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RSI Technical Note 003

Transmission-Reception Time with ODAS Serial Communication

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1 Introduction

This document can be used to estimate the minimum bit-rate of serial communication with an instrument. It details and summarizes all of the time delays that occur in the transmission of an address word and the reception of a data word using the ODAS Serial Manchester II communication link and then relates these to the bit rate of communication, the number of columns in an address matrix and the rate of sampling of the fast channels of an instrument. The strength of the received signal on a communication line decreases with increasing length of the line and bit-rate. Consequently, it is best to choose the lowest permissible bit rate for a given situation.

The serial Manchester II communication system is used with all remotely recording instruments, such as the VMP (Vertical Microstructure Profiler). A transceiver on the ship (usually a UTRANS, P026RXX) will, under the control of a computer, send addresses to one or more remote instruments. These remote instruments will respond (if there is an address match) with a data word that is returned on the communication link. The communication link is usually in simplex form where a pair of conductors is used both to send addresses and to return data. The following analysis applies to the simplex mode of operation. The communication link can also function in duplex mode, where two pairs of conductors are used, with one pair for the transmission of the addresses, and the other pair for the reception of the data. In duplex communication, the “time-of-flight” of the signals through the cable is irrelevant.

2 Definition of Symbols

Table 1: Definition of symbols. These values are the same for both the 6.9 and the 5.0 mm cables.

Symbol	Value	Description
R		Bit rate of communication, [bits/s]
B	30	Total number of bits in one address-data transmission.
N_C		The number of columns in an address matrix.
L		Length of cable, [m].
c	1.5×10^8	Speed of light in the cable, [$\mathrm{m\,s^{-1}}$].
f_S	512	Sampling rate of fast channels, [$\mathrm{s^{-1}}$].
Δ	15×10^{-6}	The sum of all bit-rate independent delays, [s].

Table 2: Bit-rate independent delays in communication. Peripherals with analog-to-digital converters (ADC) are the slowest ones.

Device	delay [µs]	Description
ADC	12	Multiplexer settling time.
UTRANS	3	Time to terminate the data-reception process.

Table 3: Bit-rate dependent delays in communication due to the transmission of an address and reception of a datum.

Device	delay [R^{-1}]	Description
RSTRANS	1	Delay in passing address bits to the serial instrument bus (SIB).
UTRANS	3	1 to transmit an address, and 2 after receipt of data.

3 The minimum bit-rate of communication

A complete transaction cycle consists of the transmission of an address from the UTRANS and the reception of a data word (for that address) at the UTRANS. A typical cycle is shown in Figure 1. The cycle starts with the UTRANS transmitting an 8-bit address (green

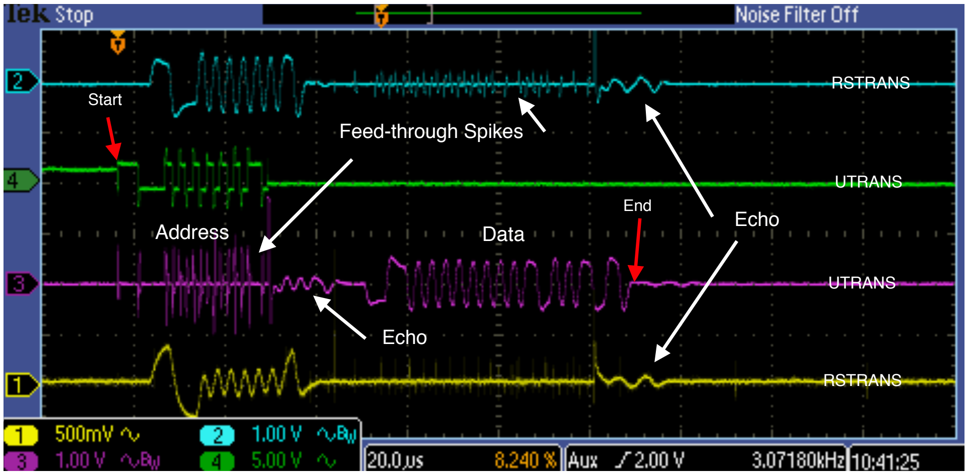

Figure 1: An oscilloscope trace of one transaction cycle. Its start and end are marked with red arrows. These signals were sent over a 1200 m long, 5.0 mm cable, at a bit-rate of 333 kbits/s.

trace in Figure 1). About 10 µs later the signal is received at the RSTRANS (yellow trace in Figure 1) and is reshaped by a proprietary amplifier to reproduce the original sharp-edged wave form (cyan trace in Figure 1). The 16-bit data response is received at the UTRANS end (magenta trace in Figure 1) and the reception ends about 150 µs after the start. The interval between the end of a cycle and the start of the next one is "idle" time and could be filled by lowering the bit-rate.

The time between successive demands for data is

$$\tau_R = \frac{1}{N_C f_S} \tag{1}$$

and equals 244 µs for a typical sampling rate of $f_S = 512\,\mathrm{s}^{-1}$ and $N_C = 8$ columns in an address matrix. The total time spent on a communication cycle must be shorter, else an address is sent before the data from the previously transmitted address has been received completely. The time spent on a transmission cycle is

$$\tau_C = \frac{B+4}{R} + \Delta + \frac{2L}{c} \tag{2}$$

where the first term is bit-rate dependent, the second term is the delay of the electronics, and the last term is the "time-of-flight" of the signals through the cable. Using 1 and 2 we can deduce the minimum bit rate, namely

$$R_{min} = (B+4)\left(\frac{1}{N_C f_S} - \Delta - \frac{2L}{c}\right)^{-1} . \tag{3}$$

The minimum bit rate increases with cable length, sampling rate, and the number of columns in an address matrix. Reducing any one of these will lower the bit-rate but this may be difficult to implement without a significant sacrifice. For example, shortening the cable limits the depth of profiling. Lowering the sampling rate may introducing some aliasing because the cut-off frequency of the anti-aliasing low-pass filters is not user adjustable. The implications of lowering the sampling rate are discussed in Application Note 010.

The bit-rate cannot be set arbitrarily. The rates that are available, and their relationship to the parameter "man_com_rate" in the ODAS-RT configuration file are presented in Table 4. The bit-rate of the UTRANS (deck-end transceiver) is set by the man_com_rate parameter, making it software adjustable. This value must match the jumper configuration of the RSTRANS inside of the instrument. Changing jumpers requires opening the instrument and setting the jumpers on JP3 (Figure 2). The jumpers represent the bits in the binary representation of man_com_rate. A pin-pair without jumpers is a 0 bit and a pair with a jumper installed is a 1 bit.

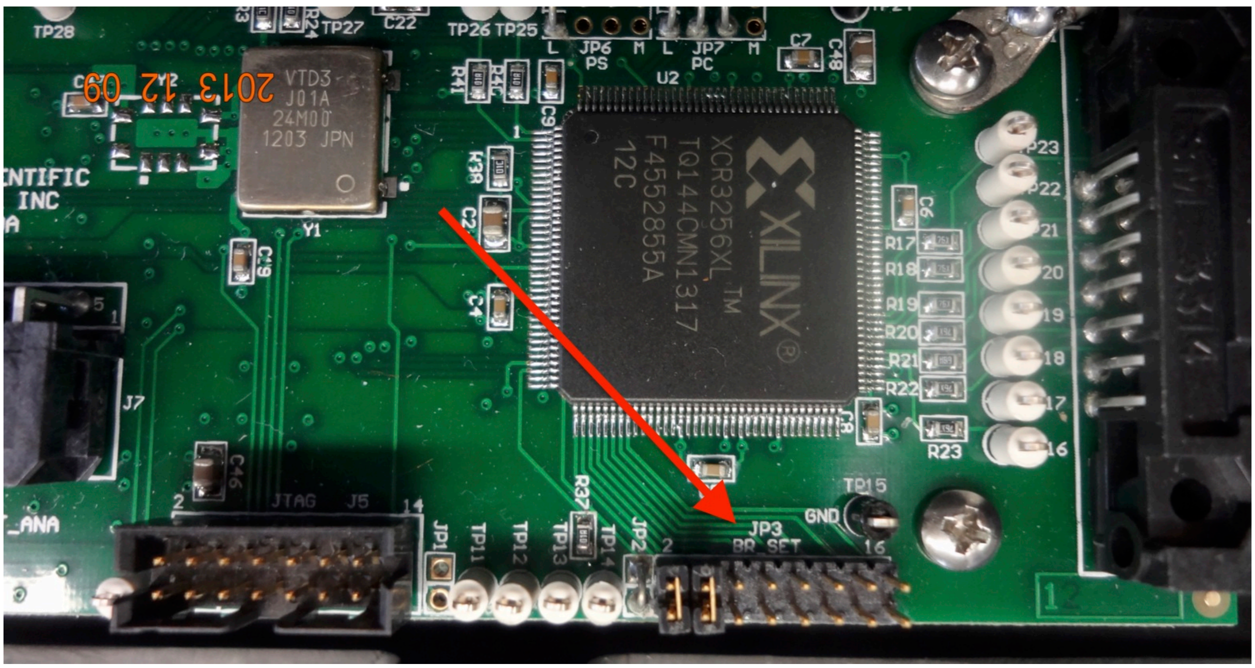

Figure 2: The pin-pair array of jumper JP3 on the RSTRANS board (red arrow). The left most pin pair is the least-significant bit (lsb) and the right most pair is the most-significant bit (msb). The value of a bit is 1 if a jumper is installed and is 0 without a jumper. In this example, the bit-rate is set to man_com_rate = 3.

The minimum bit-rates for five different cable lengths and for N_C of 8 to 12 are listed in Table 5.

Table 4: The communication bit-rate invoked by the man_com_rate parameter in the configuration file and by the jumpers (JP3) on the RSTRANS board.

R [kbits /s]	man_com_rate	Jumpers [msb $\rightarrow$ lsb]
2000	0	00000000
1000	1	00000001
500	2	00000010
333	3	00000011
250	4	00000100
200	5	00000101
167	6	00000110
143	7	00000111
125	8	00001000

Table 5: The minimum bit-rate of communication for a variety of cable lengths and number of columns in the address matrix of the configuration file, when the sampling rate of fast channels is $512\,\mathrm{s}^{-1}$. Whenever $R_{min} \geq 0.9$ times a standard rate, we show the next highest standard rate.

R_{min} [kbits /s]	R [kbits /s]	N_C	L
148	200	8	0
168	200	9	0
189	250	10	0
209	250	11	0
230	333	12	0
158	200	8	1000
180	200	9	1000
204	250	10	1000
228	333	11	1000
253	333	12	1000
160	200	8	1200
183	250	9	1200
207	250	10	1200
232	333	11	1200
259	333	12	1200
168	200	8	2000
194	250	9	2000
221	250	10	2000
250	333	11	2000
281	333	12	2000
180	200	8	3000
210	250	9	3000
242	333	10	3000
277	333	11	3000
316	333	12	3000

4 Discussion

The values listed in Table 5 should be used with caution whenever the calculated bit-rate, using (3), is larger than 80 % of a standard rate, particularly with long cables. The speed of light in the cable has been measured in air only. The speed is determined by the capacitance and inductance per unit length of the cable. The capacitance per unit length is larger when the cable is in seawater because of the added AC electrical path between pairs of conductors provided by the seawater. The time-of-flight has not been measured with a cable submerged in seawater. A user must test the instrument-cable system when the minimum bit rate is close to the actual bit rate. One method is to simply change to a bit-rate and try it. If the rate is inadequate, the “Bad Buffer” message will appear on the ODAS-RT display. To determine the headroom more precisely, the signals will have to be monitored with an oscilloscope at a test point in the UTRANS. RSI will provide instructions for such a measurement.

Using the lowest possible bit-rate provides two benefits. Firstly, the signal received at the far end of the cable (such as the yellow trace in Figure 1) is stronger, which makes it easier to recover the signal. Secondly, and more importantly, the phase shift of the signal is reduced and this brings the bit transitions closer to their original location, which greatly reduces communication errors.

Cables that have been damaged by anomalously large stresses, such as by bending it around sharp-edged objects, or by excessive twisting and hockling, may still show DC electrical characteristics that are nominal. However, the local discontinuity of resistance, capacitance and inductance will cause a partial reflection of the signals. A reflection reduces the amplitude of the transmitted signal. The reflected signal will probably get reflected back into its original direction of travel (by other discontinuities) and thereby skew the phase of the signal received at the far end. This skewing of phase can be very detrimental. Usually, the maximum stress on the cable is at the instrument end. If a cable, that previously worked well, exhibits progressive deterioration (an increase in the frequency of bad buffers, for example), then it may be necessary to trim off some of the cable at the instrument end, and re-terminate in order to re-establish successful communication. The amount trimmed from the cable is usually 50 to 200 m. The entire length of a cable should also be visually inspected for signs of damage, on a regular basis (such as before every cruise), by spooling the cable from the winch to a holding drum.

5 Appendix: Cable Characteristics

Table 6: The main physical characteristics of the cables supplied by RSI. The electrical characteristics are values measured by RSI in air.

Feature		
OD	6.9 mm	5.0 mm
Conductors	4	4
Gauge	22 (19/34)	26 (7/34)
Insulation	LPDE	LPDE
Colours	B/R/W/G	B/R/W/G
Filler	Nylon monofilament, hydrophobic gel, wrapped with adhesive mylar	Same
Strength member	Torque balanced Vectran braided layer	Same
Jacket	Polyurethane, 1.3 mm	Polyurethane, 0.76 mm
Operating		
Temperature	$-40\,°\mathrm{C}$ to $80\,°\mathrm{C}$	Same
Minimum		
Bending Radius	150 mm	100 mm
Working Load	1250 N	900 N
Breaking Strength	8600 N	6400 N
Weight, air	$0.60\,\mathrm{N\,m^{-1}}$	$0.27\,\mathrm{N\,m^{-1}}$
Weight, seawater	$0.15\,\mathrm{N\,m^{-1}}$	$0.075\,\mathrm{N\,m^{-1}}$
Resistance		
Specified	$51\,\mathrm{m\Omega\,m^{-1}}$	$89\,\mathrm{m\Omega\,m^{-1}}$
Measured	$50\,\mathrm{m\Omega\,m^{-1}}$	$134\,\mathrm{m\Omega\,m^{-1}}$
Capacitance		
Opposing Pairs	$65\,\mathrm{pF\,m^{-1}}$	$67\,\mathrm{pF\,m^{-1}}$
Adjacent Pairs	$76\,\mathrm{pF\,m^{-1}}$	$74\,\mathrm{pF\,m^{-1}}$
Inductance		
Opposing Pair	NA	$1.04\,\mathrm{\mu H\,m^{-1}}$
Adjacent Pair	NA	$1.43\,\mathrm{\mu H\,m^{-1}}$
Impedance	$120\,\Omega$	
Speed of Light	$1.54 \times 10^{8}\,\mathrm{m\,s^{-1}}$	$1.55 \times 10^{8}\,\mathrm{m\,s^{-1}}$
Refractive Index	1.95	1.94

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