Rockland Technical Note 003

— Transmission Reception Time—
Transmission-Reception Time with ODAS Serial Communication

Rolf Lueck

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Rockland Scientific International Inc.
520 Dupplin Rd
Victoria, BC, CANADA, V8Z 1C1
www.rocklandscientific.com

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info@rocklandscientific.com
tel: +1 250 370 1688

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2021-03-15	Initial version
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Contents

1 Introduction

This document is a guide to operating, maintaining and troubleshooting Rockland Scientific real-time instrumentation with UTRANS (P026RXX) and RSTRANS (P039RXX). Additional information about your real-time instrument can be found in the instrument manual. This document can also be used to estimate the minimum bit-rate of serial communication with Rockland Scientific real-time instrumentation. 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) 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 received 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 mm 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, [m s^{-1}].
f_S	512	Sampling rate of fast channels, [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-

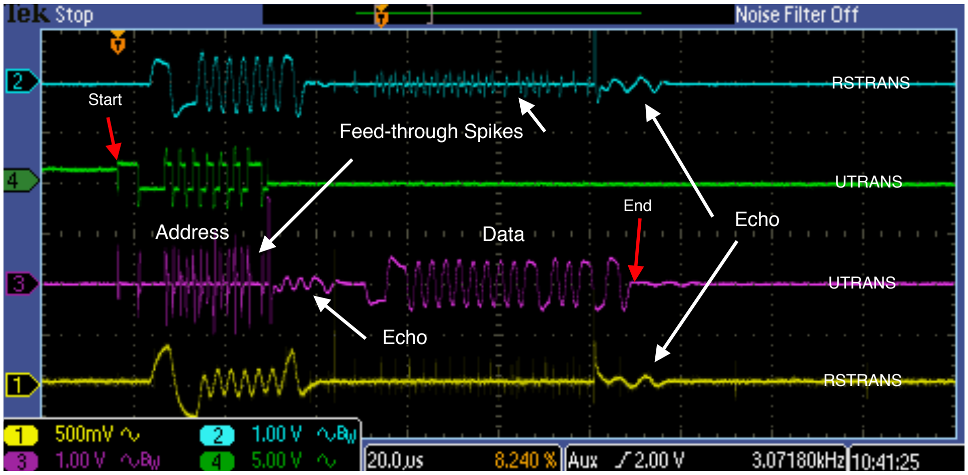

Figure 1: An oscilloscope trace of one transaction cycle. Its start and end are marked with red arrows. These signals were sent over a 1200 m long, 5.0 mm cable, at a bit-rate of 333 kbits/s.

bit address (green 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 Technical Note 010 - Design and Optimization of Anti-Aliasing Filters.

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 (setup.cfg) 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.

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

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

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 s^{-1}. Whenever $R_{min} \geq 0.9$ times a standard rate, we show the next highest standard rate. The man_com_rate corresponding to the R value is provided for reference.

R_{min} [kbits /s]	Man_com_rate	R [kbits /s]	N_C	L
148	5	200	8	0
168	5	200	9	0
189	4	250	10	0
209	4	250	11	0
230	3	333	12	0
158	5	200	8	1000
180	5	200	9	1000
204	4	250	10	1000
228	3	333	11	1000
253	3	333	12	1000
160	5	200	8	1200
183	4	250	9	1200
207	4	250	10	1200
232	3	333	11	1200
259	3	333	12	1200
168	5	200	8	2000
194	4	250	9	2000
221	4	250	10	2000
250	3	333	11	2000
281	3	333	12	2000
173	5	200	8	2500
202	4	250	9	2500
231	3	333	10	2500
263	3	333	11	2500
297	3	333	12	2500
180	5	200	8	3000
210	4	250	9	3000
242	3	333	10	3000
277	3	333	11	3000
316	3	333	12	3000

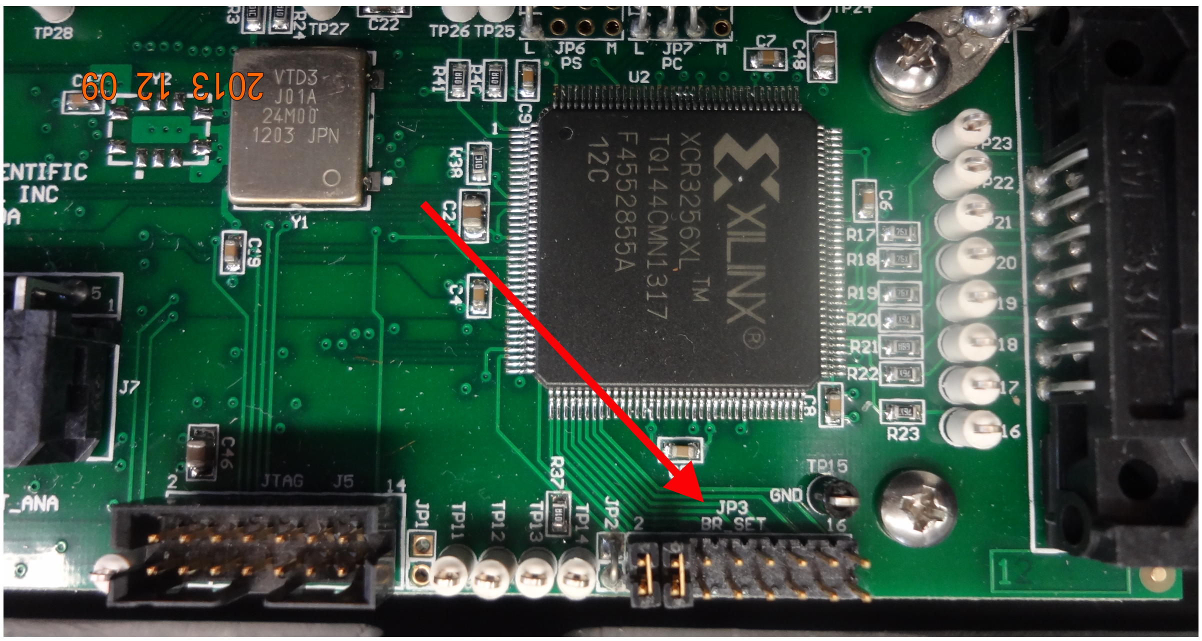

Figure 2: The pin-pair array of jumper JP3 on the RSTRANS board (red arrow). The left most pin pair is the least-significant bit (lsb) and the right most pair is the most-significant bit (msb). The value of a bit is 1 if a jumper is installed and is 0 without a jumper. In this example, the bit-rate is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

4 Discussion

4.1 Bad Buffers and Cable Length

It is not recommended to use a cable length over 2000 m as communication will be marginal and may quickly become very poor after wear and tear on the cable occurs. A "Bad Buffer" indicates that 1 record of data (typically equivalent to 1 second of data) was not received properly, is corrupt and cannot be used or recovered. Bad Buffers are displayed in the ODAS-RT software and also recorded in the logfile.txt. They can also be identified with the ODAS Matlab code using the check_bad_buffers.m function. A few bad buffers are expected and the ODAS matlab function quick_look.m will automatically resolve small numbers of these bad buffers; approximately 1 to 10 per minute. If there are larger numbers of bad buffers, the quick_look.m function will not resolve the issue. Large numbers of bad buffers are a concern and must be addressed by troubleshooting.

4.2 System Configuration

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 (by changing the man_com_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. Rockland 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.

4.3 Troubleshooting

Cables that have been damaged by anomalously large stresses, such as by bending it around sharp-edged objects (see Bend Radius in section 5), or by excessive twisting and hockling, may still show DC electrical characteristics that are nominal. However, the local discontinuity of resistance, capacitance and inductance changes the cable impedance and can cause a partial reflection of the signals. A reflection reduces the amplitude of the transmitted signal. The reflected signal might be reflected back into its original direction of travel and superimposed with the newly transmitted data. This can cause signal distortion (amplitude and phase), which can be detrimental for a reliable data transmission. 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 5 m 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.

In some cases a damaged cable may not be able to transmit all of the data. One method for troubleshooting is to reduce the amount of data being sent via the cable by either removing columns in the address matrix in the configuration file (N_C) or changing the rate in the configuration file (for example, reducing the rate from 512 to 256) and testing communication again. If this allows for good communication to occur then the issue is high data rate. Changing the rate can be used to confirm too much data is being sent, but It is important not to collect data at a rate other than 512 Hz (or other values recommended by Rockland) as this will make data processing very difficult, so to reduce data sent up the cable it is best to remove columns in the address matrix (N_C).

If communication cannot be established or large amounts of bad buffers occur it is recommended to contact the Rockland Support team at support@rocklandscientific.com.

5 Appendix: Cable Characteristics

Table 6: The main physical characteristics of the cables supplied by Rockland. The electrical characteristics are values measured by Rockland 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	−40–80 °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 Ω	
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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