1 Introduction: Integration

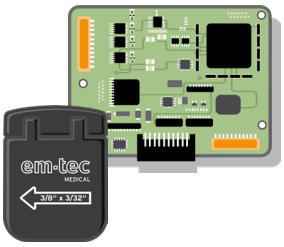

Figure 1:
Integrated Flow Measurement Solution

Flow measurement, i.e. monitoring the (blood) flow within tubing systems is an important part of many life-sustaining medical procedures such as the use of heart-lung machines (HLM) or ECMO treatments. This is why many of these devices come with an integrated flow measurement solution, meaning that the values are directly communicated to and displayed via the host and/or overall system. With our range of flow boards, the SonoTT™ SkyLark Series, and the compatible flow sensors, we offer a fully integrable flow measurement solution.

2 SonoTT™ SkyLark Series

An integral aspect when it comes to the integration of our flow measurement solution is its communication with the host system. The SonoTT™ SkyLark Series uses serial communication, meaning data transfer is carried out via one wire, one bit at a time. Within that, there are three different interfaces, i.e. types of communication, available:

- UART TTL
- CAN
- RS232

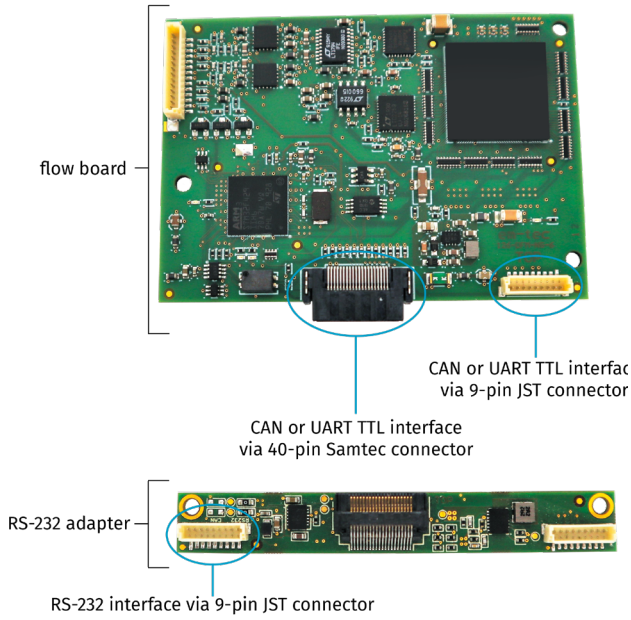

Figure 2:
Interfaces and Connectors of the SonoTT™ SkyLark Series

3 Serial Communication Basics

On the most basic level, all three of them contain the following characteristics:

- Baud rate, which describes the speed at which data is communicated, i.e. the number of bits that are transmitted within a second.
  → Consequently, higher baud rates indicate a faster data transfer.
- Stop bits: These are used to stop the data transmission denoted as “T”.
  → There are commonly 1, 1.5, or 2 bits.
- Parity bits: These bits are used to find errors within the data transfer.
  → There a different kinds of parity bits: even, odd, marked, and spaced.

With all serial communication, there are sender and receiver but the ways they interact can differ. Using the simplex method, only one of the two, i.e. only the sender OR the receiver are active at a time. This is, for instance, the case for radio or television.

An example for when both sender and receiver are active, but never at the same time, is the internet where the receiver can accept what is transmitted by the sender but cannot send at the same time and vice versa.

The full-duplex mode, also the most commonly used mode, is where both sender and receiver can transmit at any, i.e. at the same, time. This is the case for smartphone communication.

4 UART TTL

UART TTL, short for **U**niversally **A**synchronous **R**eceiver/**T**ransmitter **T**ransistor-**T**ransistor **L**ogic) describes a form of serial input/output where bits are transmitted one at a time at a specified data rate. This communication type always takes place between 0 V and Vcc, in our case the latter is set to 3.3 V. Consequently, Vcc, or 3.3 V represent a logic high, i.e. ‘1’, whereas 0 V represents a logic low, i.e. ‘0’.

4.1 Advantages of UART TTL

The UART TTL communication operates on the voltage range of microcontrollers and is therefore easy to pair and compatible with the majority of microcontrollers on the market. In addition, it is readily available and

cost-efficient, which, combined with the ease of use it provides, make it a commonly used transmission method. It is also comparatively easy to implement into embedded circuits.

4.2 Disadvantages of UART TTL

With the relatively small voltage range, the UART TTL interface is, for one, more susceptible to noise and interference and, for another, not quite as flexible when it comes to cable length as it is not suitable for longer distances. In addition, higher frequencies tend to use up more and/or higher power.

5 RS-232

Within UART communication, RS-232 refers to the **R**ecommended **S**tandard **232**, which is a telecommunications standard. As is the case for UART TTL, bits are transmitted one at a time at a pre-set baud rate, with or without parity and/or stop bits. Other than with UART TTL, however, the voltages of the RS-232 communication are more extreme, a logic high, i.e. '1', being represented by negative voltages between -3 V and -15 V and positive voltages between 3 V and 15 V representing a logic low, i.e. '0'.

5.1 Advantages of RS-232

Due to the more extreme voltages, RS-232 communication is less susceptible to noise or interferences, meaning the signal can travel longer (physical) distances while still providing valid and reliable data (the max. recommended cable length is 15 m). Given how long it has been used, it is also an interface that is well known and therefore widely available and applicable. Its simple wiring and connectors also make it a low-cost solution.

5.2 Disadvantages of RS-232

For one, the RS-232 interface does not support other communication than system to system, for another it requires a separate transceiver chips. In addition, the range is limited as higher speed can only be achieved and supported for short distances. Due to its use of both positive and negative signal voltage, the RS-232 interface has a higher power consumption, something that must be taken into account when it comes to designing the power supply.

6 CAN

Short for **C**ontrol(ler) **A**rea **N**etwork, the CAN bus was originally designed for the automotive industry before it was used in other sectors as well. It enables the serial communication between several CAN devices and is therefore often compared to a nervous system. It uses serial binary interchange to pass information from transmitter to receiver within a data frame. Data frames contain 0 to 8 bytes. Similar to UART TTL and RS-232, the speed of the data transmission depends on the set baud and output rate of the CAN bus.

6.1 Advantages of CAN

With the CAN interface, it is possible to transmit a high volume of data and information at high speed. In addition, it comes with several integrated safety features (e.g. use of swap/filling bits, message counter, little-endian format, etc.), meaning the data is well-protected and robust against outside interferences. The comparative speed of the data transmission can also benefit the bubble detection feature in applications where air-in-line is a critical component.

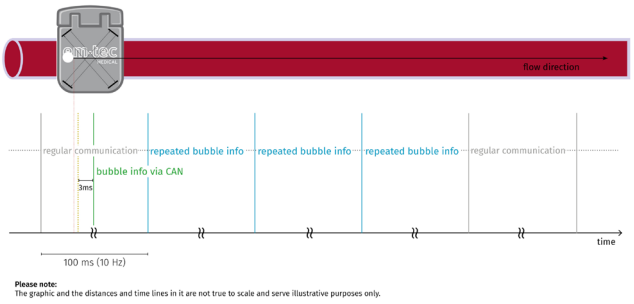

Figure 3:
SonoTT™ SkyLark gold: bubble detection via CAN interface

6.2 Disadvantages of CAN

While the CAN interface delivers a high volume of data and therefore valuable insights into the status of connected devices, the sheer volume also makes the collection and processing of information challenging. Even more so when dealing with low bandwidth and variable network conditions. In addition, the maximum cable length, i.e. distance the signal travels, must not exceed 40 meters. Furthermore, the integration of CAN tends to require more time when it comes to software integration as well as subsequent maintenance.

7 Conclusion

Depending on your specific application, the host system and the requirements of your field your interface needs will, of course, vary. This is why the SonoTT™ SkyLark Series comprises several different standard variants as well as the option to customize. With all available interfaces — UART TTL, RS-232, and CAN — the correct integration of the flow board into your overall system is key to reliable flow measurements and a seamless errorfree data transmission. Consequently, we strongly recommend starting the information exchange regarding interfaces and communication as soon as possible within your development process to ensure there are no difficulties or complications down the road. As solution-partner, we are happy to work closely with you from first idea to approved product and we strive to be part of your success by sharing our experience and expertise within the field of medical technology.

8 Contact

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