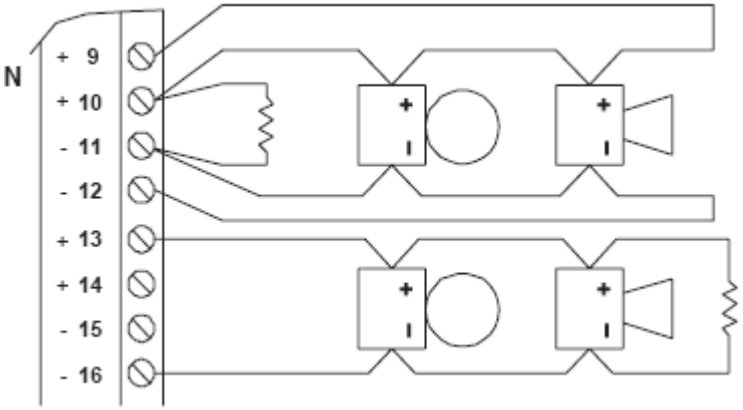
(1) For a distance not to exceed 3 m (10 ft) where the outgoing and return conductors enter or exit the initiating device, notification appliance, or control unit enclosures.

(2) Single conduit/raceway drops to individual devices or appliances.

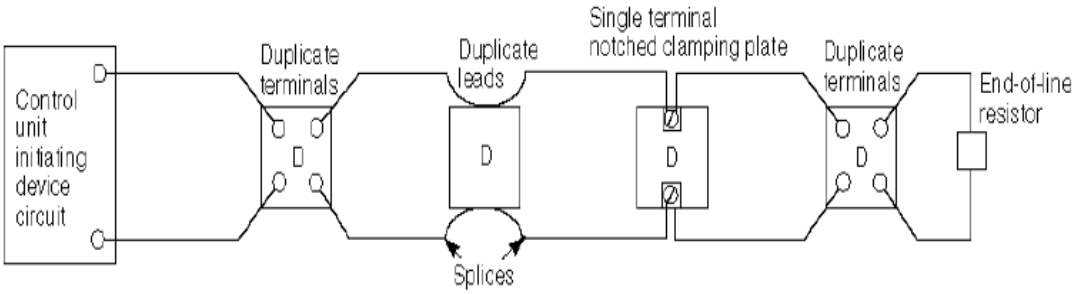
(3) Single conduit/raceway drops to multiple devices or appliances installed within a single room not exceeding 92.9 m2 (1000 ft2) in area.

*A.3.4.2.2.2 A goal of 3.4.2.2.2 is to provide adequate separation between the outgoing and return cables. This separation is required to help ensure protection of the cables from physical damage. The recommended minimum separation to prevent physical damage is 305 mm (1 ft) where the cable is installed vertically and 1.22 m (4 ft) where the cable is installed horizontally.

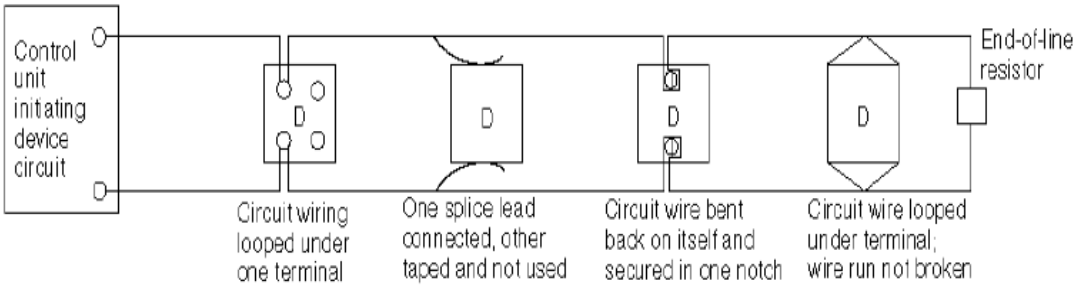
In the below illustration, the top circuit is class A, while the lower circuit is class B. If the conductor leaving terminal 13 was opened prior to connection to the first device, both devices connected to that circuit would not operate. However if the conductor leaving terminal 9 was opened prior to the first device, the devices would both have a complete circuit fed from terminal 10, allowing the devices to operate.



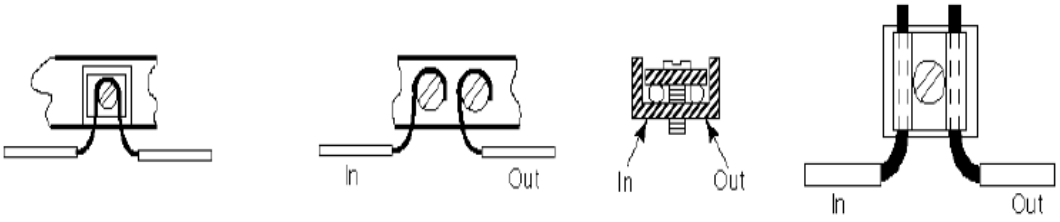
Device Termination:
Regardless of other installation considerations and methods, termination of the devices does have an consequence on the performance of the circuit. Without proper termination and installation methods at the device, the circuit may not achieve the desired performance.



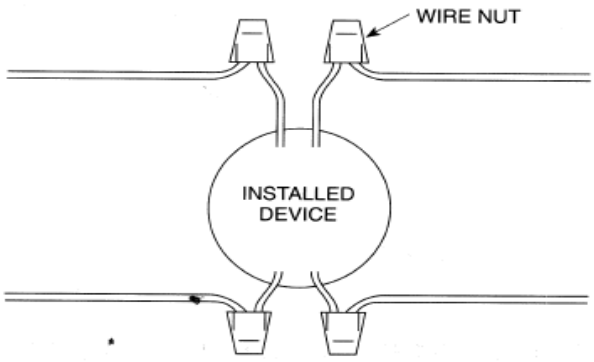
Correct wiring method — two-wire detectors



Incorrect wiring method — two-wire detectors

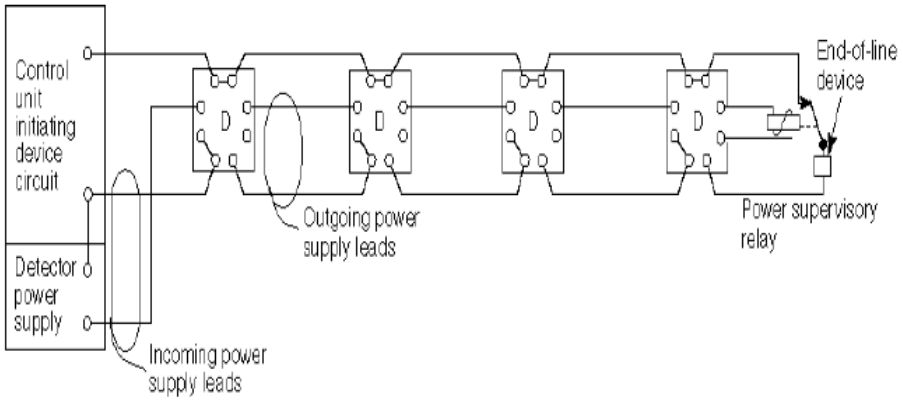


Incorrect **Correct — separate incoming and outgoing conductors**

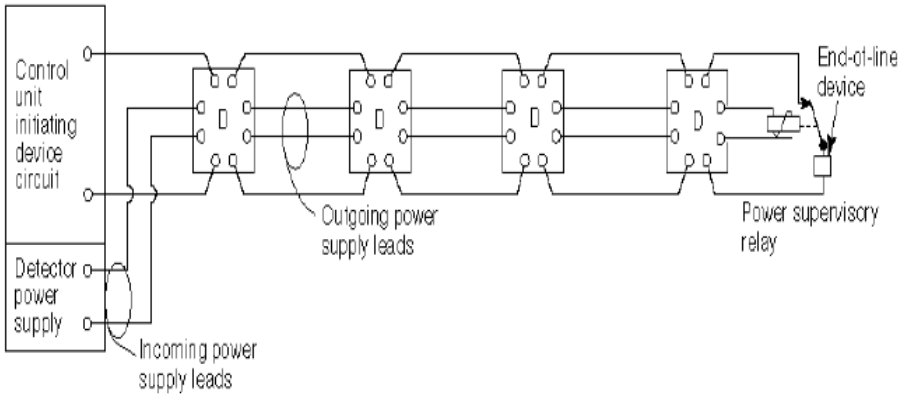


Four Wire Circuit:

It is important to differentiate between class "A" and 4-wire circuits. 4-wire circuits refer to initiating circuits that utilize a separate pair to provide power to the device separate from the initiating or signaling line circuit. This configuration does not draw power from the initiating or signaling line circuit, but requires that the separate power circuit be supervised at the end of the circuit(s).



Illustrates four-wire smoke detector employing a three-wire connecting arrangement. One side of power supply is connected to one side of initiating device circuit. Wire run broken at each connection to smoke detector to provide supervision.



Illustrates four-wire smoke detector employing a four-wire connecting arrangement. Incoming and outgoing leads or terminals for both initiating device and power supply connections. Wire run broken at each connection to provide supervision.

D = Detector

Sprinkler Connections:
3-8.3.2.4.1 A dry-pipe or preaction sprinkler system supplied with water by a connection beyond the alarm-initiating device of a wet-pipe system shall be equipped with a separate waterflow alarm-initiating pressure switch or other approved means to initiate a waterflow alarm.
3-8.3.2.4.2 The number of waterflow switches permitted to be connected to a single initiating device circuit shall not exceed five.
3-8.3.3.1 The provisions of 6.8.5.7 shall apply to the monitoring of sprinkler systems, other fire suppression systems, and other systems for the protection of life and property for the initiation of a supervisory signal indicating an off-normal condition that could adversely affect the performance of the system.
3-8.3.3.1.1 The number of supervisory devices permitted to be connected to a single initiating device circuit shall not exceed 20.

3-8.3.1.2 For fire alarm systems employing automatic fire detectors or waterflow detection devices, at least one fire alarm box shall be provided to initiate a fire alarm signal. This fire alarm box shall be located where required by the authority having jurisdiction.

Evacuation Systems:
3-8.4.1.1.3 The system shall be designed so that failure of equipment or a fault on one or more installation wiring conductors of one notification appliance circuit shall not result in functional loss of any other notification appliance circuit.
3-8.4.1.1.4 All circuits necessary for the operation of the notification appliances shall be protected until they enter the evacuation signaling zone that they serve. Any of the following methods shall be considered acceptable as meeting the requirements of this subsection:
(1) A 2-hour rated cable or cable system
(2) A 2-hour rated shaft or enclosure
(3) A 2-hour rated stairwell in a building fully sprinklered - NFPA 13

Combination Systems:
3-8.2.2 If common wiring is used for combination systems, the equipment for non-fire alarm systems shall be permitted to be connected to the common wiring of the system. Short circuits, open circuits, or grounds in this equipment or between this equipment and the fire alarm system wiring shall not interfere with the monitoring for integrity of the fire alarm system or prevent alarm, supervisory, or fire safety control signal transmissions.

An example of this is the keypad connections for the primary fire alarm keypad on an Ademco Vista-100 alarm panel. The primary fire alarm keypad utilizes an isolated connection so that other security keypads will not adversely affect the fire alarm portion of the system.

Sub-panel connections:
3-8.1.2.1 Each interconnected control unit shall be separately monitored for alarm, trouble, and supervisory conditions.

Trouble Contacts:
Automatic fire alarm signal initiation devices that have integral trouble signal contacts shall be connected to the initiating device circuit so that a trouble condition within a device does not impair alarm transmission from any other initiating device.

This requirement also extends to multiple devices connected to the same circuit. In a standard circuit configuration the circuit shall be connected to alarm input or output control terminations on all devices on the circuit ahead of any terminations to trouble contacts.

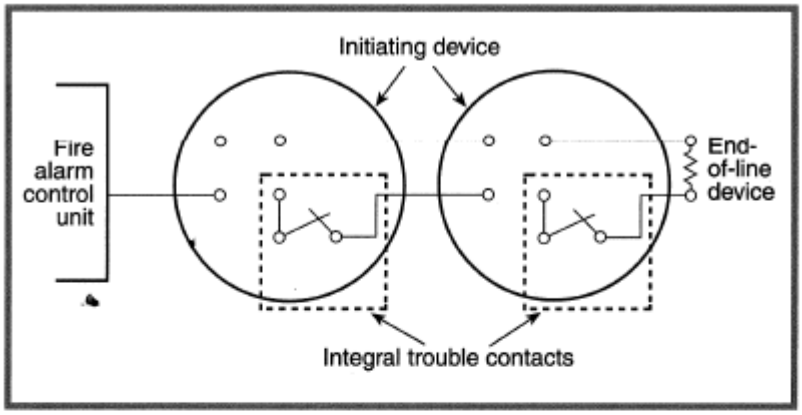


Exhibit 3.4 *Incorrect method of connection of integral trouble contacts. (Source: Hughes Associates, Inc., Warwick, RI)*

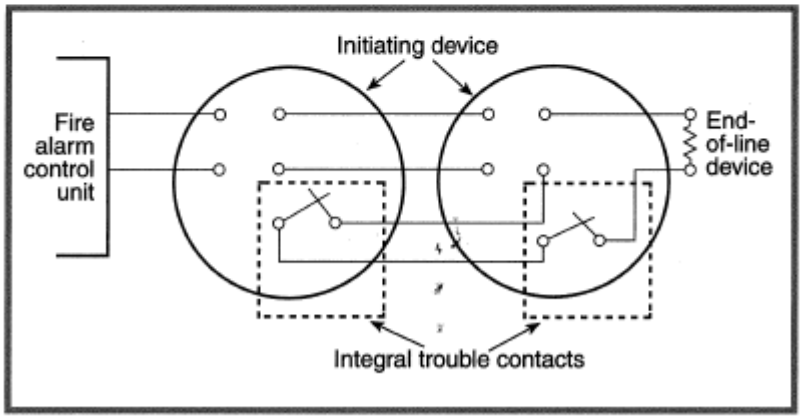


Exhibit 3.5 *Correct method of connection of integral trouble contacts. (Source: Hughes Associates, Inc., Warwick, RI)*