Network Length and Voltage Drop

The two primary factors limiting a fieldbus segment length are (1) the protocol communication limits and (2) the acceptable voltage drop. Each of the protocols limits the segment and, in some protocols, the drop lengths. (See the protocol specifications in each section on length for each of the protocols.) However, another limiting factor, which must be taken into account, is the voltage drop experienced from current flow over the network.

Factors affecting voltage drop include:

- Current flow over the network
- Barrier voltage output (repeaters) or resistance (zener barrier)
- Cable and connector resistance

The acceptable voltage range of the protocol also dictates the amount of voltage drop that can be tolerated. Operating voltage ranges for FieldLink supported protocols are listed in ***Figure 1***.

Figure 1

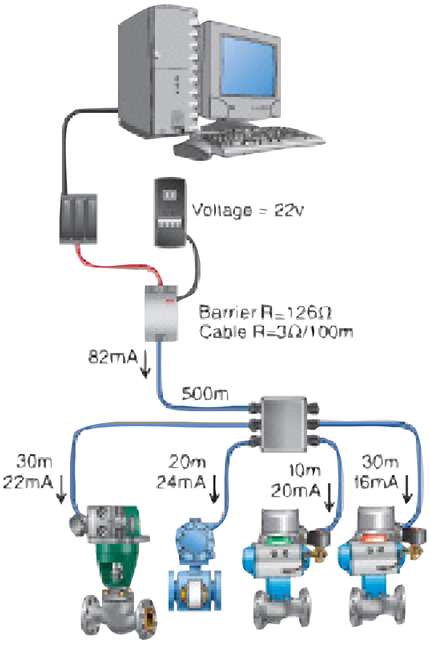
Protocol	Operating Voltage Range
AS-Interface	26.5 to 31.6 VDC
DeviceNet	11 to 25 VDC[1]
Profibus PA	9 to 32 VDC
Foundation Fieldbus H1	9 to 32 VDC

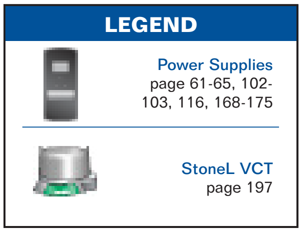
1. Power supplied on separate wires from communication signal.

Protocols such as Modbus RS485, DeviceNet and PROFIBUS-DP have a pair of wires for signal and a separate pair for powering the device and auxiliary outputs. For these protocols the acceptable voltage drop may be dictated by the auxiliary load requirements (solenoids, relays, etc.) and the manufacturer's specific requirements for the device.

Protocols such as AS-Interface, PROFIBUS-PA and Foundation Fieldbus H1 have the signal overlaid onto the power carrying wires (2-wire network). Voltage levels on these protocols are dictated by the requirements of the standard

Intrinsically Safe Network Example
(FF H1 and PROFIBUS-PA)





Using the 61158-2 physical layer (Foundation Fieldbus H1 and Profibus PA) with an instrinsic safety barrier, the voltage drop is calculated as follows:

- Barrier voltage drop
  $126\Omega \times .082A = 10.3V$
- Cable voltage drop (generalized worst case)
  $(530m/100m) \times 3\Omega \times .082A = 1.3V$
- Total voltage drop
  (barrier drop + cable drop + protected drop connector)
  $10.3V + 1.3V + 1.0 = 12.6V$

Minimum voltage available to the network is 9.4V, (22V – 12.6V). Since the minimum voltage allowed is 9V (see ***Figure 1***) this is marginal.

By substituting field devices with an average current draw of 16 mA, the voltage drop is re-calculated as follows:

4 devices x 16mA/device = 64mA

- Barrier voltage drop
  $126\Omega \times .064A = 8.1V$
- Cable voltage drop
  $(530m/100m) \times 3\Omega \times .064A = 1.0V$
- Total voltage drop
  (barrier + cable + protected drop connector)
  $8.1V + 1.0V + 1V = 10.1V$

Minimum voltage available to the network is 11.9 V. This is above the 9V minimum and is acceptable.

AS-Interface Voltage Drop Example

Current Level for Quartz VCTs

AS-I module operating current: 20mA max.

AS-I module output current to solenoid:

Given - 2.4 watt coil @ 24VDC (other vendor)

Given - 28VDC AS-I module output voltage

- Standard coil current → 2.4W/24V = 0.100A
- Coil resistance → 24V/.100A = 240Ω
- AS-I output current → 28V/240Ω = 0.117A

Total AS-I Current:

0.020A + 0.117A = 0.137A or 137 mA

Current Level for Axiom VCTs

AS-I module operating current: 20mA max.

AS-I module output current to solenoid:

Given - 0.50 watt coil @ 24VDC (integral)

Given - 28VDC AS-I module output voltage

- Standard coil current → .05W/24V = 0.021A
- Coil resistance 24V/.021A – 1143Ω
- AS-I output current → 28V/1143Ω = 0.025A

Total AS-I Current:

0.020A + 0.025A = 0.045A or 45 mA

The AS-I network is able to carry significant current levels enabling field devices to control conventional coils for solenoid and relay operation. Voltage drop due to cable length becomes a consideration at higher current levels.

The voltage drop calculations for the network below are as follows:

Total current consumption on network
12 x .137A (Quartz VCTs) + 12 x .045A (Axiom VCTs) = 2.19A

- Cable voltage drop
  to 1st drop connector → 2.19A x 40m x (2Ω/100m) = 1.75V
  to 2nd drop connector → 2.01A x 3m x (2Ω/100m) + 1.75V = 1.87V
  ...to 6th drop connector → 1.87V + 1.83A x 3m x (.02) + 1.65A x 8m x (.02) + 1.11A x 3m x (.02) + .56A x 3m x (.02) = 2.36 volts

- Drop connector voltage drop
  → 1.0V (protected drop connector) + .137A x 2m x (.02) = 1.01V

- Total voltage drop (worst case)
  (Cable drop + connector drop)
  → 2.36V + 1.01V = 3.37V

Voltage available at the last VCT under worst case conditions is 30V less 3.37V, or 26.6 Volts. Since the system will operate properly above 26.5 volts this circuit is acceptable. However, if there are concerns that the circuit is marginal, a lower power solenoid may be selected for the Quartz VCT, or Axioms may be used for the entire network, which will provide an additional margin of reliability.