Using Computations In COM To Determine Tx SNDR

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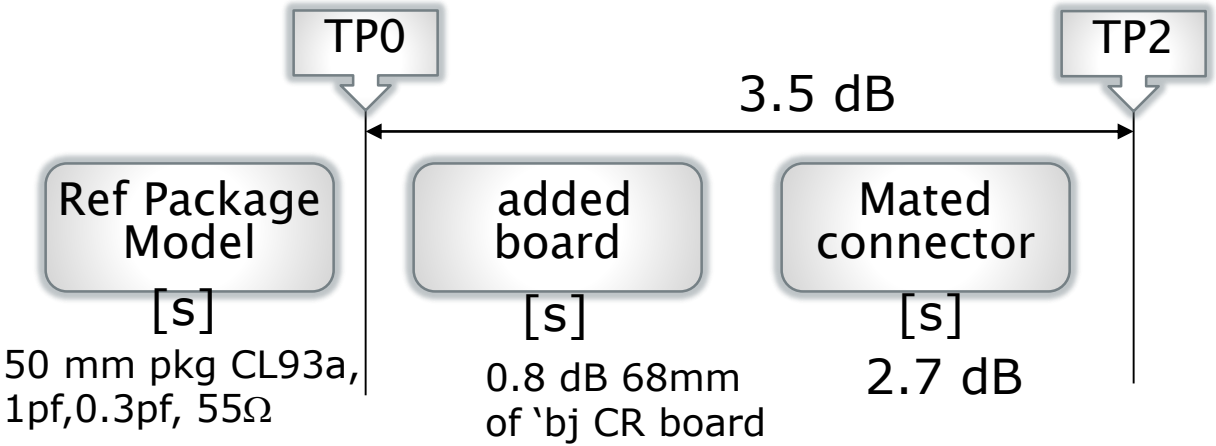
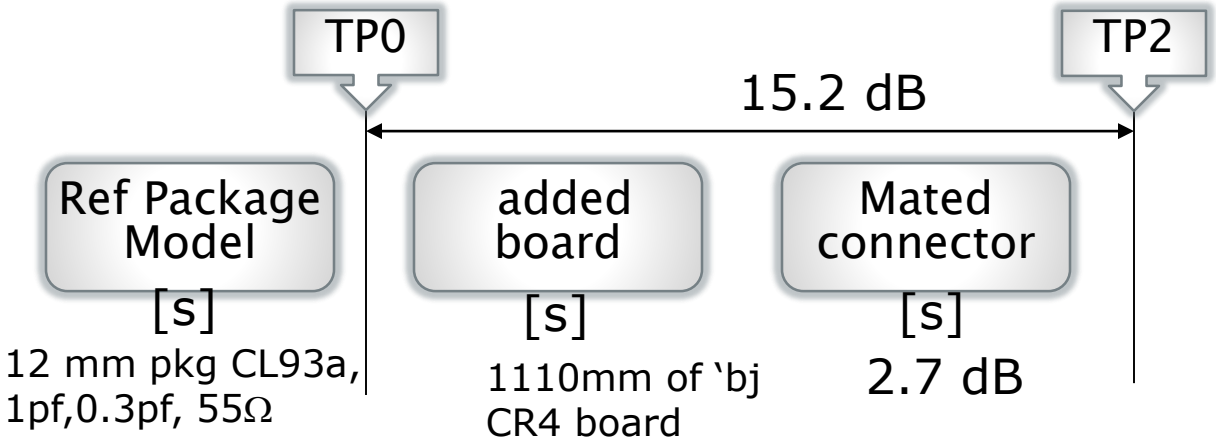
5Gb/s Tx Drive Set up (loss spec'ed at 5.156GHz)



2.5Gb/s Tx Drive Set up is physically the same

5Gb/s Tx Enclosure Set up (loss spec'ed at 5.156GHz)



2.5Gb/s Tx Enclosure Set up is physically the same

SNDR estimate using COM from Channel Models

- COM has interim and an informational reported value. The Matlab COM code reports the peak of the unequalized pulse
- Setting DFE0 and b(1) to zero forces the sample point to be at the peak of the pulse as in eq. 93A-25. This makes it easy for 2.5G

$$h^{(0)}(t_s - T_b) = h^{(0)}(t_s + T_b) - h^{(0)}(t_s)b(1)$$

- FOM is essentially an estimate of SNDR (minus distortion)
- The basic idea is to use Eq. 93a-36, zero out certain sigmas and re-calibrate to the pulse peak

$$FOM = 10\log_{10}\left(\frac{A_s^2}{\sigma_{TX}^2 + \sigma_{ISI}^2 + \sigma_J^2 + \sigma_{XT}^2 + \sigma_N^2}\right)$$

SNDR estimate using COM from Channel Models

- Use TP0-TP2 thru and crosstalk channel models
- For 2.5G set jitter to zero eta_0 to 0 and SNDR to what we expect for a chip. Force As to the peak value by not using any DFE or Tx FFE.
- For 5G use Tx_SNR for tx chip (as in COM table), use spec DFE, and force Tx FFE to zero,
  - FOM1 reduces to dB10(As^2/(σ_isi^2+σ_tx^2)
  - Record As (available signal)
  - Record Pmax=peak_uneq_pulse_mV
  - Tx_SNDR=FOM1+dB10(Pmax^2/As^2)
- Vf is steady_state_voltage_mV when Np is set to the value specified for the PMD
- p_{max}/Vf=peak_uneq_pulse_mV/ steady_state_voltage_mV

5Gb/s Tx Drive Configuration

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	5.15625	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1e-3 0]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[12]	mm	[test cases]
z_p (NEXT)	0	mm	[test cases]
z_p (FEXT)	0	mm	[test cases]
z_p (RX)	0	mm	[test cases]
C_p	[3e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 50]	Ohm	[TX RX]
f_r	1.55159038	*fb	
c(0)	0		min
c(-1)	1		[min:step:max]
c(1)	0		[min:step:max]
g_DC	[0]	dB	[min:step:max]
f_z	12.890625	GHz	
f_p1	12.890625	GHz	
f_p2	5.16E+01	GHz	
A_v	0.4	V	
A_fe	0.4	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	5	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0	UI	0.0
A_DD	0	UI	0.0
eta_0	0	V^2/GHz	
SNR_TX	30	dB	12.6
R_LM	1		
DER_0	1.00E-12		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	logical	

ps

ps

mV RMS

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\COM_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.06	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	1	logical
INCLUDE_CTLE	0	logical
INCLUDE_TX_RX_FILTER	1	logical

COM_CONTRIBUTION	0	logical

1

Table 93A–2 parameters		
Parameter	**Setting**	**Units**
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_Z_c	78.2	Ohm [Tx Rx]

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_tau	6.191E-03	ns
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_Z_c	110	Ohm
z_bp (TX)	68	mm
z_bp (NEXT)	68	mm
z_bp (FEXT)	0	mm
z_bp (RX)	0	mm

2.5Gb/s Tx Drive Configuration

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	3.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1e-3 0]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[12]	mm	[test cases]
z_p (NEXT)	0	mm	[test cases]
z_p (FEXT)	0	mm	[test cases]
z_p (RX)	0	mm	[test cases]
C_p	[3e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 50]	Ohm	[TX RX]
f_r	1.55159038	*fb	
c(0)	0		min
c(-1)	1		[min:step:max]
c(1)	0		[min:step:max]
g_DC	[0]	dB	[min:step:max]
f_z	7.8125	GHz	
f_p1	7.8125	GHz	
f_p2	3.13E+01	GHz	
A_v	0.4	V	
A_fe	0.4	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	0	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0	UI	0.0
A_DD	0	UI	0.0
eta_0	0	V^2/GHz	
SNR_TX	30	dB	12.6
R_LM	1		
DER_0	1.00E-12		

ps

ps

mV RMS

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\COM_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.06	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	1	logical
INCLUDE_CTLE	0	logical
INCLUDE_TX_RX_FILTER	1	logical

COM_CONTRIBUTION	0	logical

1

Table 93A–2 parameters		
Parameter	**Setting**	**Units**
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
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board_tl_tau	6.191E-03	ns
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board_Z_c	110	Ohm
z_bp (TX)	68	mm
z_bp (NEXT)	68	mm
z_bp (FEXT)	0	mm
z_bp (RX)	0	mm

2.5Gb/s Tx Enclosure Configuration

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	3.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1e-3 0]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[50]	mm	[test cases]
z_p (NEXT)	0	mm	[test cases]
z_p (FEXT)	0	mm	[test cases]
z_p (RX)	0	mm	[test cases]
C_p	[3e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 50]	Ohm	[TX RX]
f_r	1.55159038	*fb	
c(0)	0		min
c(-1)	1		[min:step:max]
c(1)	0		[min:step:max]
g_DC	[0]	dB	[min:step:max]
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f_p1	7.8125	GHz	
f_p2	3.13E+01	GHz	
A_v	0.4	V	
A_fe	0.4	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	0	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0	UI	0.0
A_DD	0	UI	0.0
eta_0	0	V^2/GHz	
SNR_TX	30	dB	12.6
R_LM	1		
DER_0	1.00E-12		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	logical	

ps

ps

mV RMS

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\COM_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	0.1	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	1	logical
INCLUDE_CTLE	0	logical
INCLUDE_TX_RX_FILTER	1	logical

COM_CONTRIBUTION	0	logical

1

Table 93A–2 parameters		
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package_tl_tau	6.141E-03	ns
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package_Z_c	78.2	Ohm [Tx Rx]

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Parameter	**Setting**	
board_tl_tau	6.191E-03	ns
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_Z_c	110	Ohm
z_bp (TX)	1100	mm
z_bp (NEXT)	1100	mm
z_bp (FEXT)	0	mm
z_bp (RX)	0	mm

5Gb/s Tx Enclosure Configuration

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	5.15625	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1e-3 0]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[12]	mm	[test cases]
z_p (NEXT)	0	mm	[test cases]
z_p (FEXT)	0	mm	[test cases]
z_p (RX)	0	mm	[test cases]
C_p	[3e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 50]	Ohm	[TX RX]
f_r	1.55159038	*fb	
c(0)	0		min
c(-1)	1		[min:step:max]
c(1)	0		[min:step:max]
g_DC	[0]	dB	[min:step:max]
f_z	12.890625	GHz	
f_p1	12.890625	GHz	
f_p2	5.16E+01	GHz	
A_v	0.4	V	
A_fe	0.4	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	5	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0.000	UI	0.0
A_DD	0	UI	0.0
eta_0	0.00E+00	V^2/GHz	
SNR_TX	30	dB	12.6
R_LM	1		
DER_0	1.00E-12		
Operational control			
COM Pass threshold	3	dB	
Include PCB	1	logical	

ps

ps

mV RMS

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\COM_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	6.00E-02	ns
T_r_meas_point	0	logical
T_r_filter_type	1	logical

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	1	logical
INCLUDE_CTLE	0	logical
INCLUDE_TX_RX_FILTER	1	logical

COM_CONTRIBUTION	0	logical

Table 93A–2 parameters		
Parameter	**Setting**	**Units**
package_tl_tau	6.141E-03	ns
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_Z_c	78.2	Ohm [Tx Rx]

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_tau	6.191E-03	ns
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_Z_c	110	Ohm
z_bp (TX)	1110	mm
z_bp (NEXT)	1110	mm
z_bp (FEXT)	0	mm
z_bp (RX)	0	mm

1

cd

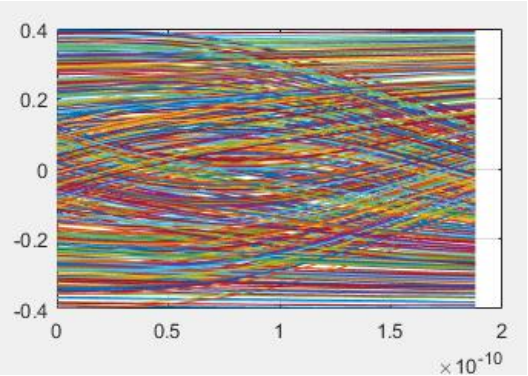
Fitting with PRBS9

	2.5 Host	2.5 Drive	5G Host May use CTLE to align data pattern	5G Drive
Transmitter steady-state voltage, vf (max.)	600mv	600mv	600mv	600mv
Transmitter steady-state voltage, vf (min.)	400 mv Np=100	400 mv Np=100	285mv Np=8	360mv Np=8
Linear fit pulse peak (min)	0.42Vf Np=100	0.84Vf Np=100	0.41 Vf Np=8	0.85Vf Np=8
SNDR	5.6dB Np=3 for sigma	25dB Np=3 for sigma	16 dB Np=8	28dBNp=8

It would be useful to double check and results with existing channel files.

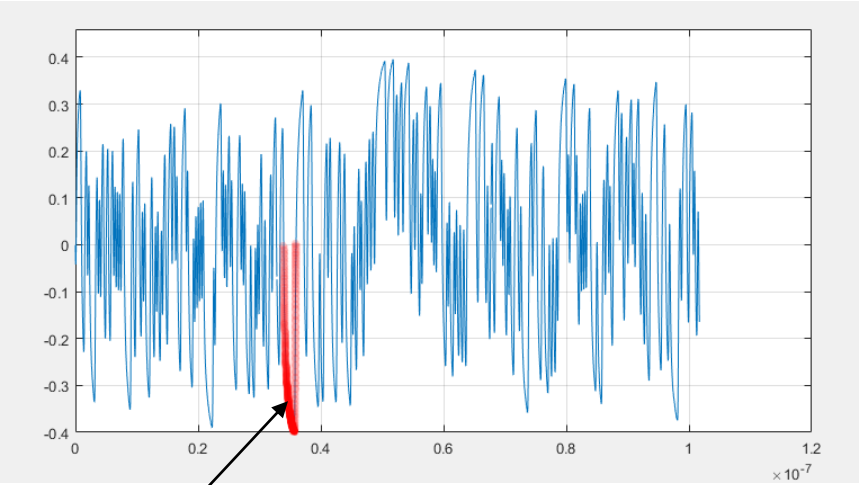
Double Checking Tx Parameters from Measurements with example procedure (TxFt Matlab)

- As a aid to fitting a CLTE may be used to align the data pattern and then a data pattern many be extracted from the data.
  - Fitting is performed with the unfiltered signal once the data pattern has been aligned
- The high loss 5G channel the unfiltered eye diagramed has a closed eye
  - 15 dB channel eye diagram



Procedure – Step 1

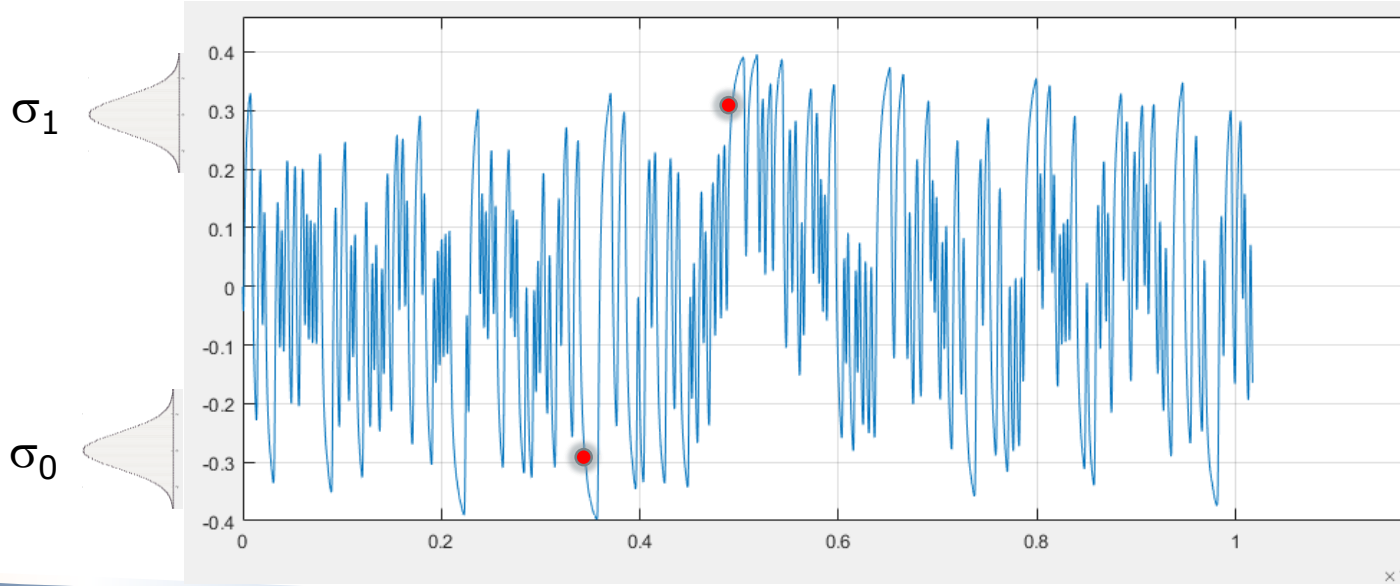
- Trigger on the longest run of bits. For PRBS9 it is a 8 bit sequence.
- Average the waveform at least 100 times
- Save the averaged waveform as voltage-time csv file



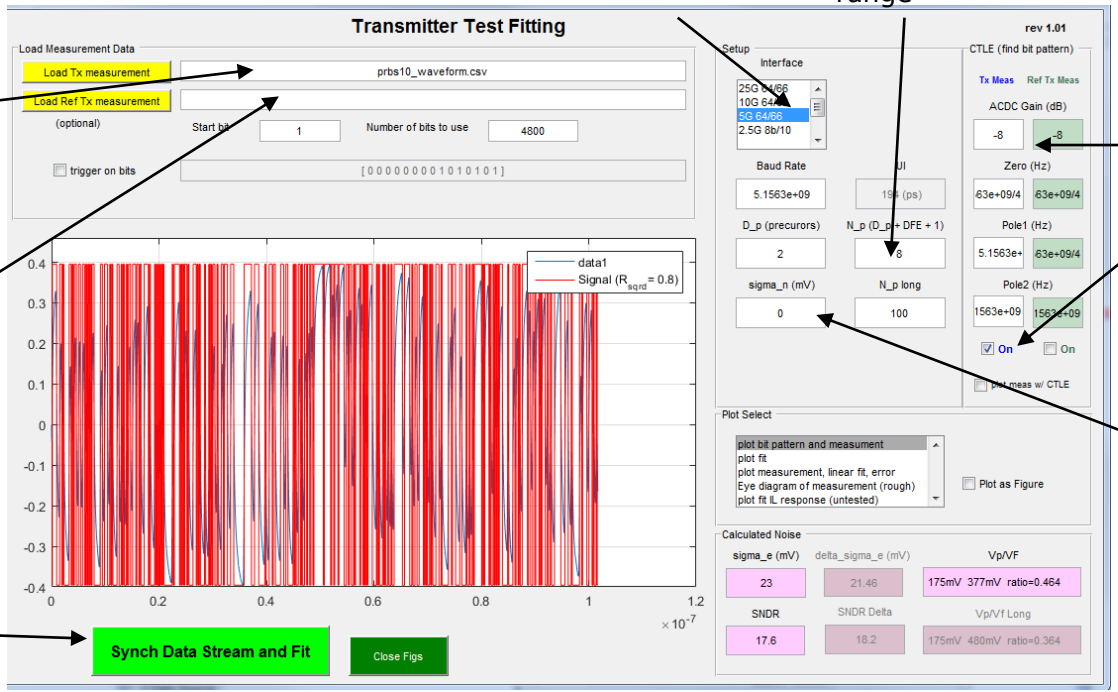
Procedure – Step 2 noise voltage

- With averaging off, choose 2 points, one on a run of ones and the run of ones zeroes
- Acquire voltage histograms and get a sigma value for each

$$\sigma_n = \sqrt{{\sigma_1}^2 + {\sigma_0}^2}$$



Step 3: Example procedure (TxFt Matlab)



Data rate selected

Select Np for fitting range

V-T averaged waveform Measured at tp2

V-T averaged waveform Measured at tp2 for no Tx eq.

Iteratively add equalization until data and signal is aligned

Enter $\underline{\sigma}_n$ voltage from noise measurement

The GO button

Results