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BRINGING ORDER INTO THE CHAOS OF MULTICHANNEL SYSTEMS USING TRANSDUCERS WITH INTEGRATED IDENTIFICATION

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ABSTRACT
For many years the measurement community has desired transducers with built-in (integral) identification to ease the task of installation of instrumentation. This paper describes how a commercially available component has been adapted to fulfil this requirement. Some possible applications in multichannel systems are described.

HARDWARE CONSIDERATIONS
For the hardware to be considered as suitable, a certain number of requirements has to be fulfilled by the memory and the interface components employed e.g.

- Operation over standard coaxial cable as used for ICP®-accelerometers and in compliance with these.
- Bidirectional communication allowing easy storing of information inside the transducer.
- Transducer hardware must be small, light and cheap. Power requirement must be low.
- "Add on" hardware which does not interfere with the orginal transducer circuit.
- Simple interface to conditioning unit's microcontroller.
- Allow at least 100 m cable between transducer and conditioning unit.
- Allowing extended functionality built into the transducer as a growth path.

The suggested hardware solution is based on a Dallas Semiconductor component family which communicates via a unique, two-wire interface called MicroLAN™. One of these components is an E^2PROM, and with a little additional hardware this device fulfils the requirements.

IMPLEMENTATION OF INTERFACE

The two-wire interface demands are set by the standard co-axial interface used for accelerometers with built-in constant current line drive (i.e. ICP®) amplifiers. Once the requirement for a two-wire interface has been fulfilled, the implementation in other transducers, where separate wires are available, poses no problems (e.g. a normal positive supply wire could be used for identification). Various well-known solutions (I^2C, FSK, activation by power up or current modulation) were examined and rejected, mainly due to their need for custom design.

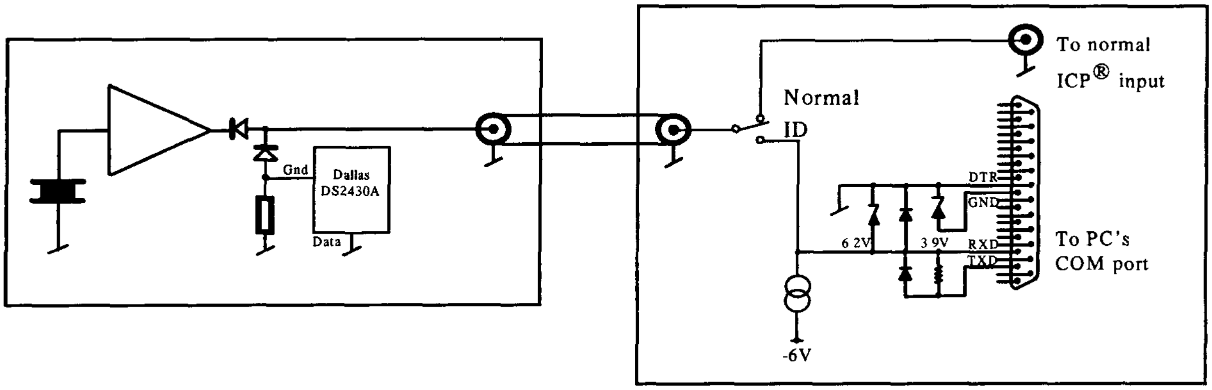


Fig.1. Principle of implementation of integrated identification with PC support for ICP® transducers. Transducer (left) connected via a co-axial cable to interface (right)

By using a reverse current technology for switching between the normal analogue mode and the digital communication mode, the chosen MicroLAN™. interface fulfils all the stated needs. This technique enables switching between the analogue and the digital mode using only two standard diodes. The switching is performed by using the normal positive current supplying the ICP® transducer to block for the ID component, and conversely, a negative current supplying the ID components to block the analogue amplifier. This principle is shown in Fig.1. which also show the simplicity of the receiving device. Primarily an additional current device is needed for supplying the negative current for the ID-device. The microcontroller or PC maintain the communication and translation of signals to and from the MicroLAN™. component(s) in the transducer.

FUNCTIONALITY

The MicroLAN ™. concept opens the possibility for placing different specialized components inside the transducer. The feature that enables this is a unique number (address) which identifies each manufactured component. These components make it possible to implement one or more functions such as:

Identification: This feature is the main driver for obtaining communication with a transducer. As a supplement to the normal calibration chart, some of the most relevant information may be stored inside the transducer, so if one has a transducer, then one also has the data one needs. An example of this kind of information is shown in Fig.3.

Gain adjustment: Transducers often consist of two items; firstly a device to transform the physical properties into an electrical signal (e.g. piezoelectric discs and a seismic mass in an accelerometer). Secondly, the device is normally followed by a conditioning circuit that transforms the output impedance and the signal level so the signal may be of practical use outside the transducer. The dynamic range of this electrical circuit is frequently much smaller than the dynamic range of the physical transformer (for an accelerometer 160 dB are reduced to about 120 dB), therefore some compromise may be necessary when constructing the transducer. With a feature such as MicroLAN™, it is possible for the user to switch the internal gain inside the transducer to obtain the best working condition for the measurement setup. For the transducer manufacturer this technique has great benefits. To-day many mechanical adjustments and selections are the only way to obtain a specified sensitivity of a transducer. Potentiometers adjusted via MicroLAN™. make it possible, as the last stage in the production, to adjust the basic sensitivity of a transducer to specified value.

Self-test of transducers: is mandatory when they are used for protection or monitoring costly machinery or processes. Such transducers are often hard to access because they are built into the machinery. MicroLAN™. may solve this problem without additional cabling requirements, enabling on/off switching of the test-signal generated in the transducer.

Temperature or pressure measurements: are possible.
On/off switch enabling for instance multiplexing several transducers on the same cable as shown in Fig.2.

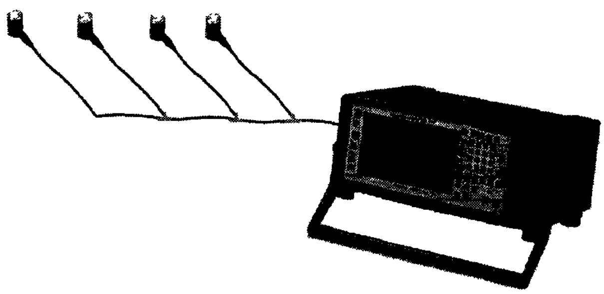


Fig.2. Example of a possible multi-drop system with integrated transducer identification

STORAGE OF RELEVANT TRANSDUCER DATA

As mentioned above, the main application is to put transducer relevant data into the transducer. Standarisation work is currently progressing under IEEE to define the structure and contents of such a "Tranducer Electronic Data Sheet" (known as TEDS). The interface specification, where this MicroLAN™. concept is only one of several possibilities, is being considered in the IEEE 1451.4 working group.

At Brüel & Kjær, two types of transducers are essential for our core markets: accelerometers and microphones but many other kinds of transducers may benefit from the integration of specifications in the transducer itself. Brüel & Kjær have built for demostration purposes a 64bit PROM+256bit E^2PROM from Dallas Semiconductor (type DS 2430A) into a microphone preamplifier (Fig.3) and an accelerometer. Used with a predefined set of templates, this small memory is capable of storing all relevant information necessary for characterizing the transducer (Fig.4.).

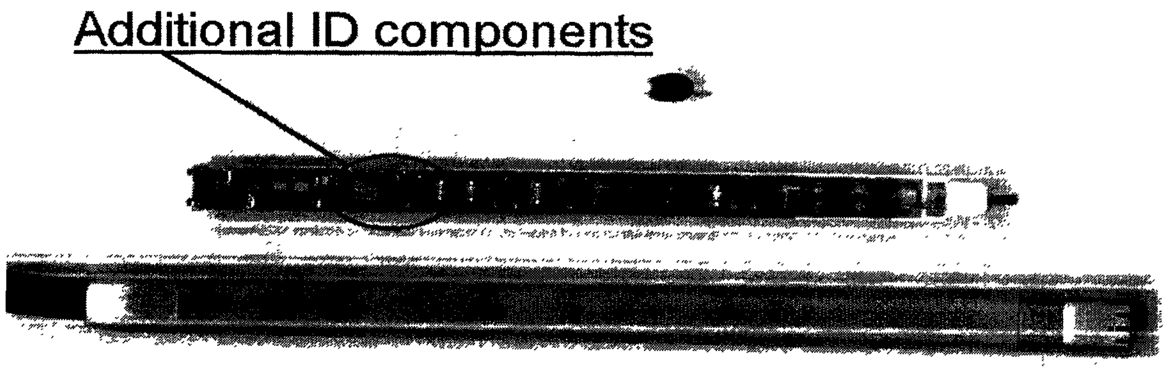
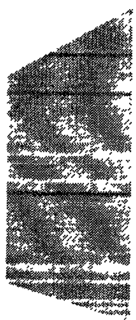


Fig.3. Prototype of 1/4" microphone preamplifier with integrated transducer identification

Manufacturer	Brüel & Kjær
Type	4321
Serialno.	1234567
Calibration date	Sept. 5, 1997
Absolute sensitivity	4,01mV/PA
Calibration person	HEL
Transfer poly coef. 6	1,305E-25
Transfer poly coef. 5	-1,117E-20
Transfer poly coef. 4	2,657E-16
Transfer poly coef. 3	4,637E-14
Transfer poly coef. 2	-5,931E-08
Transfer poly coef. 1	-4,273E-05
Physical position	#1
User data	



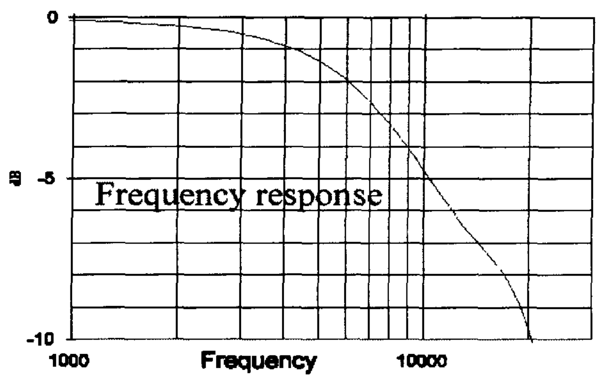


Fig.4. Example of data relevant for a microphone and preamplifier set. Polynomial coefficients describe the frequency response

SYSTEMS WITH INTEGRATED TRANSDUCER IDENTIFICATION

A simple prototype system has been implemented using microphones and ICP® preamplifiers in conjunction with signal conditioning units capable of communicating with the transducers. Such a system would be useful when the transducers are mounted where access is difficult. The integrated transducer identification concept has been implemented on a test basis in the Brüel & Kjær IDA System (Intelligent Data Acquisition System) which can manage up to 3000 transducer channels. Such large transducer arrays are used in, for example, Spatial Transfomation of Sound Fields systems (STSF) and Non-stationary STSF systems.

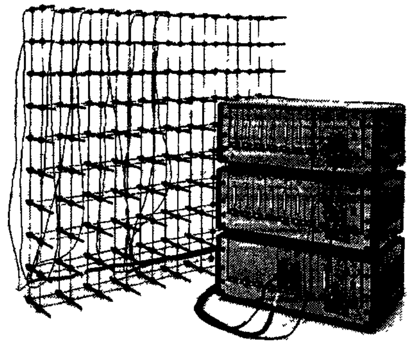


Fig.5. Example of a multichannel array system where integrated transducer identification is a great advantage during installation and calibration

CONCLUSIONS

The measurement community would be best served with transducers with integrated identification. A number of conditions, however, have to be fulfilled (e.g. two-wire system, low power consumption) to make this concept successful. The main points to be decided are a standardised transducer interface and a uniquely identifiable set of templates. It has been described how a commercially available component can fulfil these requirements. Implementation of such a system would greatly reduce the time and effort involved in installation and calibration of measurement systems and of multichannel measurement systems in particular.

The authors would like to take the opportunity to encourage both users and transducer manufacturers alike to participate in the discussions to ensure that the coming IEEE 1451 standard is designed to fit the measurement community's needs.