APPLICATION NOTE

ANE019 | M12 A-Coded Circular Connectors
Use Cases

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01. INTRODUCTION

M-12 Circular Connectors are sturdy, mechanically and environmentally resistant components fit for industrial and outdoor uses. Therefore, a sizable number of field bus protocols use them as electrical and mechanical interface between end-devices, as part of their physical layer (as per the OSI model formalism).

M12 circular connectors exist in several codings, for example A, B, D or X among others. However, in this application note, we are going to focus on the use cases of the M12 A-Coded from Würth Elektronik product range in physical layers. The focus will be on industry-oriented interconnect

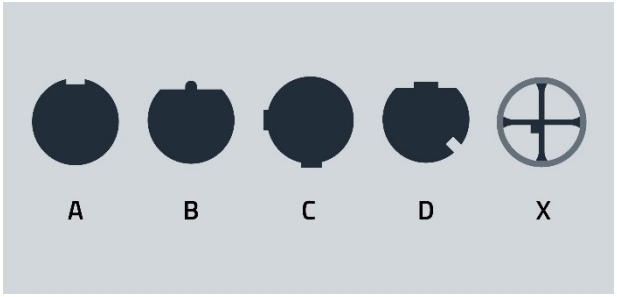

Figure 1 - *M12 coding overview*

02. M12 A-CODED IN ETHERNET-OVER-TWISTED-PAIR PHYSICAL LAYER

Ethernet over Twisted Pair (EOTP) is one of the most important physical layers for Ethernet and a sizeable amount of industrial protocols work on the Ethernet data link and physical layers standards. However, the M12 are not the native connectors upon which the EOTP interface has been developed.

The Ethernet standard serves as a basis for the EtherCAT, EtherNet/IP, PROFINET, CC-Link IE, POWERLINK, SERCOS III and Modbus TCP protocols.

2.1 10BASE-T

The 8-pin M12 A-Coded circular connector can be used as a replacement for the RJ45 in an ANSI/TIA-568 Category 3 Cabling system, used for the 10 Mb/s 10BASE-T Ethernet interface. The Cat 3 cable is made of four 100 ohm differential impedance twisted pairs.

In this case, when wiring a RJ45 (8P8C Modular Plug) to a M12 A-Coded circular connector, the assignment in Figure 2 is advised.

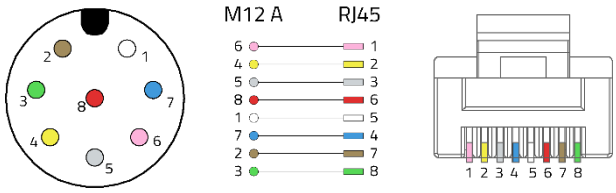

Figure 2 - *10BASE-T M12 to RJ45 pin assignment*

When wiring a M12 A-Coded circular connector to a M12 A-Coded circular connector, a pin assignment as shown in Figure 3 is recommended.

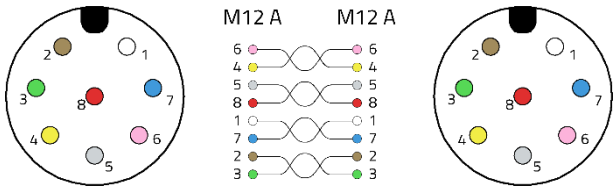

Figure 3 - *10BASE-T M12 to M12 pin assignment*

These pin assignments minimize the delay skew between contacts of the same pair. This wiring is a widespread configuration for A-Coded M12 EOTP cabling. While 10BASE-T only uses 2 pairs for signal transmission, it is not advised to only have 2 pairs in the cable nor to use a 4-pin A-Coded circular connector as it may cause confusion with other widespread uses. For 2-pair EOTP cabling with M12, a D-coded connector is recommended.

2.2 100BASE-T

For 100 Mb/s EOTP standards, D-Coded circular connectors will generally be used with 2-pair cables. However, it is possible to make an interface using an A-Coded circular connector by following the same pin assignment as for the 10-BASE-T.

When designing such an interface, the signal integrity has to be taken into consideration. The entire cable assembly, including connectors, have to fit within the category of the cable assembly as per ANSI/TIA-568. Each of the male/female connector pair and the cable itself will have

losses and crosstalk budgets not to exceed. It is advised to test the S-parameters of such an interface, depending mostly of the cable category and cable length.

2.3 Higher BASE-T

For higher data rate EOTP standards, X-Coded circular connectors will generally be used with 4-pair cables. However, it is possible to make an interface using a M12 A-Coded circular connector by following the same pin assignment as for the 10-BASE-T as with 100BASE-T, and with the same signal integrity considerations. Such an interface will generally need to have a much shorter cable length.

Signal integrity performances of M12 A-Coded circular connectors and cable assemblies will be the subject of a further Application Note.

03. M12 A-CODED IN IO-LINK PHYSICAL LAYER

IO-Link is a standardized digital data transfer and power supply protocol between a programmable hub and sensors or actuators peripherals.

IO-Link describes the electromechanical interface as 4 or 5-pin A-Coded M12 circular connectors linked with a 3 or 5-wire 20 meter cables. The port associated with 3-wire cable will be called "Class A" and the port associated with 5-wire cable will be called "Class B".

The Master hub ports will always be 5-pin M12 A-Coded receptacles. On the Device port, it can be a captive cable, or a M12 A-Coded 4 or 5-pin depending on the wanted cross-compatibility.

Let us have a view on the needed pinouts for different Class A and Class B connections.

3.1 Class A, 3-wire cable

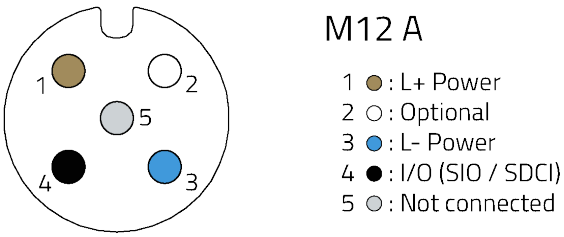

Figure 4 - *Class A port on the Master side will be a 5-pin M12 A-Coded receptacle*

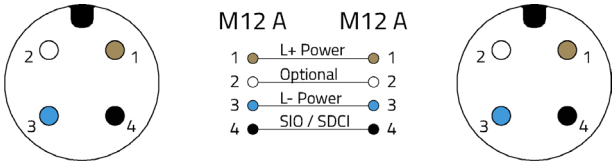

Figure 5 - *Class A ports on the cable side will be 4-pin M12 A-Coded plugs*

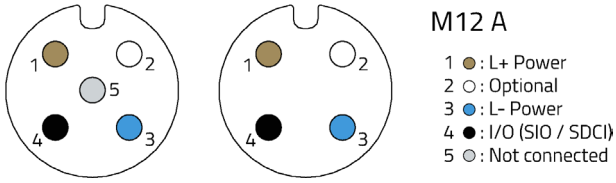

Figure 6 - *Class A port on the Device side will be a 4- or 5-pin M12 A-Coded receptacle*

3.2 Class B, 5-wire cable

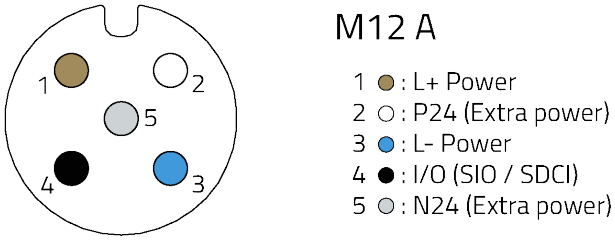

Figure 7 - *Class B ports and cables on Hub and Device sides will be 5-pin M12 A-Coded receptacles*

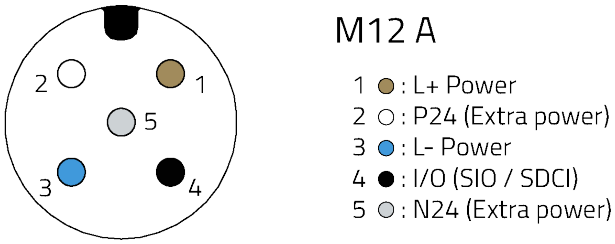

Figure 8 - *IO-Link Class B2 plug*

04. M12 A-CODED IN USB 2.0 PHYSICAL LAYER

The Universal Serial Bus is one of the most common connectivity layers on the market. USB in its 2.0 revision can be used as a power supply and high-speed data bus. M12 A-Coded circular connectors can be used to offer a mechanically sturdier ending to a USB 2.0 cable.

USB 2.0 cable assemblies use 2 power pins for VBUS and GND and a 90 ohm differential impedance twisted pair for the USB signal. The 4-pin M12 A-coded circular connector can be used to transmit USB signaling.

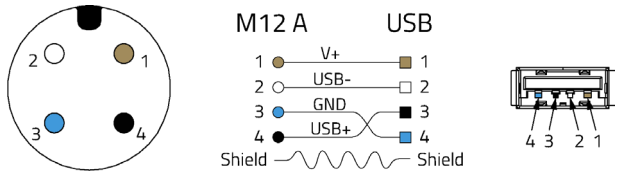

Figure 9 - *M12 A-Coded plug to USB 2.0 pinout*

If the termination is a mini or micro USB connector, the ID pin can be wired as such on a 5-pin M12 A-coded circular connector. Connector shielding can be connected to the cable shielding braid.

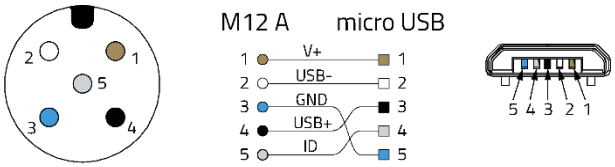

Figure 10 - *M12 A-Coded plug to micro USB 2.0 connector*

USB cables generally have lengths of 1 to 3 m. Connector shielding can be connected to the cable shielding braid.

05. M12 A-CODED IN IN INDUSTRIAL BUS SYSEMS

5.1 M12 A-Coded in CANbus Physical Layer

The CANopen and DeviceNET use the CANbus layer to operate. While it was initially designed to use a small form-factor D-SUB connector, a popular interface for the CANbus is the 5-pin M12 A-coded circular connector.

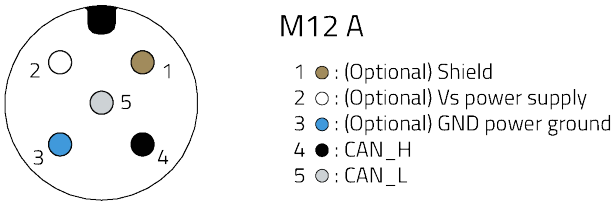

Figure 11 - *CANbus pinout at 5-pin M12 A-coded plug*

Only the CAN_H and CAN_L signal pair wired to the pins 4 and 5 are mandatory, however this configuration lets you supply power to the device. The wiring for the signal pair should be a 120 ohm twisted wires pair in 40-meter cables.

5.2 M12 A-Coded in RS-485 Physical Layer

The RS-485 physical layer is widely used for the Modbus, OSDP, SSCP, SCSI-2, SCSI-3, Profibus, Nanoréseau, DMX 512 and AES 3 industrial protocols.

5-pin or 4-pin shielded A-Coded are used for RS-485. The wiring will be mostly dependent on the needed power supply but will always include at least the balanced TxD/RxD pair in position 2 and 4 to minimize the delay skew.

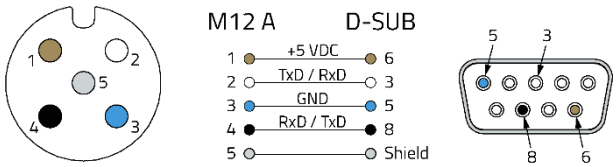

Figure 12 - *RS-485 pinout at M12 A-coded receptacle*

Please note that the M12 A-Coded circular connectors are used for half-duplex RS-485. For full-duplex RS-485, M12 B-coded circular connectors are generally used.

The cable length will directly affect the data rate. For a 1200 meter cable, it will be limited to 100 Kb/s, while for 12 m and below, it will be possible to transmit 35 Mb/s. The signal pair impedance must be 120 ohm.

5.3 M12 A-Coded in Profibus Physical Layer

M12 A-Coded circular connectors are used as power supply connectors for Profibus peripherals.

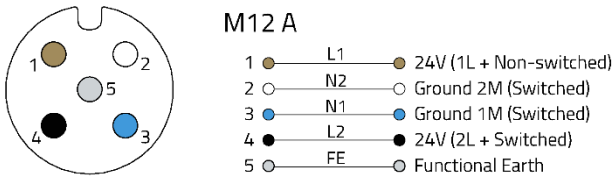

Figure 13 - *PROFIBUS Pin assignment for 5-pin M12 A-Coded receptacle*

M12 B-Coded circular connectors are used for Profibus signal transmission.

5.4 M12 A-Coded in RS-422, RS-423 and RS-232 Physical Layer

8-pin, 5-pin or 4-pin M12 A-Coded circular connectors can be used for RS-422, RS-423 or RS-232. The wiring will be mostly dependent on the needed signal, power supply and ground return needed. There is no set pinout for these.

For RS-422, at least one pair of wires will have to be balanced. The conductors will need to have the same length, and thus only some pin combinations will be possible. In the 4 or 5- pin M12 A-Coded circular connectors, only the 2 and 4 contacts will have the same length. In the 8-pin M12 A-Coded connectors, the pairs are pins 1-2, 3-7 and 4-6. Therefore, it is possible to have one differential pair in a 4 or 5-pin and 3 pairs in 8-pin M12 A-Coded circular connectors.

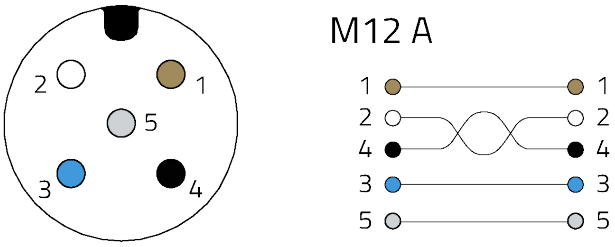

Figure 14 - *RS-422 / RS-423 pinout one balanced pair (plug)*

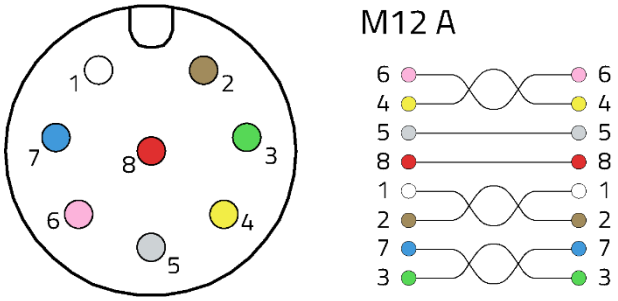

Figure 15 - *RS-232 pinout with 3 balanced pairs (receptacle)*

06. CONCLUSION

M12 A connectors are quite versatile and can be used with several communication protocols and fieldbuses, they are not bound to a single protocol. Moreover, they are able to work in harsh environments (vibration, dust, water), thanks to their high IP-rating & their steady screw-locking. Those two features allow these M12 A connectors to be a must in automation industry especially for all sensors, actuators connections.

For higher-rated Ethernet protocols, other codings such as D or X can be used. (This will be expanded in a later appnote.)

07. PHYSICAL LAYER – M12 A OVERVIEW

Physical Layer	Suitable M12 A-coded
10BASE-T	8-pole
100BASE-T	8-pole
Higher BASE-T	8-pole
IO LINK Class A (Master)	5-pole
IO LINK Class A (Cable)	4-pole
IO LINK Class A (Device)	4-pole or 5-pole
IO LINK Class B	5-pole
USB A 2.0	4-pole
micro USB 2.0	5-pole
CANbus	5-pole
RS-485	4-pole or 5-pole
RS-422	4-pole or 5-pole
RS-423	4-pole or 5-pole
RS-232	8-pole

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