# MAINTENANCE AND DECODING OF **FIELD BUSES**

Today, most of the electrical appliances that we use include internal electronics. These circuits often need to communicate via data buses, either with ancillary systems, such as remote sensors, or with control systems. This is particularly true in industry, where a single PLC remotely manages multiple sensors and actuators.

Formerly, communication with these buses took place via an analogue signal using the "4-20 mA" network. This communication mode had many disadvantages, including the need for extensive equipment and complex wiring, thus increasing the time required for installation. For this reason, digital communication standards have been developed and are now widely used to avoid these problems.

"Fieldbus" is a general term which corresponds to a method of communication between different systems. There are many standards: those specific to manufacturers and those standardized according to the equipment involved. Here are a few examples of fieldbuses used in different sectors of activity:

**Maintenance**

**Measurements**

**Analysis**

**Diagnostics**

CANopen® FlexRay™ KNX lin LOCAL INTERCONNECT NETWORK PROFIBUS®

Measure up

# The example of the automotive sector

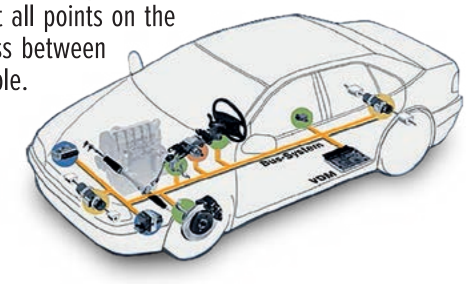
The new means of intra-system communication have allowed developments in the systems. The most obvious example is in the automotive industry. In this sector, with the development of safety and analysis systems such as airbags, anti-lock braking systems (ABS) and electronic stability programs (ESP), the number of sensors and actuators on vehicles is constantly increasing. Each of these systems could be linked directly to the vehicle's computer via data buses, but this would require too much cable.

Fieldbuses are therefore installed throughout the vehicle and are connected to each sensor and actuator. These are the only means of communication between the brakes, the airbags and the speedometer.

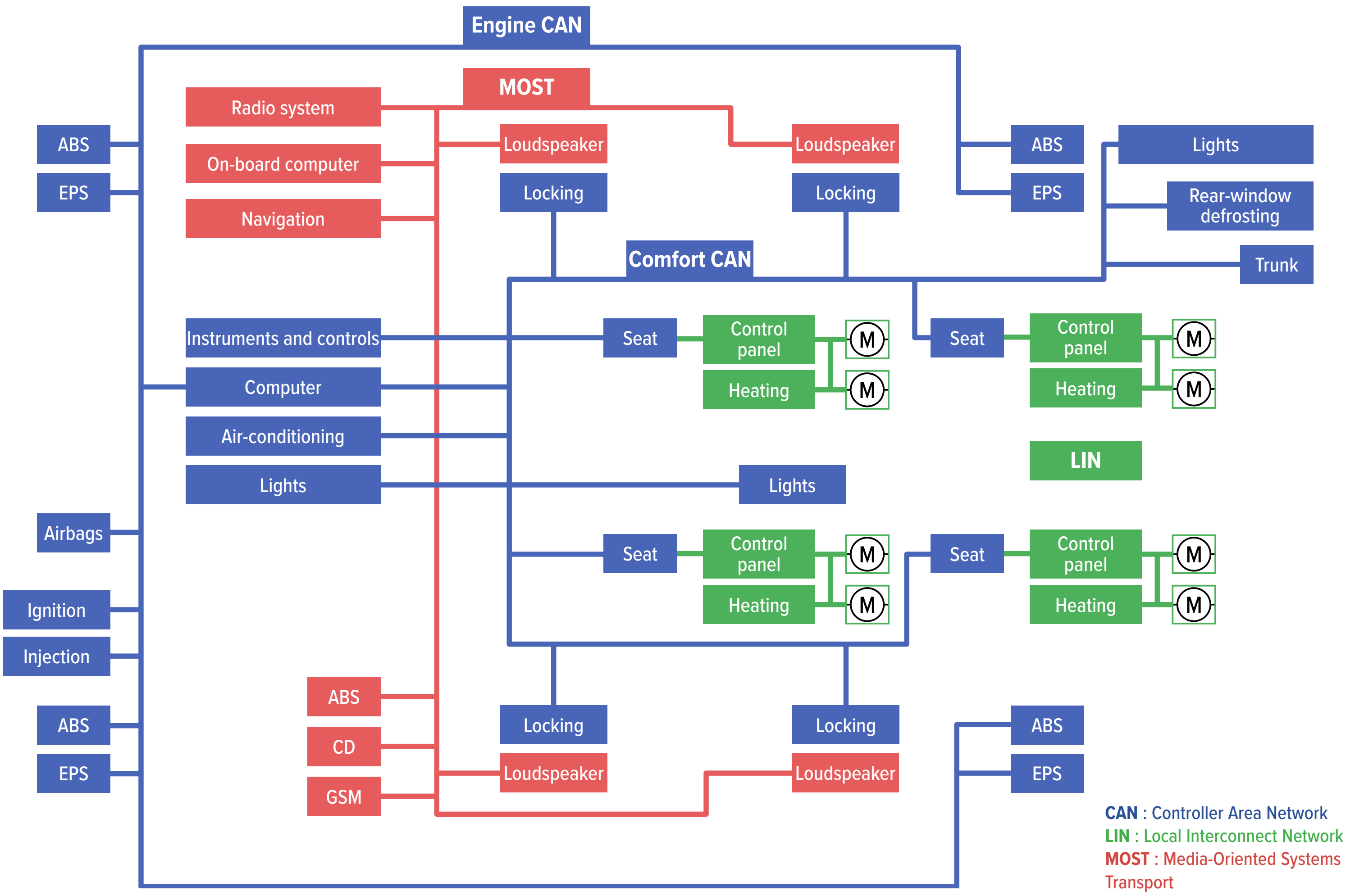
This provides numerous advantages:

- less wiring
- lower production costs due to savings on equipment
- easier maintenance as there is only one communication channel

In addition, performance is improved because the data are available at all points on the bus and direct access between two systems is possible.



The diagram below shows a possible fieldbus configuration in a car. The CAN bus is divided into two groups, one dedicated to the engine and management of the safety equipment, and the other to the "driver comfort" equipment. The LIN bus is incorporated as a "subset" of the CAN bus. The MOST bus meanwhile, manages the car's audio and video systems.



# Specific applications for each bus

There are so many different buses because each one handles a specific requirement. Due to their design, their specifications, the standards governing them, their speed of communication and the physical medium used, each bus has its specific application. Below is a non-exhaustive list of the main fieldbuses, accompanied by short explanations of their uses. The buses underlined are compatible with the **Scopix BUS** oscilloscope for physical integrity testing. The buses marked with * are compatible with the logic analysis performed by the **DOX 3000** models.

## Industry and information technology sectors:

**AS-I**: serial fieldbus for managing 124 or 248 sensors and/or actuators.

**FipWay**: fieldbus for Schneider TSX Series 7 PLCs.

**ProfiBus**: a proprietary fieldbus which was so successful that it has become a standard. There are 3 variants, 2 of which are used in industry. **DP** for decentralized peripherals, a real-time bus designed for PLCs and **PA**, for measuring and monitoring equipment in hazardous environments.

**SPI***: full-duplex bus using 4 logic signals: SCLK, MOST, MSO, SS

**RS232***: bus used in computing and industry for inter-system communication.

**Ethernet**: bus widely used in computing because internet connection is achieved via this bus. Implemented all over the world, it is characterized by different speeds.

**ProfiNet** (industrial Ethernet): bus based on Ethernet for quick, reliable communication between systems.

## Automotive and aviation sectors:

**CAN***: the main bus used in the automotive sector. This bus uses multiplexing and allows the implementation of several computers in one vehicle.

**LIN***: bus used in recent vehicles which is slow, reliable and economical.

**FlexRay**: bus particularly appreciated for its high speed and reliability.

**TTP**: bus used in aviation because of its high reliability.

**MOST**: bus which uses optical fibre as its physical medium. It is implemented in top-of-the-range vehicles to manage the telematics.

Other buses specific to aviation handled by the **SCOPIX BUS: MIL STD 1553 and ARINC 429**

## Home automation and building sectors:

**DALI**: protocol for managing lighting in the home automation sector. It can be used to control up to 64 ballasts/sensors individually.

**I²C***: bus used in home automation and domestic applications which is particularly easy to implement and is compatible with most of the microcontrollers on the market.

**KNX**: protocol for managing and supervising processes and systems in the building sector and home automation. Widely used because it is compatible with a large number of physical media, such as radio waves, powerline communication, Ethernet or an electrical connection.

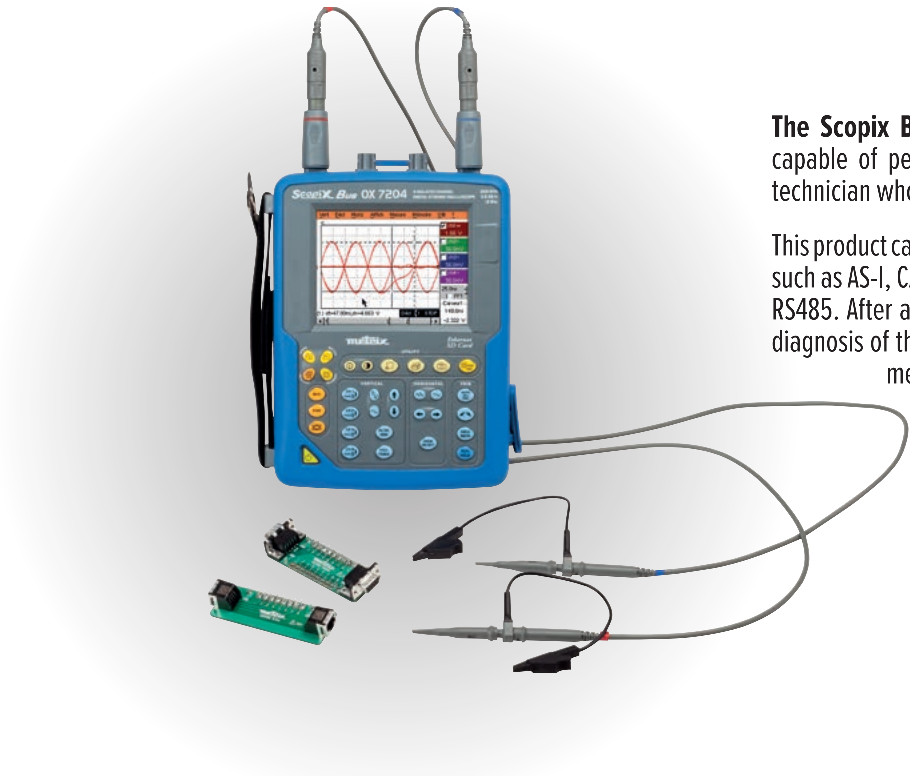
# Maintenance of fieldbuses

The standardization of equipment and software has some disadvantages. As data access only takes place via the bus, the sensors and actuators have to be “smart” to transmit the information on the bus. In addition, error management may also be performed via the bus, rather than using hardware. As a result, maintenance is different for a fieldbus. After physical analysis of the bus, automation specialists analyse the data transmitted on the network. They perform decoding according to the network standards to determine whether the program is operational and whether communication between all the different elements is satisfactory.

# Physical analysis

This physical analysis has to be reliable as it represents the direct link between the different equipment items. By checking that it is working properly, it is possible to detect all sorts of anomalies, including broken links, impedance problems which might cause erroneous transmission, etc.

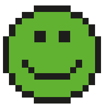
For example, it allows you to check whether the length of the line has an effect on communication, as some fieldbuses may cover very wide areas, such as an entire work site. This analysis can also detect if the wrong type of cable (impedance too high, etc.) has been used.



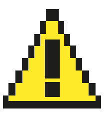

**The Scopix Bus** from **Metrix**® is a rugged, easy-to-use instrument capable of performing this type of analysis under the control of the technician who installs the fieldbus.

This product can be used to check the physical layer of the main fieldbuses, such as AS-I, CAN, DALI, Ethernet, FlexRay, KNX, LIN, Profibus, RS232 and RS485. After analysing the fieldbus, the instruments generates a global diagnosis of the line's status. The instrument is connected to the bus by means of interfacing boards and oscilloscope probes. This allows maintenance in situ, without having to shut down the network.

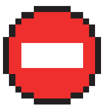
**Opposite: the results of the analysis of an RS232 bus at 9,600 bauds.**



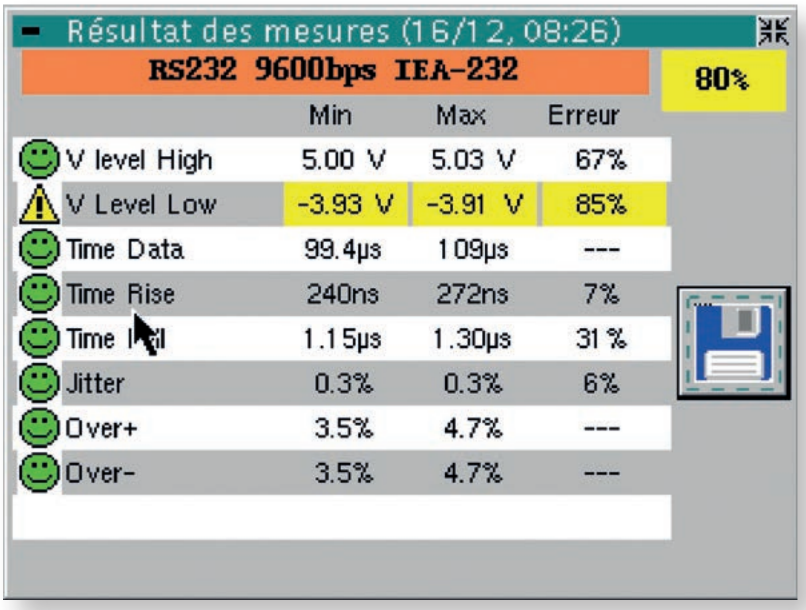
This symbol indicates that the measurements comply with the standard.



This signal indicates a deviation from the standard which nevertheless remains acceptable.



When the measurement is completely outside the tolerance range, it is marked with this symbol.



Résultat des mesures (16/12, 08:26)

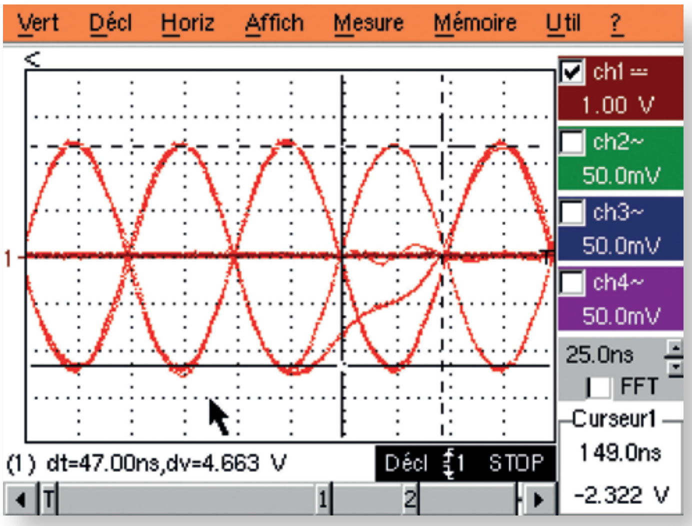
RS232 9600bps IEA-232 — 80%

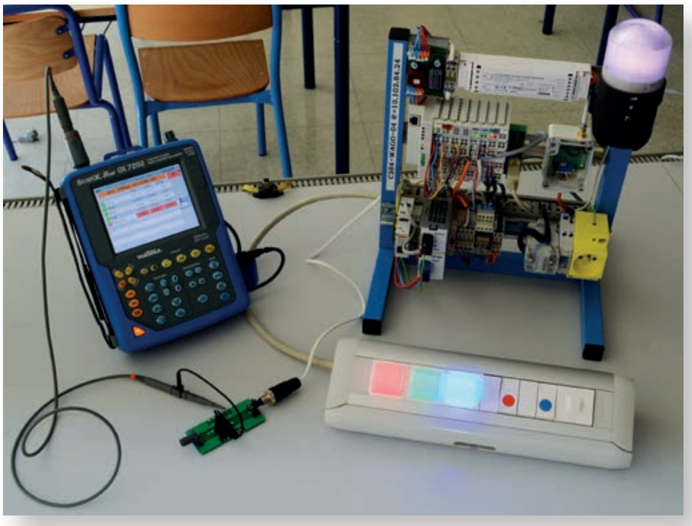
| | Min | Max | Erreur |
|---|---|---|---|
| V level High | 5.00 V | 5.03 V | 67% |
| V Level Low | -3.93 V | -3.91 V | 85% |
| Time Data | 99.4µs | 109µs | --- |
| Time Rise | 240ns | 272ns | 7% |
| Time Fall | 1.15µs | 1.30µs | 31 % |
| Jitter | 0.3% | 0.3% | 6% |
| Over+ | 3.5% | 4.7% | --- |
| Over- | 3.5% | 4.7% | --- |

A visual inspection of the signal quality can be obtained using the eye diagram button on the **SCOPIX III** instrument.

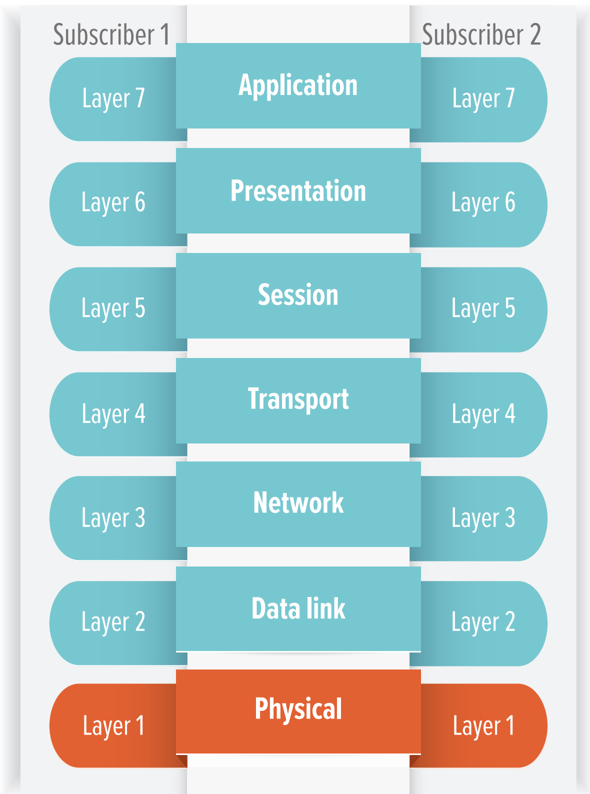
When this instrument is used with the SX-Bus software, it is also possible to create customized bus analysis files. All you need to do is find out the physical specifications of the bus in question and enter them in the software, which then generates the corresponding bus analysis file.

All this makes **Scopix Bus** the ideal tool for analysing the physical layer. It is also equipped with oscilloscope, multimeter and recorder modes for accurate measurements on the sensors or actuators in the system, thus ensuring all-round maintenance.



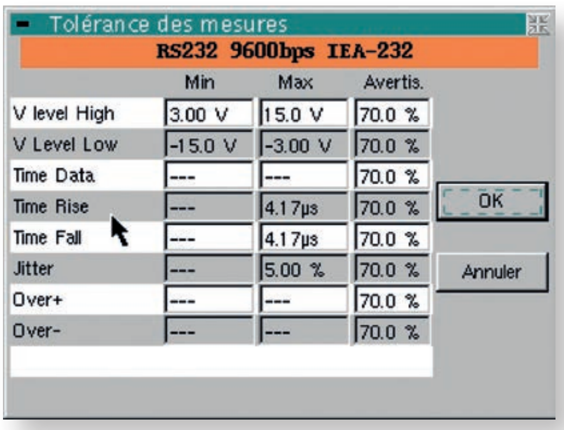
## Standardization of the buses




The International Standardization Organization (ISO) examined a large number of network structures. The ISO defined a network model allowing designers to set up networks capable of communicating with one another and working together (interoperability). This led to publication of the OSI (Open Systems Interconnection) protocol in 1984. This model is divided into 7 layers, from physical transmission through to processing of the data.

The communication protocols are the rules defining the dialogue between layers on the same level in two different systems.

**Scopix BUS** performs analysis of **layer 1,** the physical layer, and determines whether the electrical characteristics of the fieldbus comply with the standard specifications. The standards concerned are indicated in the fieldbus documentation and can be displayed on the **Scopix BUS**.



Tolérance des mesures

RS232 9600bps IEA-232

| | Min | Max | Avertis. |
|---|---|---|---|
| V level High | 3.00 V | 15.0 V | 70.0 % |
| V Level Low | -15.0 V | -3.00 V | 70.0 % |
| Time Data | --- | --- | 70.0 % |
| Time Rise | --- | 4.17µs | 70.0 % |
| Time Fall | --- | 4.17µs | 70.0 % |
| Jitter | --- | 5.00 % | 70.0 % |
| Over+ | --- | --- | 70.0 % |
| Over- | --- | --- | 70.0 % |

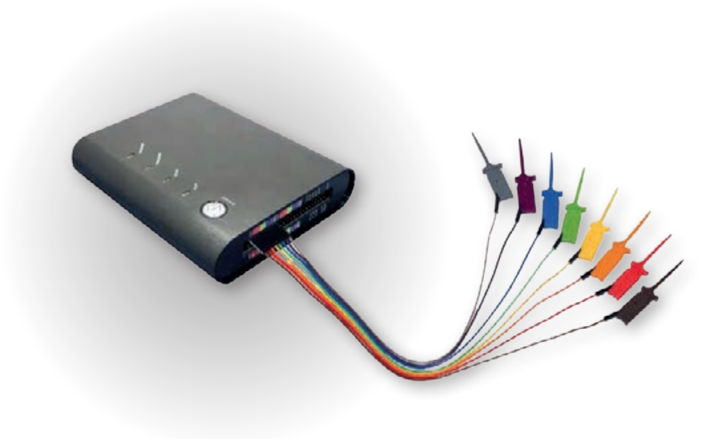
OK

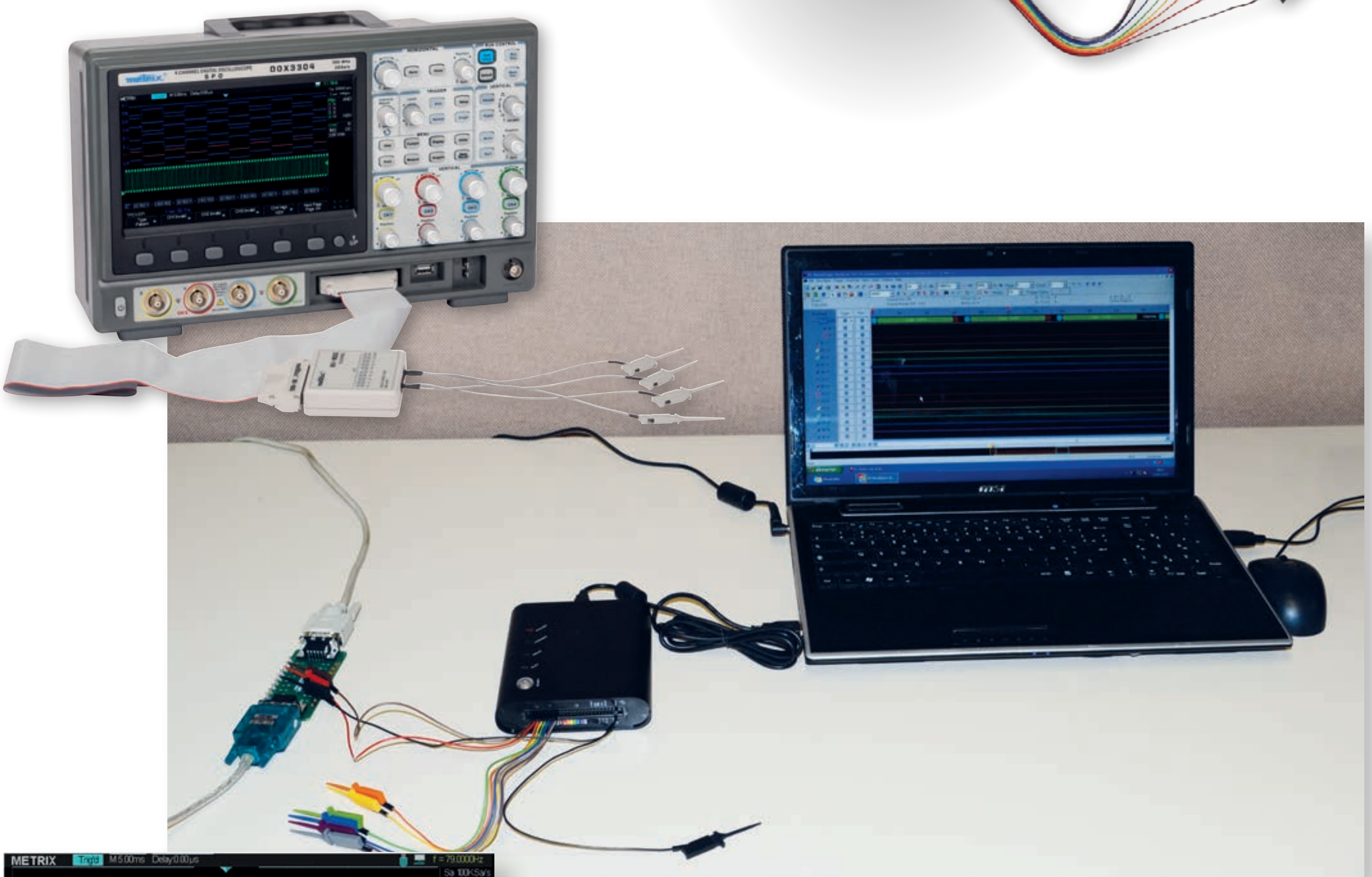
Annuler

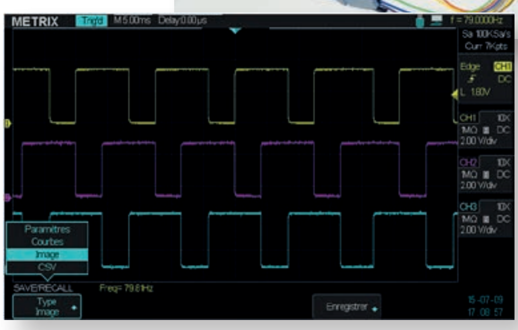
# Bus decoding

If a communication problem occurs between two machines  and the physical analysis shows that the link is good, it may be the data circulating on the bus which are erroneous. This means it is necessary to decode the frame(s) circulating on the bus in order to determine whether the data are valid. This is not done by the technician who installed the fieldbus, but by the automation specialist or electronic engineer who knows the signal which should circulate on the bus. Decoding can be parameterized by protocol according to the type of bus.

**METRIX**® proposes 2 products that meet these criteria: the LX1600-P bus-decoding logic analyser and the **DOX 3000 (DOX 3104 & DOX 3304)** oscilloscopes which can be used to decode the main logic bus protocols such as CAN, I2C, LIN, SPI and UART links (possibility of decoding more than 100 buses with LX or with the **DOX-MSO3LA** logic probe).





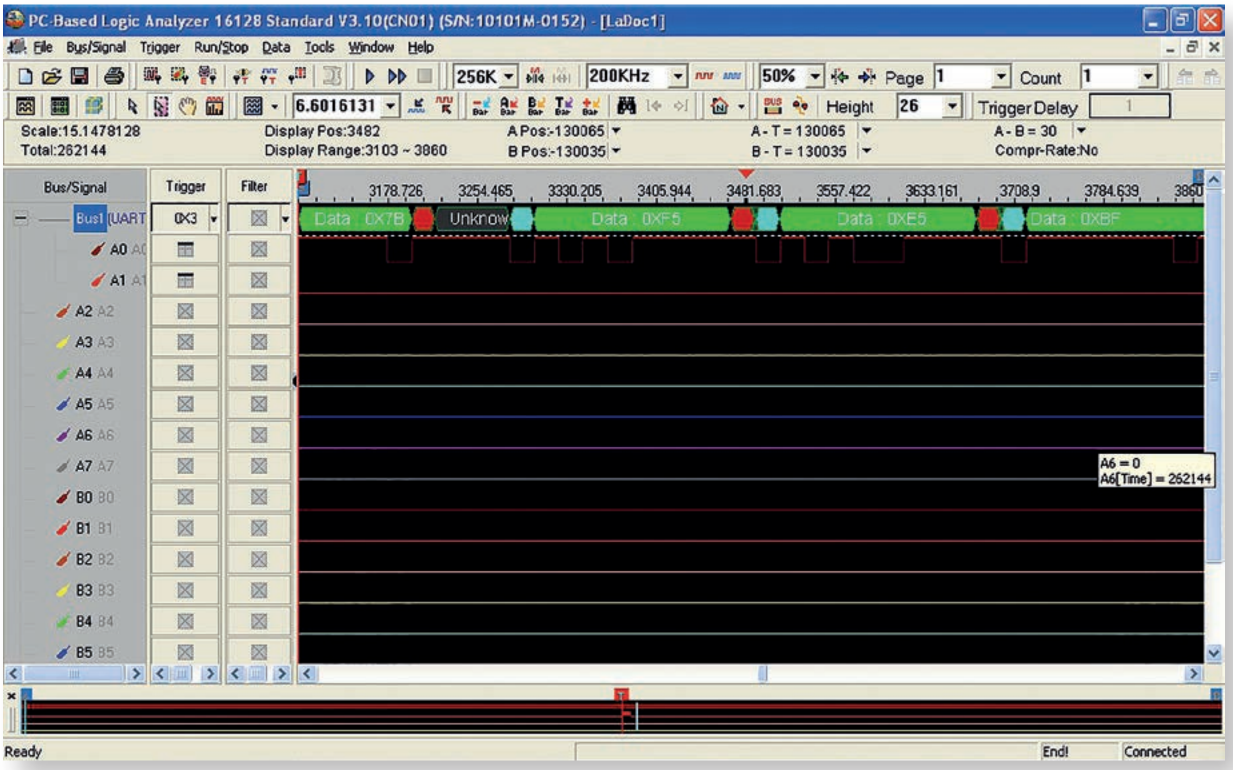


As well as decoding, the **DOX3000** models also display the analogue frame of the signal.

To use this instrument, you need to connect the fieldbus data lines to the analyser. The connections depend on the bus. For example, for $I^2C$, you will have to connect the SDA data line and the clock for correct decoding. Once you have made the connections, the rest of the set-up is handled by the computer by means of the **Logic Analyser** software supplied with the instrument.

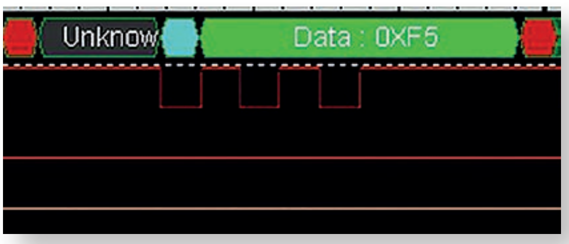
# A bus for each application

Example of the RS232 bus




The software enables the different signals to be grouped per group of buses. In this way, it is easy to connect several buses to the instrument and then group them separately in the software. This allows global analysis of the system if it has several dependent buses operating simultaneously.

The previous example corresponds to the serial bus of a **SCOPIX** communicating with a computer via an RS232 serial link at a speed of 9,600 bauds.




The A0 line is the TX from the oscilloscope, while A1 is RX. It can thus be seen that the oscilloscope continuously transmits to the computer, but the computer does not transmit anything. The link is configured so that there is no acknowledgement of receipt.

After configuring the transmission speed, the number of data bits, the parity and the acknowledgement of receipt in the software, you must start capture by pressing the instrument's "Start" button. Once the signal has been captured, it is decoded automatically. You then have to analyse the data and perform the comparison. Here, this begins with the display of "Unknown" until decoding has begun. At that moment, the line is considered to be idle. Then comes the start bit (in blue), the data in green (F5 in hexadecimal, i.e. 245 in decimal) and the stop bit in red.

# Hexadecimal notation

Any system involving electronics communicates in binary, made up of successive zeros and ones. With the increase in computing power due to technological advances, it has become inconvenient to use binary directly to perform manual verification. A more compact type of notation, using base 16 (hexadecimal) allows easy conversion into binary. Binary code is converted into hexadecimal by grouping the digits (the bits) four by four. Hexadecimal can be converted back to binary by replacing each hexadecimal digit with 4 binary digits.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Binary** | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1000 | 1001 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 |
| **Hexadecimal** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
| **Decimal** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

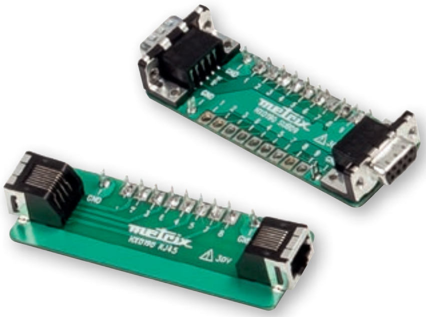

# SCOPIX BUS, OX7202-BUS & OX7204-BUS

With their 200 MHz bandwidth ensuring high performance, these models benefit from the versatility of the **SCOPIX**, offering **5 tools in 1** :

- oscilloscope,
- multimeter,
- FFT analyser,
- recorder,
- bus analyser.

The **SCOPIX BUS** models offer 2 or 4 isolated 600 V CAT III input channels.

The patented **PROBIX** system of "plug and play" accessories ensures quick and error-free implementation of the models. The coefficients, scales and units of the sensors and the configuration of the channels are managed automatically. The probes and adapters are recognized immediately as soon as they are connected.




The Ethernet interface with web server allows you to control the instrument remotely and transfer curves or screenshots without any additional software. FTP server/client communication is also available.

The HX0190 and HX0191 boards assist with connection: they are equipped with SUBD9, RJ45, M12 or 8-wire screw connectors.

# LX1600-PC, DOX3104 & DOX3304

The **DOX 3000** models and the **LX1600** logic analyser are measurement tools which allow you to monitor the binary changes in the signals (0 and 1) over time on several logic channels: data bus, inputs-outputs from a microcontroller or microprocessor.

The LX1600-PC and DOX3000 models can be used to decode the main fieldbuses



**FRANCE**
**Chauvin Arnoux**
190, rue Championnet
75876 PARIS Cedex 18
Tél : +33 1 44 85 44 85
Fax : +33 1 46 27 73 89
info@chauvin-arnoux.fr
www.chauvin-arnoux.fr

**UNITED KINGDOM**
**Chauvin Arnoux Ltd**
Unit 1 Nelson Ct, Flagship Sq, Shaw Cross Business Pk
Dewsbury, West Yorkshire - WF12 7TH
Tel: +44 1924 460 494
Fax: +44 1924 455 328
info@chauvin-arnoux.co.uk
www.chauvin-arnoux.com

**MIDDLE EAST**
**Chauvin Arnoux Middle East**
P.O. BOX 60-154
1241 2020 JAL EL DIB - LEBANON
Tel: +961 1 890 425
Fax: +961 1 890 424
camie@chauvin-arnoux.com
www.chauvin-arnoux.com

CHAUVIN ARNOUX GROUP