

Title: Maximal Data-Rates of TTTech Systems**Description**

Communication speed for TTP using AS8202 or AS8202NF controllers with MFM coding is up to 5 Mbit/s. Not only the throughput of the controller chips (transmitter and receiver), but also the signal transmission in the physical layer limits the data rate.

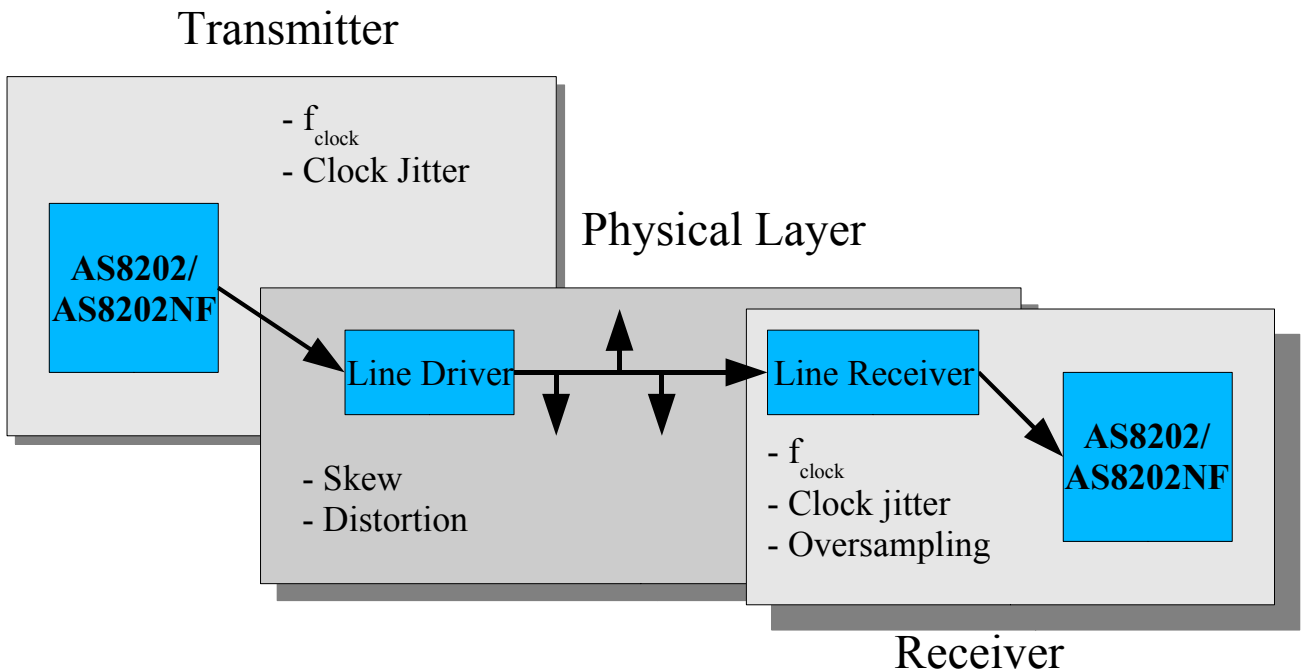


Figure 1) Transmission System and Parameters which Influence Transmission Speed

Computation of the maximal data rate requires knowledge of both, the parameters of the controller and the parameters of the physical signal transmission. The controller's parameters are well known, but limits of the timing distortion introduced by the physical transmission system have to be determined by the user for the each application. No general values can be given as they depend on numerous parameters (i.e., line driver/receiver type, cable length, number of nodes on the bus, termination networks, transmission line filters, common mode distortion etc.).

Table 1 summarizes the maximal data-rates for a TTTech cluster (MFM coding) in different configurations.

Controller	Configuration	Data Rate	Comment
<i>AS8202</i> <i>AS8202NF</i>	<i>osr</i> = 8 25 ns jitter tolerance	5 Mbps	TTTech standard products, restrictions apply ¹
	<i>osr</i> = 10 40 ns jitter tolerance	4 Mbps	TTTech standard products
	<i>osr</i> = 8 25 ns jitter tolerance LTC1685 transceiver ²	5 Mbps	The fast transceiver permits high data rates with less restrictive cabling
	<i>osr</i> = 10 40 ns jitter tolerance AS 8221 transceiver	4 Mbps	Values based on AS8221 specification ³
	<i>osr</i> = 6, <i>f_{clk}</i> = 30 MHz 33 ns jitter tolerance AS 8221 transceiver	5 Mbps	Values based on AS8221 specification ³ . See Note 4

osr...oversampling rate

Table 1) Achievable Data Rates for Typical Configurations

Note 1) Under laboratory conditions (0..60°C, cabling as delivered by TTTech, negligible common mode distortion) all products permit transmission of 5 Mbps. If longer cables are used the data rate can not be guaranteed, although typical clusters will work without a problem.

Note 2) Available on request.

Note 3) Not available today.

Note 4) In case of AS8202 the PLL has to be disabled.

Computation of the Maximal Data Rate

To ensure reliable data transfer, the TTP-controller has to be set up according to the properties of the physical transmission. The maximal timing distortion introduced by the transmission plus timing deviations of the controllers have to be equal or smaller than the *edge_jitter_tolerance* parameter (specified in TTP-Plan).

$$t_{ejt} = t_{skew} + t_{sh} + t_{jr} + t_{jt} + t_{skt}$$

holds, where:

t_{ejt} edge jitter tolerance,

t_{skew} transmission skew,

t_{sh} receiver FF setup and hold time,

t_{jr} worst case receiver jitter,

t_{jt} worst case transmitter jitter.

t_{skt}..... digital skew of the transmitting controller,

All jitter and skew values are positive. Receiver and transmitter jitter have to include the PLL jitter, when the internal PLL is used.

The parameter *edge_jitter_tolerance* is a multiple of the sampling period t_s , $t_{ejt}=m t_s$. The values of t_{ejt} are restricted depending on the oversampling rate (table 2).

oversampling rate	t_{ejt}
8	$t_{ejt} = t_s$
10	$t_s \leq t_{ejt} \leq 2 t_s$
12	
14	$t_s \leq t_{ejt} \leq 3 t_s$
16	
18	$t_s \leq t_{ejt} \leq 4 t_s$
20	

Table 2) Possible Values for *edge_jitter_tolerance* (t_{ejt}).

For the shortest bit duration follows,

$$t_{bit} = OSR \cdot t_s$$

$$t_s = \frac{t_{sh} + t_{jr} + t_{jt} + t_{skt} + t_{skew}}{m}$$

$$t_{bit} = \frac{OSR}{m} (t_{sh} + t_{jr} + t_{jt} + t_{skt} + t_{skew}).$$

where

t_{bit} bit time

OSR oversampling rate,

t_s sampling period.

The achievable data rate is either limited by the maximal sampling frequency divided by the oversampling rate, or by the physical layer.

$$f_{bit\ max} = \min \left(\frac{m}{OSR \cdot t_{sh} + t_{jr} + t_{jt} + t_{skt} + t_{skew}}, \frac{f_{s\ max}}{OSR} \right)$$

f_{bitmax} maximal data rate.

The document “Timing Requirements for Manchester and MFM Coded Transmission” (Doc. Nr. D-C2NF-A-HW-01) gives insight in the function of the bit-coder and decoder modules of the AS8202 and the AS8202NF. The formulas given above are based on this document.