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Transmission-Reception Time with ODAS Serial Communication

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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 Micro-structure 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, 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 transmission-reception time is irrelevant.

Definition of Symbols

Table 1. Definition of symbols.

Symbol	Value	Description
R		Bit rate of communication, [bits per s]
B	30 or 40	The total number of bits in one address plus one data word. Old instruments with a hardware Manchester chip use 40 bits – 16 for each addresses and data, 3 for preamble and 1 for parity for each of address and data. New instruments, have the Manchester function programmed into the Xilinx chip, and use 30 bits – 8 for addresses, 16 for data, 3 for pre-amble, and none for parity.
N_C		The number of columns in the address matrix. A complete description of the address matrix is in the ODAS4-RT User Manual.
$\tau=2L/c$		Round trip travel time for signals in the cable [s].
L		Length of cable [m].
c	155×10^{6}	The speed of signals in the cable [m/s] ~ one-half the speed of light in vacuum.
Δ		The sum of all delays that are independent of the bit rate R [s].
f_s	512	Sampling rate of the fast channels [1/s].
t_s	667×10^{-9}	Period of the sequence clock used to orchestrate firmware operations [s].

Fixed-length Delays

Table 2. Fixed length delays in communication. Therefore, Δ = 17 x 10^{-6} seconds

Device	Amount [t_s]	Description
RTRANS P004RXX	2	Time to assert I_Address_Valid
AD Converter P006RXX	12	The analog-to-digital converter is the slowest peripheral in an instrument, so only it needs to be considered for timing purposes. The delay consists of MUX settling-, conversion-, and signaling-time.
UTRANS P026RXX	3	This is the time to signal the reception of a data word and to release the Instrument Bus.

Bit-Rate Dependent delays

Table 3. The bit-rate dependent delays total to $4R^{-1}$ seconds.

Device	Amount [R^{-1}]	Description
RTRANS P004RXX	1	There is a delay of 1 unit before a data word is transmitted.
UTRANS P026RXX	3	There is a delay of one unit of before an address is transmitted and 2 units after a data word has been received..

The Equations

The time for a "sweep" through a row of the address matrix is

$$\tau_c = f_s^{-1}. \tag{1}$$

The time spent to communicate the addresses in a row, plus the time spent to receive the data words for this row is

$$N_c = \left(\frac{B+4}{R} + \Delta + \frac{2L}{c}\right) \tag{2}$$

and this must be shorter than the time to sweep through a row of the address matrix (1). In (2), the first term in brackets is the bit-rate dependent delay, the next is the fixed length delay and the last term is the round-trip time of flight of the signals. These apply to each address, and the total delay is their sum multiplied by the number of columns in the address matrix, N_c. The transmission of an address and the reception of a data word must be completed before the next address is sent. Therefore, (1) must exceed (2), or

$$\frac{1}{f_s} > N_c\left(\frac{B+4}{R} + \Delta + \frac{2L}{c}\right) \tag{3}$$

and, upon a little re-arranging, we find that the bit-rate must exceed

$$R > \frac{B+4}{\frac{1}{N_c f_s} - \Delta - \frac{2L}{c}} \tag{4}$$

The minimum rate increases with cable length, the number of columns and the sampling rate. 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. An example of a lowered sampling rate is shown the third row of table 5. The number of columns can be reduced by placing all slow channels into a single column. Beyond that, some fast channels may have to be eliminated or moved into the slow column (with the possibility of significant aliasing).

The bit-rate cannot be set arbitrarily. The rates that are available, and their relationship to the parameter "man_com_rate" in the ODAS4 setup 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 in RTRANS or RSTRANS inside of the instrument (which requires opening the instrument and invoking a "hardware adjustment"). The jumpers represent the bits in the binary representation of man_com_rate. The jumper set is label JP4 on all versions of RTRANS (P004RXX) and RSTRANS (P039RXX).

Table 4. The bit-rate of communication invoked by the man_com_rate parameter and the corresponding jumper setting (JP4) of RTRANS or RSTRANS in an instrument.

R [kbits/s]	man_com_rate	Jumpers [msb ↔ 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

Some typical minimum bit-rate values for a variety of configurations are tabulated below.

Table 5. The minimum bit-rate for communication for a range of columns in the address matrix $8 \le N_c \le 12$, and cable length $0 \le L \le 3000$ m. Most instruments have $B = 30$ which provides a lower minimum bit-rate than early instruments which have $B = 40$.

f_s [Hz]	$R > \frac{B+4}{\frac{1}{N_c f_s} - \Delta - \frac{2L}{c}}$ [kbits/s]	*R* [kbits/s]	N_c	*L [m]*	*B*
512	194	200	8	0	40
512	220	250	9	0	40
470	196	200	9	0	40
512	247	250	10	0	40
512	274	333	11	0	40
512	302	333	12	0	40
512	205	250	8	1000	40
512	235	250	9	1000	40
512	266	333	10	1000	40
512	298	333	11	1000	40
512	331	333	12	1000	40
512	219	250	8	2000	40
512	253	333	9	2000	40
512	289	333	10	2000	40
512	327	333	11	2000	40
512	367	500	12	2000	40
512	234	250	8	3000	40

Table 5. The minimum bit-rate for communication for a range of columns in the address matrix $8 \le N_c \le 12$, and cable length $0 \le L \le 3000$ m. Most instruments have B = 30 which provides a lower minimum bit-rate than early instruments which have B = 40.

f_s [Hz]	$R > \frac{B+4}{\frac{1}{N_c f_s} - \Delta - \frac{2L}{c}}$ [kbits/s]	R [kbits/s]	N_c	L [m]	B
512	273	333	9	3000	40
512	315	333	10	3000	40
512	361	500	11	3000	40
512	411	500	12	3000	40
512	150	200	8	0	30
512	170	200	9	0	30
512	191	200	10	0	30
512	212	250	11	0	30
512	233	250	12	0	30
512	159	200	8	1000	30
512	182	200	9	1000	30
512	206	250	10	1000	30
512	230	250	11	1000	30
512	256	333	12	1000	30
512	169	200	8	2000	30
512	195	200	9	2000	30
512	223	250	10	2000	30
512	252	333	11	2000	30
512	283	333	12	2000	30
512	180	200	8	3000	30
512	211	250	9	3000	30
512	244	333	10	3000	30
512	279	333	11	3000	30
512	318	333	12	3000	30

Discussion

The first few instruments produced by RGL Consulting Ltd and Rockland Scientific International, Inc. used a hardware chip to implement the Manchester II communication protocol. This applies to instruments with serial numbers smaller than SN006. This chip only supports 16-bit words, adds a parity bit and a pre-ample of 3 bits. Consequently, 16-bit words are used for address even though the values are only in the range of 0 to 255, and 8-bits is sufficient to communicate the address values. After considerable effort, we have developed the code to implement the Manchester II encoding and decoding into the programmable logic chips that are used in all of our instruments. This gives us the freedom to reduce the word size to 8-bits for address and to eliminate the parity bit. Thus, newer instruments require only 30 bits for the complete transmission of an address and the reception of its corresponding data word. The minimum bit-rate is, thereby, reduced significantly.

Most new instruments do not have a RTRANS and use, instead, the RSTRANS. The delays are the same for these two boards.

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