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Tutorial DeviceNet

1 - Introduction

DeviceNet is a digital, multi-drop network to connect sensors, actuators and automation systems in general. It was developed for maximum flexibility between field equipments and interoperability among different manufacturers.

Originally introduced in 1994 by Allen Bradley, the DeviceNet transfered its technology to ODVA in 1995. (Open DeviceNet Vendor Association) is a non-profit organization made up by hundreds of companies worldwide that maintains, promotes and disseminates the DeviceNet and networks based on the CIP (Common Industrial Protocol) Currently, 300 companies are registered members, and more than 800 offer DeviceNet products all over the world.

The DeviceNet network is classified as a devicebus network, whose characteristics are high speed, byte-level communication that include analogical equipment communication and high diagnostic power by the network devices (as shown on figure 1.1).

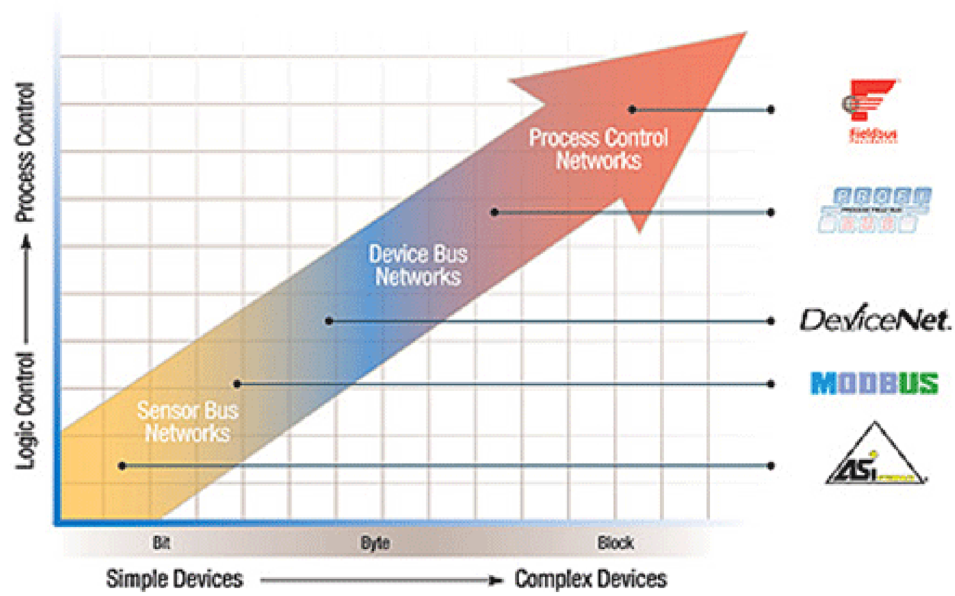


Figure 1.1: *Technological Scenes – Source: ATAIDE, F.H. (2004)*

The DeviceNet technology is an open automation standard aiming at transporting 2 types of information:

- Cyclic data from sensors and actuators directly related to control and
- Non-cyclic data indirectly relates to control, like configuration and diagnostics.

The cyclic data represent information exchanged periodically between the field equipment and the controller. On the other hand, the non-cyclic are information exchanged eventually during the configuration or the field equipment diagnostics.

The physical layer and the access to the DeviceNet network is based on the CAN (Controller Area Network) technology and the CIP protocol upper layers, which define an architecture based on objects and the conection between them.

The CAN was originally developed by BOSCH for the European automobile market to substitute the expensive wiring for a low-cost network for cars. As a result, the CAN provides fast and reliable response for application mainly used on the automotive area.

A DeviceNet network may have up to 64 devices, with one device on each node addressed from 0 to 63. Anyone of them may be used. There is no restriction for using them, although the use of the 63 is not recommended, as this is normally used for commissioning.

See below an example of a DeviceNet network.

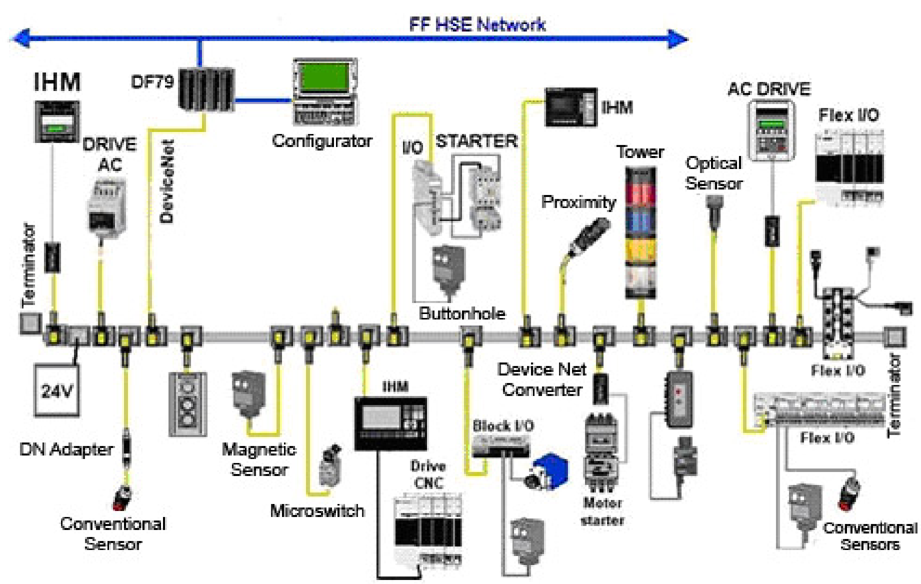


Figure 1.2: *Example of a DeviceNet network*

1.2 - Características da rede

- Topology based on trunk line (main trunk) with droplines (derivations).
- The trunkline must be made of a thick DeviceNet cable and the droplines with a thin or flat cable. Similar cables may be used provided that their electrical and mechanical characteristics are compatible with the specs for DeviceNet cables.
- Allows the use of repeaters, bridges, routers and gateways
- Supports up to 64 nodes, including the master, addressed from 0 to 63 (MAC ID).
- Double-pair cable: one for 24V power and the other for communication.
- Insertion and removal by hot process, without disturbing the network.
- Supports equipments powered by 24V network or having their own source.
- Uses open or sealed connectors
- Protection against inversion of connections and short circuits.
- High network current capacity (up to 16 A).
- Uses shelf-power sources.
- Several sources may used on the same network to meet application needs involving load and cable length.
- Selectable communication rate: 125, 250 e 500 kbps.
- Communication based on I/O connections and question and answer model.
- Diagnostics for each equipment and the network.
- Efficient transportation of discrete and analogical control data.
- Detection of duplicated network address.
- Extremely robust communication mechanism for electromagnetic interference.

1.2.1 - DeviceNet Protocol

DeviceNet is one of the three open technologies and standardized network, whose application layer uses the CIP (Common Application Layer). Together with ControlNet and EtherNet/IP it has a common object structure, in other words, it is independent from the phisical layer and the data link layer. This layer is a standard application layer that united to open hardware and software interfaces constitutes a universal connection platform between components in an automation system, from plant floor to internet level. Figure 1.2 shows a CIP overview in an OSI model.

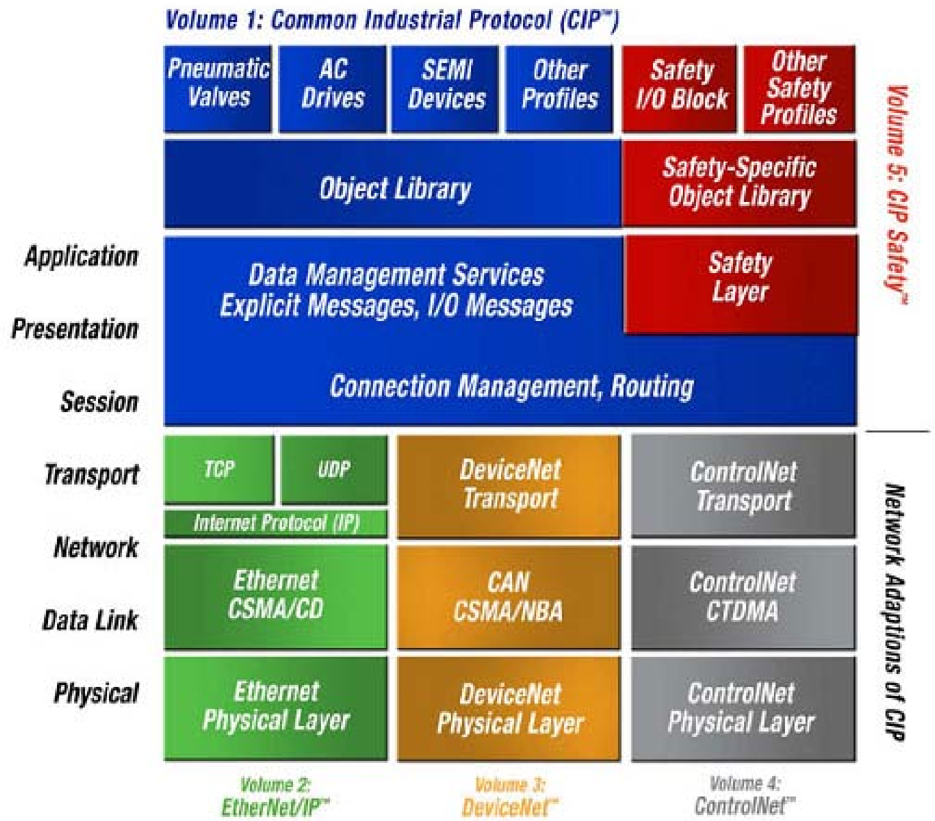


Figure 1.3 *– The OSI model for CIP objects (source: ODVA)*

The CIP has two main functions:

- Transportation of control data in the I/O devices
- Transportation of configuration information and diagnostics of the system being controlled

A DeviceNet node is then modeled by a set of CIP objects that encapsulate data and services determining its behavior.

The Object Model

A DeviceNet node is modeled as a collection of objects. An object provides an abstract representation of a particular component in a product. An object example and an object class have attributes or data that provide services (methods or proceedings) and implement behaviors. nodes attributes, examples, classes and addresses (0 – 63) are addressed with a number.

There are mandatory objects (contained in every device) and optional objects. Optional objects are those that mold the device according to its category (also known as profile), such as: AC/DC Drive, bar code reader, or pneumatic valve. For being different, each one of them will also have a different set of objects.

For more information, see the DeviceNet specification (http://www.odva.org/)

The Data Link Layer

DeviceNet uses the CAN standard on the data link layer. The minimum overhead required by the CAN protocol on the data link layer improves the DeviceNet work when dealing with messages. The DeviceNet data frame uses only one data frame type from the CAN protocol (among other existing ones). The protocol uses a minimum band width to transmit CIP messages. The DeviceNet data frame format is shown on figure 1.4.

1bit	11 bits	1 bit	6 bits	0-8 bytes	15 bits	1 bit	1 bit	1 bit	7 bits	3 bits
Start of Frame	Identifier	RTR bit	Control Field	Data Field (0...8 bytes)	CRC Sequence	CRC Delimiter	Ack Slot	Ack Delimiter	End of Frame	Interframe Space
Arbitration Field										

Figure 1.4 *– Data frame format*

1.2.2 - Communication Modes

The DeviceNet protocol has two basic types of message - cyclic I/O and explicit message. Both are suitable for a particular type of data, as described below:

- ***Cyclic I/O***: synchronous telegram type used for processing priority data between a producer and one or more consumers. They are divided according to the data exchange method. The main ones are:
  - ***Polled:*** method of communication where the master sends a telegram to each one on its slave list (scan list). As soon as the request is received, the slave responds promptly to the master. This process is repeated until everyone is consulted and the cycle restarts.
  - ***Bit-strobe***: method of communication where the master sends the network a telegram with 8 data bytes. Each bit of these bytes represents a slave that responds according to its program, if addressed.
  - ***Change of State***: method of communication where the exchange of data between master and slave only occurs if the values monitored/controlled change, up to a time limit. When this limit is reached, the transmission and the reception will go on, even without alterations. The configuration of this time variable is executed in the network configuration program.
  - ***Cyclic:*** another method of communication similar to the previous one. The only difference is in the message production and consumption.   In this type, every data exchange is performed in regular time periods regardless of being altered or not. These intervals are also adjusted on the network

configuration software.

- ***Explicit Message***: type of non-priority, general use telegram. Used mainly in non-synchronous jobs like parameterization and configuration of equipments.

1.2.3 - Configuration File

Every DeviceNet node has a configuration file associated, called EDS (Electronic Data Sheet). This file keeps important data on the device work and must be registered on the network configuration software.

1.3 - Physical layer and Transmission Means

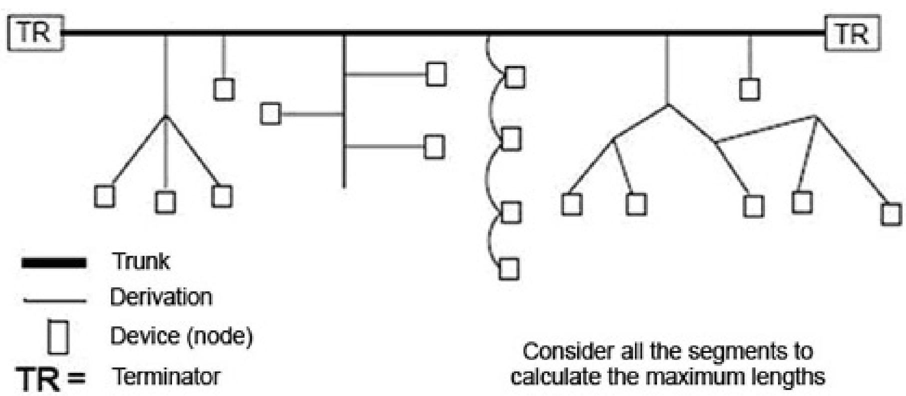
The DeviceNet uses a trunk line/drop line type of network topology that allows for both the signal wiring and the power source to share the same cable. The power supplied by a source connected directly to the network has the following description:

- 24Vdc;
- DC outlet isolated from the AC inlet;
- Current capacity compatible with the installed equipments;
- The total length of the network varies according to the transmission rate (125,250, 500Kbps)

Consult also the document “DeviceNet Cable System - Planning and Installation Manual - http://www.odva.org/” for more information on how to install the DeviceNet network.

1.3.1 - Network topology

The DeviceNet specs define the acceptable topology and components. The topology variations are also showed below:



The specs also detail the ground system, the mix of thick and thin cables, termination and power source.

The basic trunk line - drop line topology uses 1 cable (two twisted pairs separated for power and signal). Thick or thin cable may be used for trunk lines or drop lines. The distance between network extremes varies with the data rate and cable length.

RATE DATA	125 Kbps	250 Kbps	500 Kbps
Length of main bus with thick-trunk cable	500 m	250 m	100 m
Length of main bus with thin-trunk cable	100 m	100 m	100 m
Maximum length of a main bus maximum-drop	6 m	6 m	6 m
Accumulated length of a main bus cumulative-drop	156 m	78 m	39 m

1.3.2 - Cables

There are 4 types of standard cables: thick, medium, thin and flat. Most commonly used are the thick cable for the trunk line and the thin cable for the dropline.

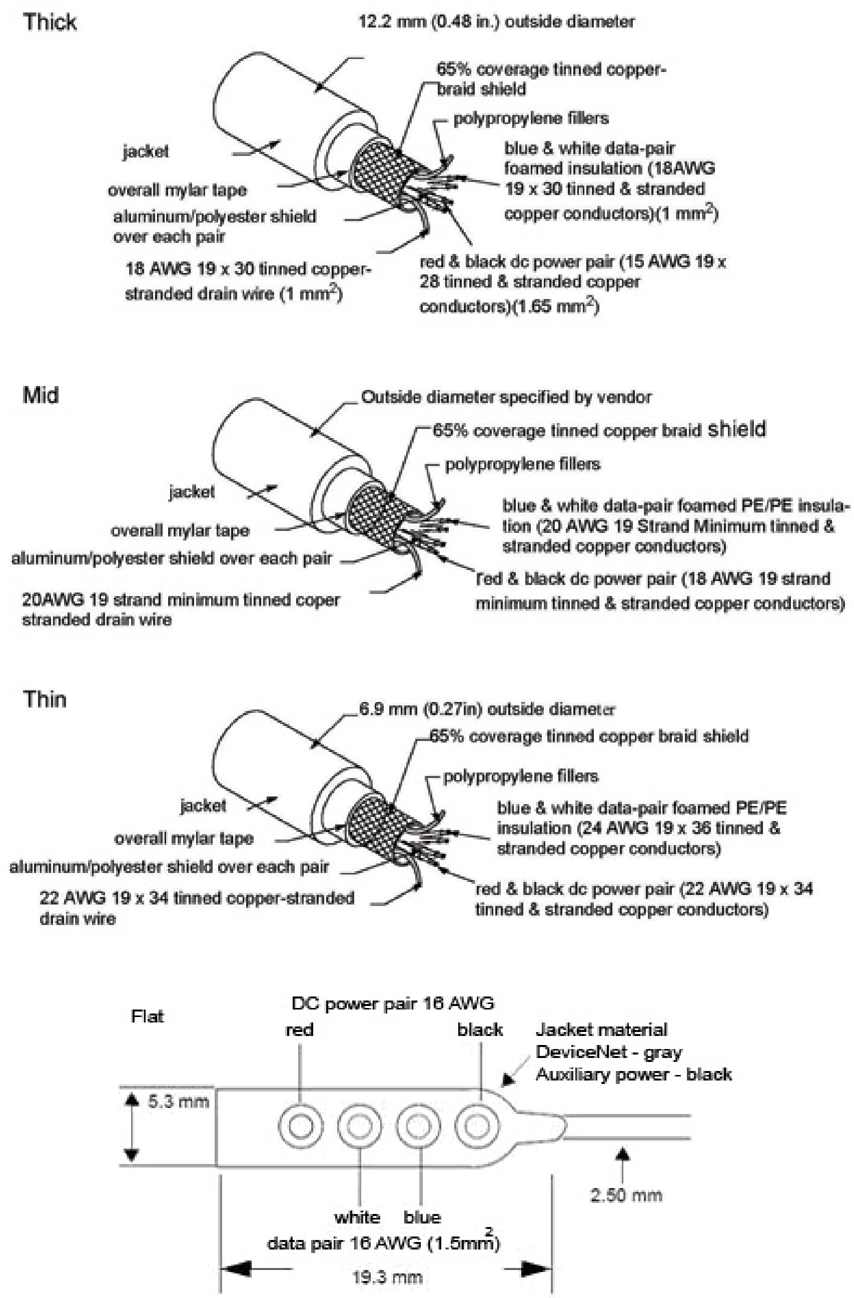


Figure 3.66 *– Anatomy of DeviceNet standard cables*

The most used DeviceNet thin and thick cables have 5 conductors identified and used according to the following table:

Wire Color	Signal	Round Cable	Flat Cable
White	CAN_H	DN Signal	DN Signal DN
Blue	CAN_L	DN Signal	DN Signal
Naked wire	Drain	Shield	Not used
Black	V-	Power	Power
Red	V+	Power	Power

Table 1 *– Color scheme of DeviceNet cables*

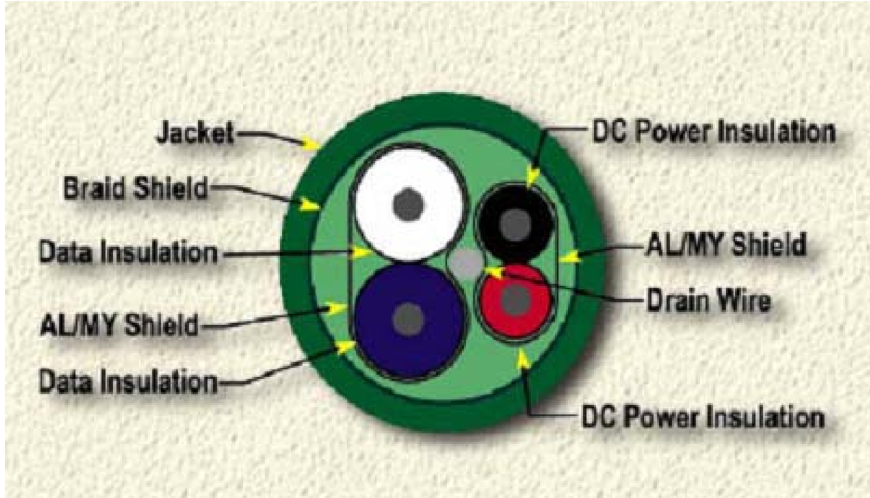


Figure 3.67 *– View of DeviceNet Standard cable components*

Power Taps can be added at any network point, making possible obtaining redundancy on network power source. The trunk line current is 8 amp on a thick wire and 3 amp maximum current on a thin wire. An optic isolated project option allows for externally energized devices (e.g. startup of AC drivers and solenoid valves) sharing the same bus cable. Other CAN-based networks provide only a single power source for the entire network.

The devices can be powered directly on the network and communicate through the same cable. Nodes can be removed or inserted on the network without turning the network off.

1.3.3 - Connectors

There are three basic connector types: open, mini-sealed and micro-sealed. Choosing which depends on the application and the characteristics of the equipment or the connection needed. See on the following figures the wire code for each type of connector.

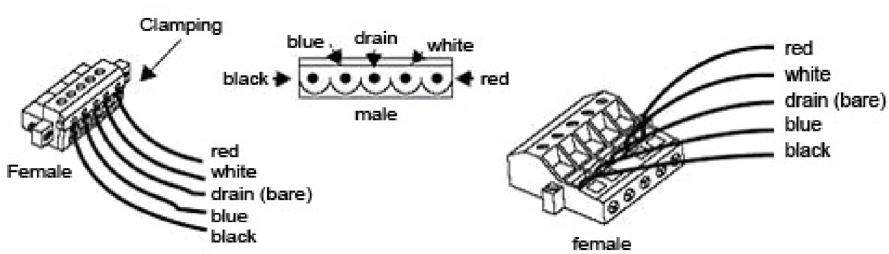
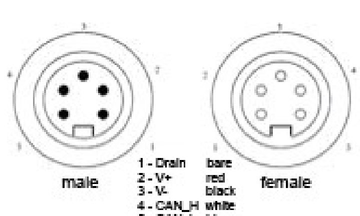


Figure 3.67 *- Open style connector*



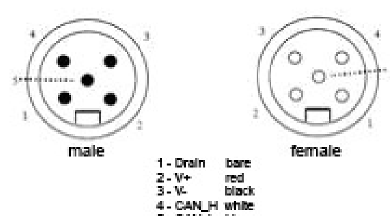


Figure 3.68 – *Mini-sealed connector*

Figure 3.69 *– Micro-sealed connector*

1.3.4 - Network terminators

The DeviceNet network terminators help minimize communication reflections and are essential for the network to work. The termination resistors (121W, 1%, ¼ W) must be located on the trunk line ends, between the white and blue CAN_H and CAN_L wires.

- Do not locate the terminator inside an equipment or a connector that, when removed, also removes the terminator causing a general failure on the network. Leave the terminator always independent and insulated on the trunk line ends, preferably inside the protection boxes or the passage boxes.
- To check if the terminations are on the network, measure the resistance between the white and blue CAN_H and CAN_L wires, with the network turned off: the resistance measured must be between 50 and 60 Ohms.

Wire Color	Signal	Usage Round	Usage Flat
white	CAN_H	signal	signal
blue	CAN_L	signal	signal
bare	drain	shield	n/a
black	V-	power	power
red	V+	power	power

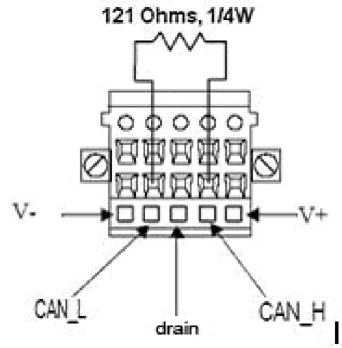


Figure 3.70 *– Connection of the termination resistors.*

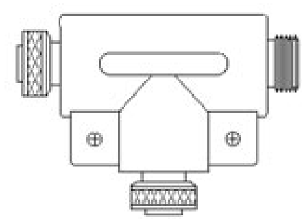
1.3.5 – TAP derivators

There are several types of TAP derivators to be connected in a DeviceNet type of network. They are classified as:

T-Port Tap

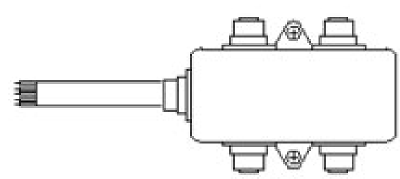
1.3.5.1 - "T-Port TAP" Derivation

The T-Port derivator connects a simple device or a drop line derivation through a fast-plug style connector.



1.3.5.2 –DevicePort device Derivation

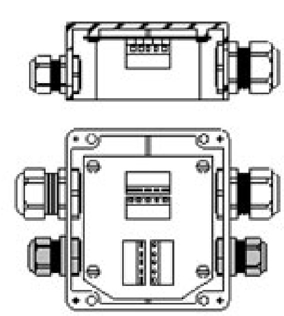
DevicePort are sealed components that connect to the trunk line via drop line through fast disconnection connector type. Device Ports exist only for devices compatible with DeviceNet network and can connect 4 or 8 devices.



DeviceBox Tap

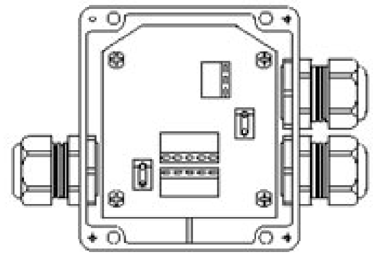
1.3.5.3 - DeviceBox type Derivation

DeviceBox are passive elements that connect directly the DeviceNet devices to the trunk line through terminal connections up to 8 knots. They have removable sealed cover that allow for mounting on the machine or the plant floor.



1.3.5.4 - PowerTap power source Derivation

The PowerTap has over-current protection for the thick type cable. With diode protection it is possible to use multiple PowerTaps, which makes possible using several power sources.



1.3.6 - Led Indicators

Although a DeviceNet product do not require indicators, if this is the case, they must comply with the DeviceNet specifications. A Module Status Led and a Network Status Led, or a combination of both are recommended.

The indicator(s) consist of a green-red Led that can show On, Off and Blinking signals. The Module Status Led indicates if the device is powered and operates properly. The Network Status Led indicates the status of the communication link.

For more information, visit the ODVA site
http://www.odva.org/