The effect of receiver bandwidth on Stressed Receiver Sensitivity

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802.3bs Optical Ad hoc 10-3-2017.

Introduction

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- With the change in the FIR reference receiver filter from T/2 spaced to T spaced the reference receiver bandwidth was reduced to a 4th order BT filter with bandwidth of 0.5*Baud rate.
- This presentation investigates the effect this has on the stressed receiver sensitivity signal calibration and also on the performance expected in this test by receivers with various bandwidths.
- The work was started in support of comment r03-16 against 802.3bs draft 3.3 but was unfortunately not completed in time for that comment resolution.
- The simulations were performed with Matlab code implementing SECQ as per 802.3bs draft 3.3 which didn't change in draft 3.4

Block diagram with sinusoidal interferer moved after Tx filter

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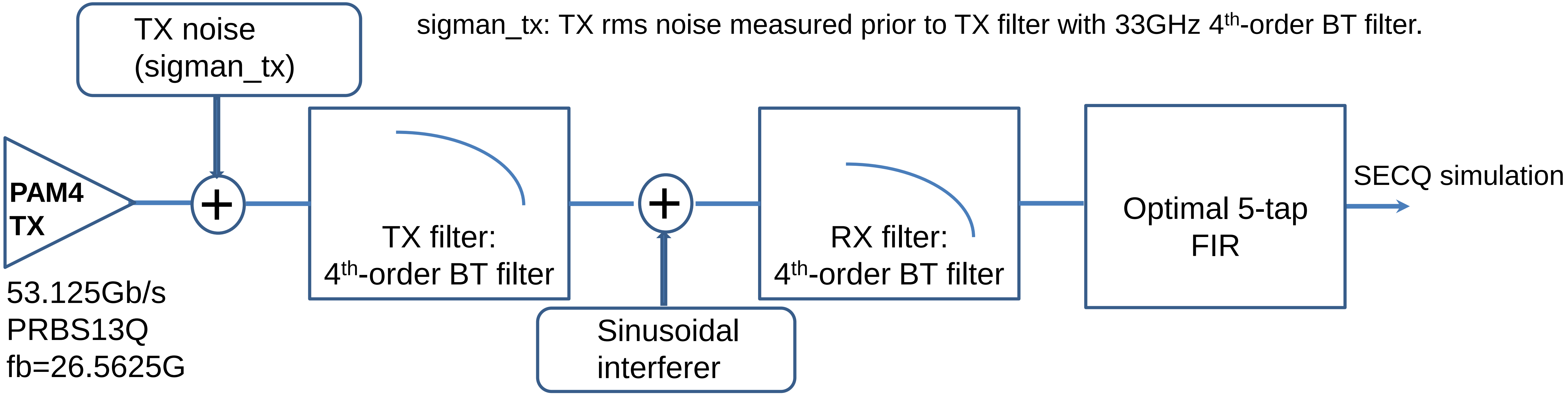
sigman_tx: TX rms noise measured prior to TX filter with 33GHz 4th-order BT filter.



$$N(f) = A \times |H_{bt}|^2$$

$$\int_f N(f)df = 1$$

$$C_{eq} = \sqrt{\int_f N(f) \times |H_{eq}(f)|^2 df}$$

$$Assume\ \sigma_s = 0$$

$H_{bt}: transfer\ function\ of\ Rx\ 4th\ order\ BT\ filter$

$H_{eq}: transfer\ function\ of\ optimal\ 5tap\ FIR\ filter$

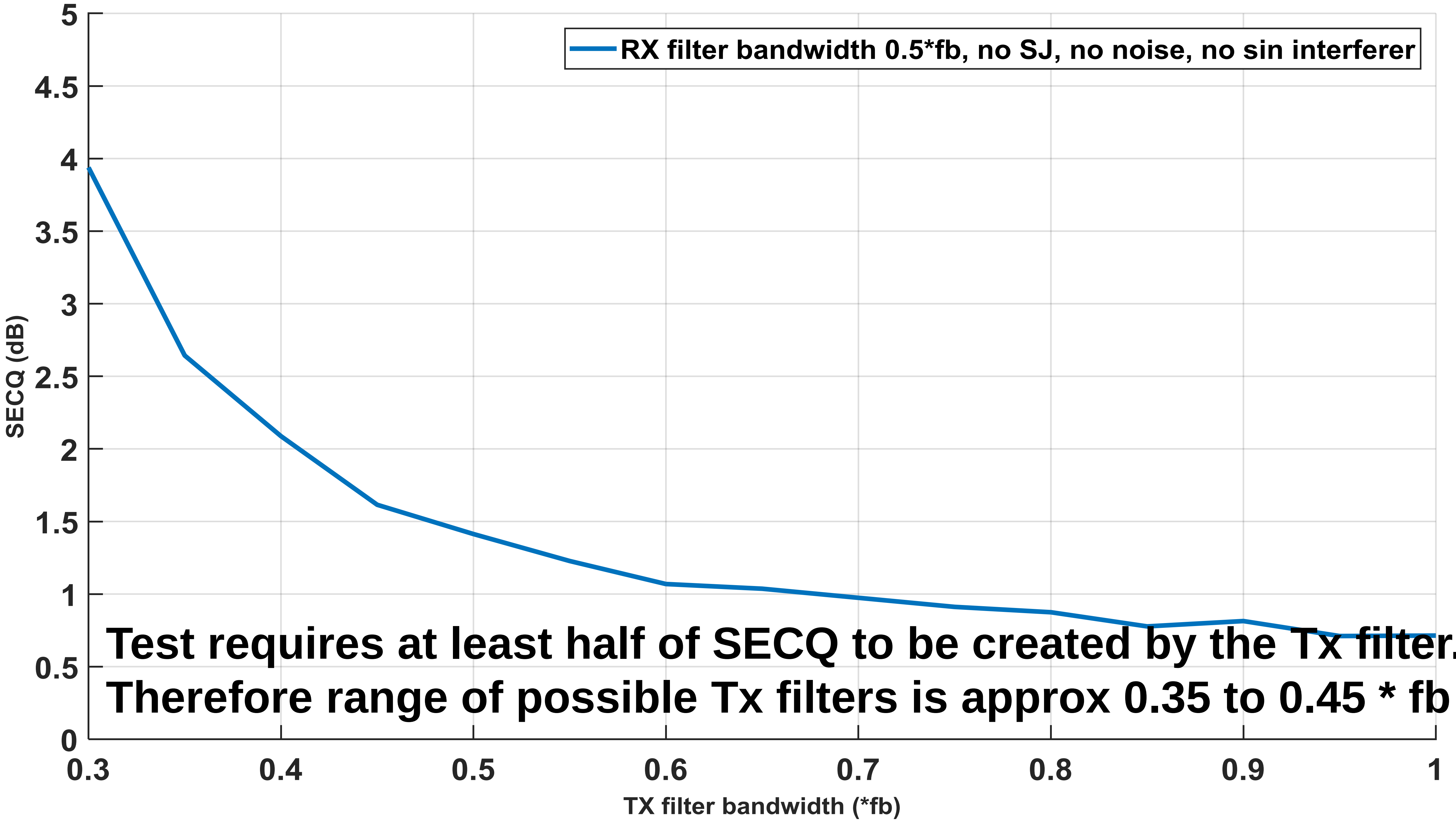
$Calibrate\ A\ to\ make\ integration\ of\ N(f)\ equal\ one\ for\ H_{bt}\ w/rx\ bandwidth\ for\ SECQ\ simulation$

$$SECQ = 10log10(\frac{QMA_{outer}}{6} \times \frac{1}{3.414\sigma_G})$$

$Calibrate\ A\ to\ make\ integration\ of\ N(f)\ equal\ one\ for\ H_{bt}\ w/\ 0.5fb\ bandwidth\ for\ RX\ performance\ simulation$

$$RX\ performance = 10log10(\frac{QMA_{outer}}{6} \times \frac{1}{3.414\sigma_G})$$

SECQ vs. TX filter bandwidth w/o SJ, noise or sinusoidal interferer (RX filter bandwidth = 0.5*fb)

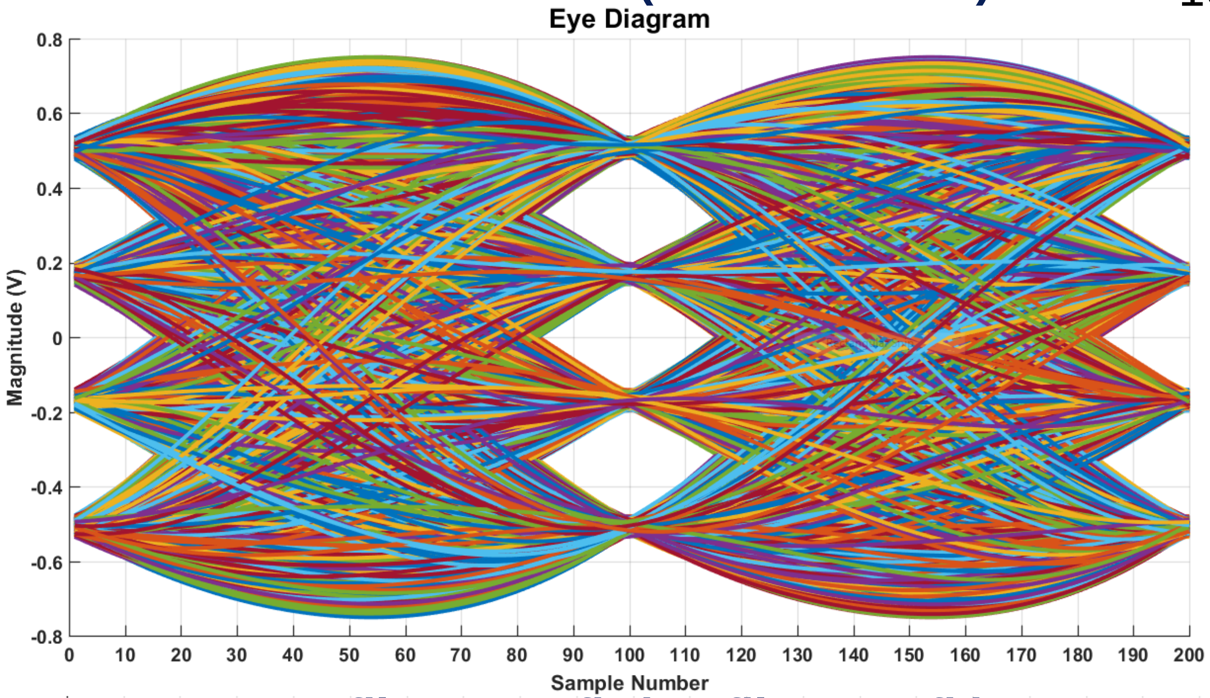


Test requires at least half of SECQ to be created by the Tx filter. Therefore range of possible Tx filters is approx 0.35 to 0.45 * fb

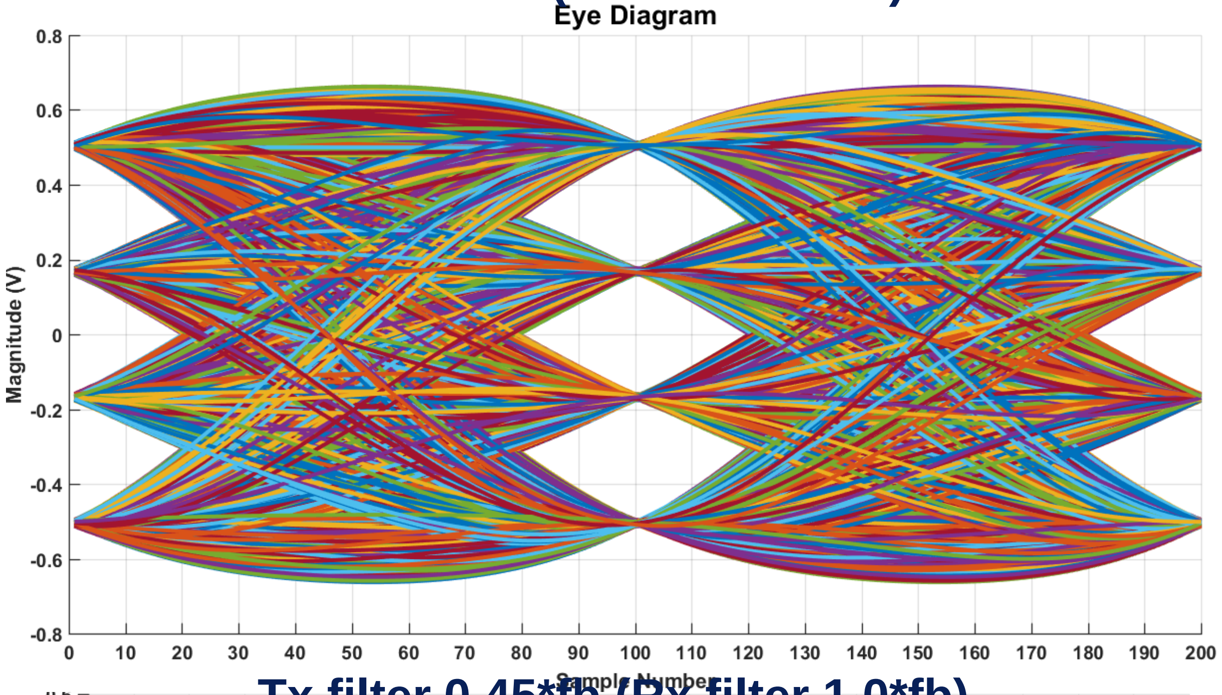
No SJ, No Noise, Equalized eye diagrams.

100 samples per UI

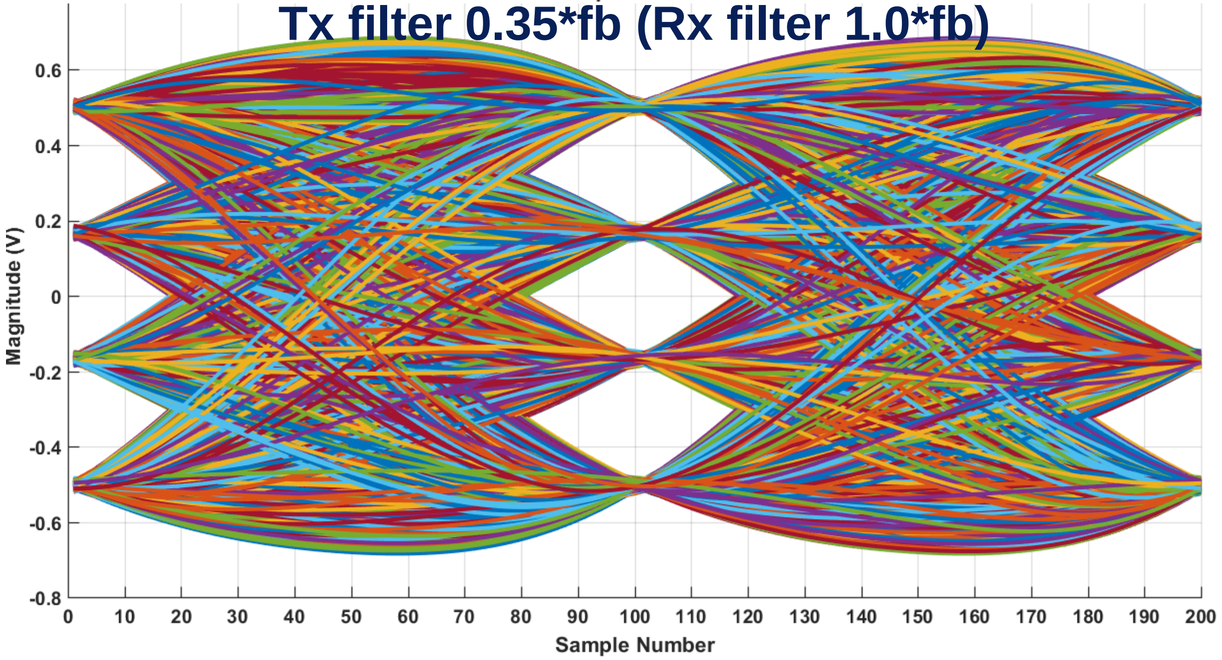
Tx filter 0.35*fb (Rx filter 0.5*fb)



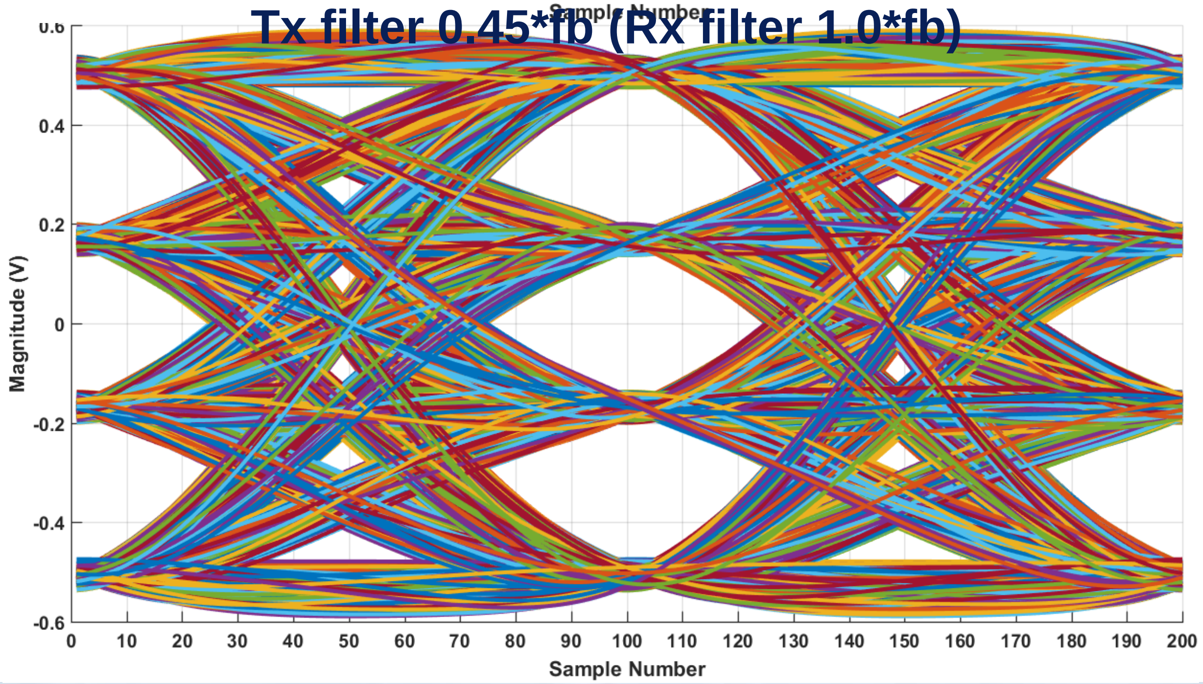
Tx filter 0.45*fb (Rx filter 0.5*fb)



Tx filter 0.35*fb (Rx filter 1.0*fb)



Tx filter 0.45*fb (Rx filter 1.0*fb)

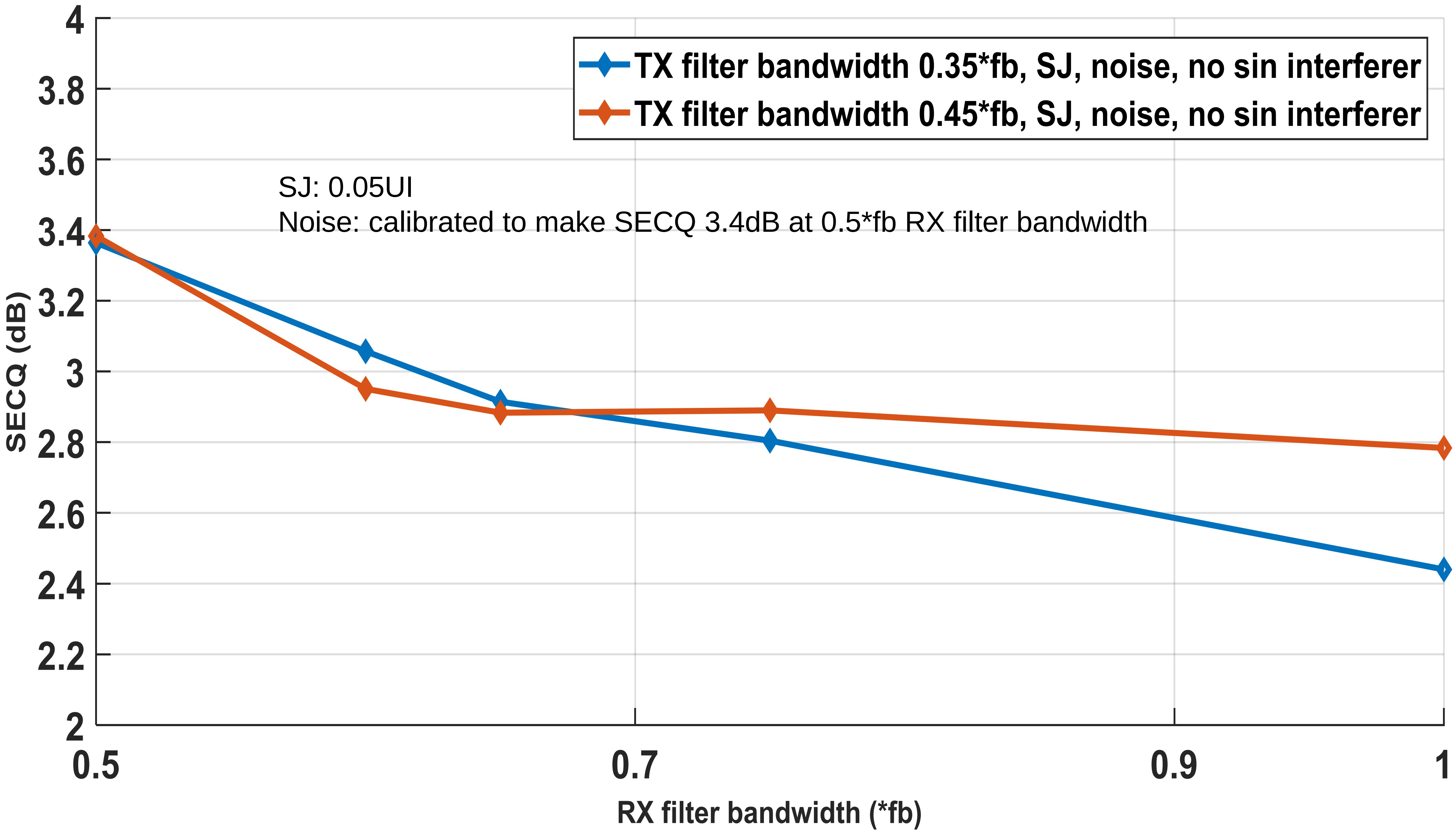


Effect of Rx bandwidth on SECQ

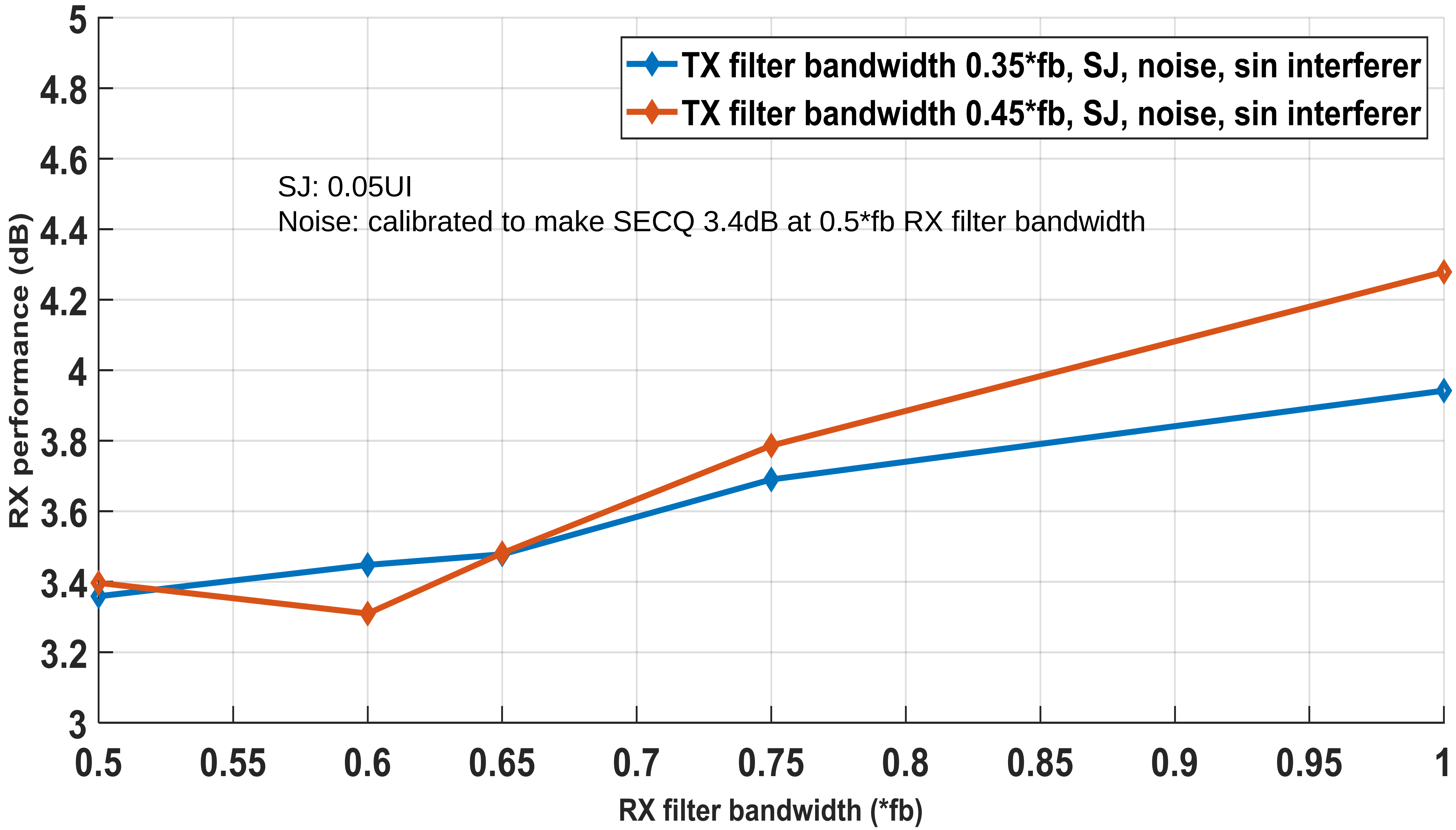
- **0.05UI SJ at 10MHz and Tx noise were added to increase the SECQ to 3.4dB. For both the Tx filter bandwidth of 0.35*fb and 0.45*fb**
- **This completes the calibration of the stressed receiver sensitivity signal.**

- **The bandwidth of the Rx filter was then swept to see how the bandwidth of the DUT would effect the stressed receiver sensitivity result. Two different results are presented.**
  - The straight SECQ results. (Which is saying how much noise the Rx can add)
  - A Receiver Performance metric = SECQ + 10*log10(sqrt(Rx bandwidth/(0.5*fb))). (This assumes that the receiver has white noise at its input and the noise it adds is therefore larger if its bandwidth is wider).

SECQ vs. RX filter bandwidth w/ SJ and noise



RX performance vs. RX filter bandwidth w/ SJ and noise



Comments on the results.

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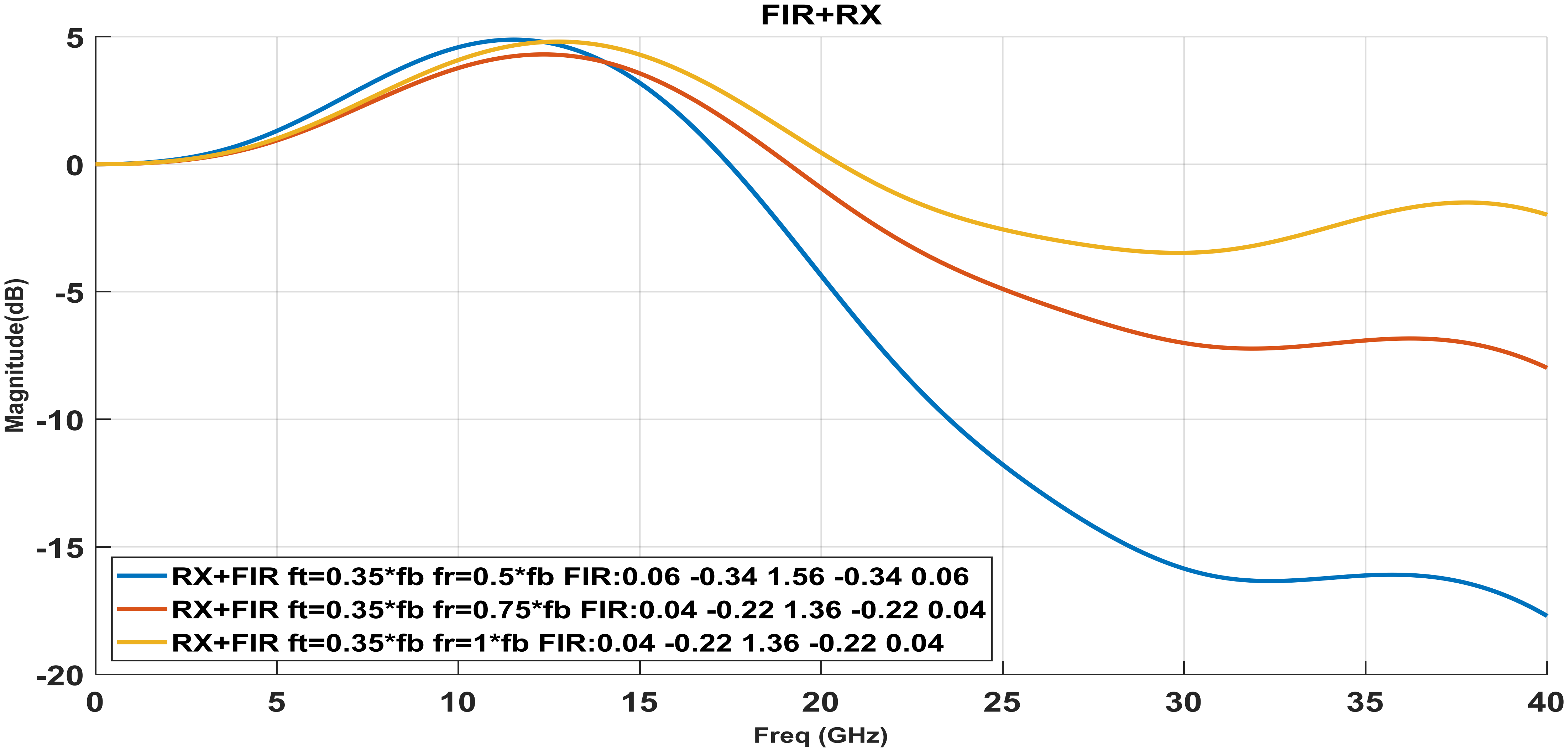
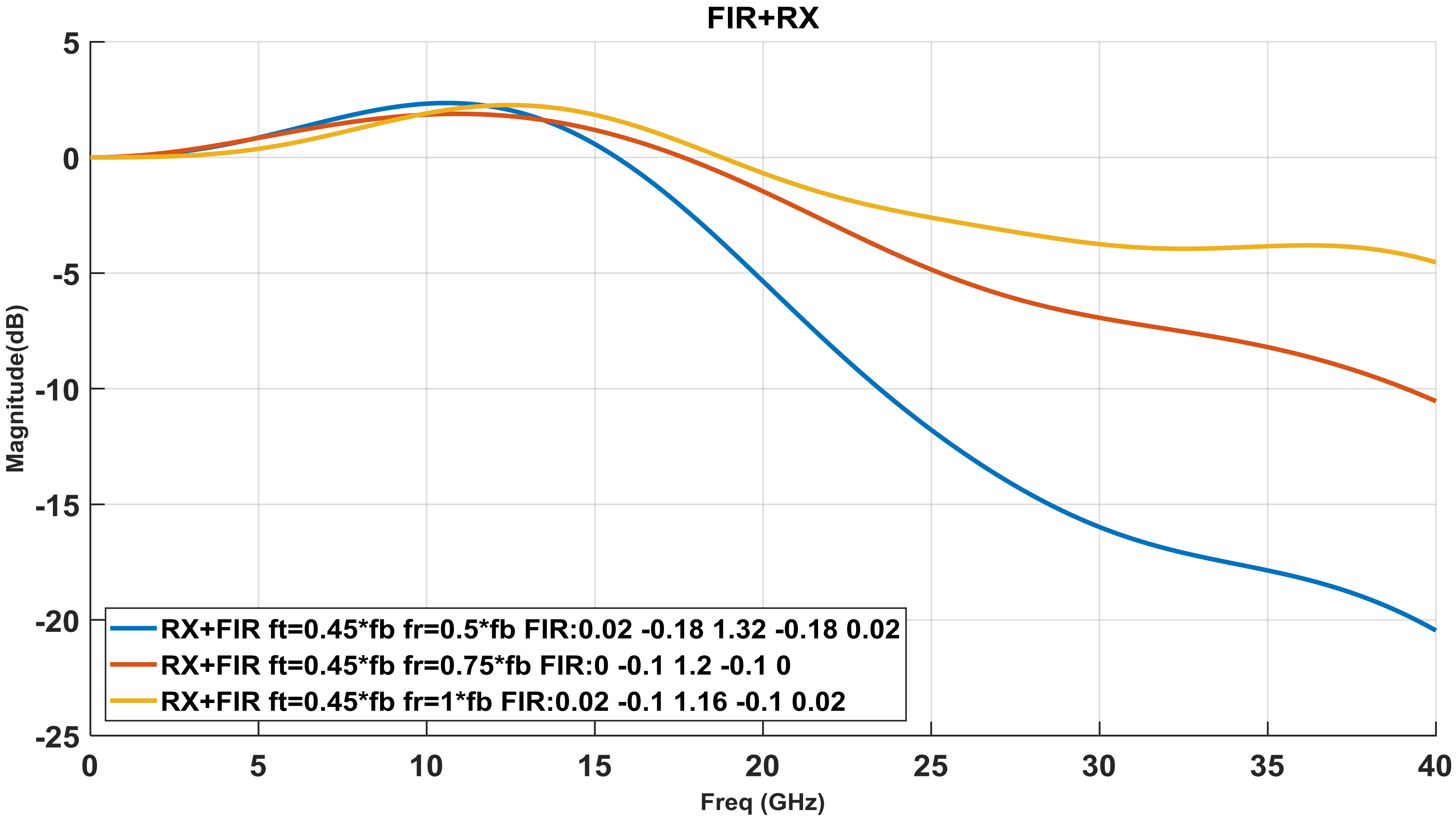
- Although the SECQ does drop for wider Rx bandwidth, that is an artificial result of the normalization of the receiver integrated noise. When the additional noise of a wider Rx bandwidth receiver is taken into account there is not a significant advantage in the stressed receiver test for having a wider bandwidth receiver. In fact the performance is fairly flat.
- To investigate why this might be the case the frequency response of the combination of the Rx filter and optimized FIR filter was plotted for the various conditions.

RX+FIR transfer function loss: ft = 0.35*fb



The FIR filter is re-optimizing itself keeping the Receiver response (Receiver filter plus FIR filter) approximately unchanged up to the Nyquist frequency.

RX+FIR transfer function loss: ft = 0.45*fb



Analysis of the effect of adding extra high frequency interference.

- The solution proposed in comment r03-16 was investigated as a surrogate for what might happen if a transmitter had high frequency problems. The sinusoidal interferer at 0.71*fb was added without the SJ and noise to increase the SECQ by 0.1dB and also by 0.4dB then the SJ and noise were added to make the SECQ=3.4dB.

RX performance vs. RX filter bandwidth with sinusoidal interferer to increase SECQ by 0.1dB plus SJ, and noise

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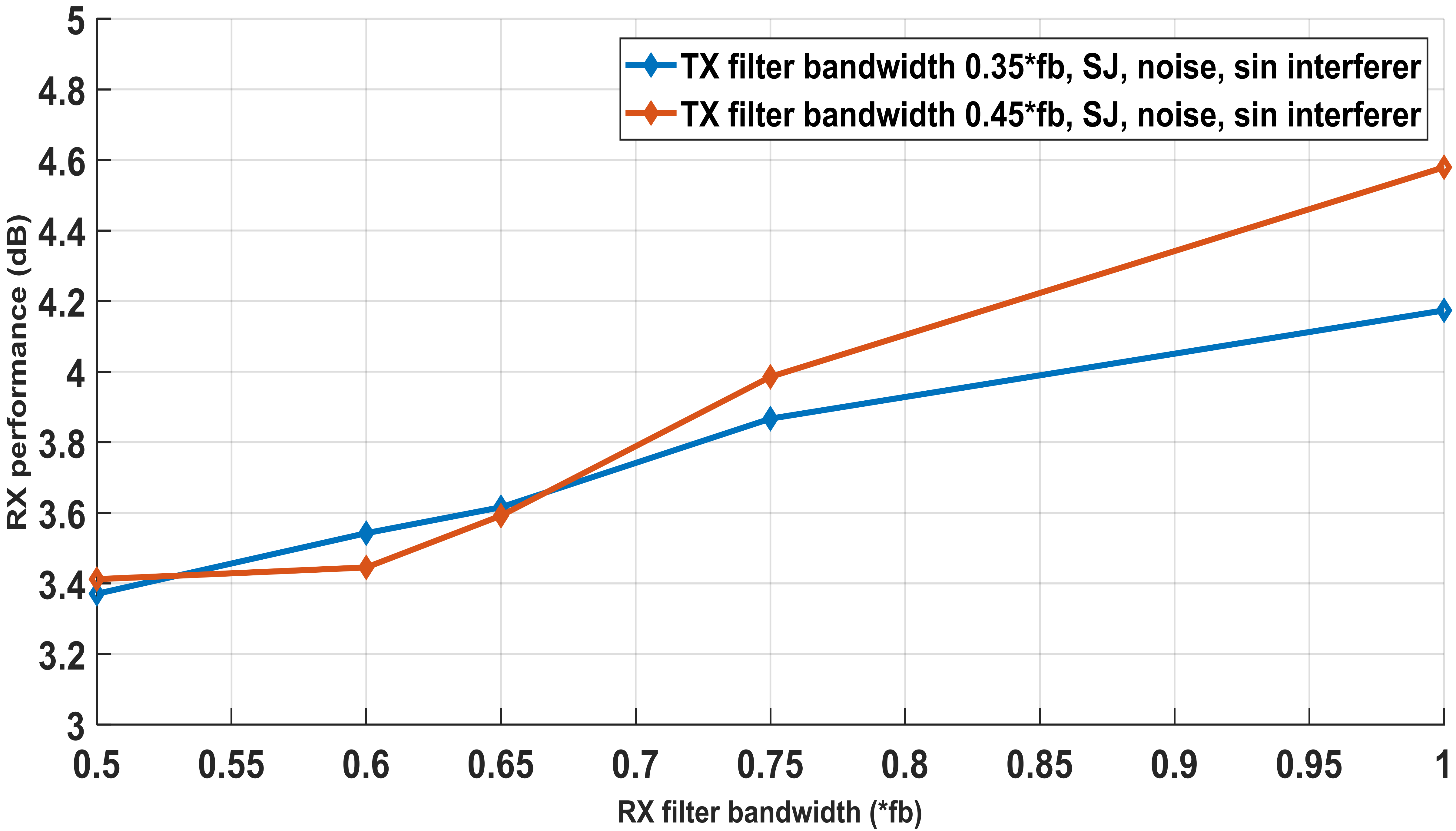
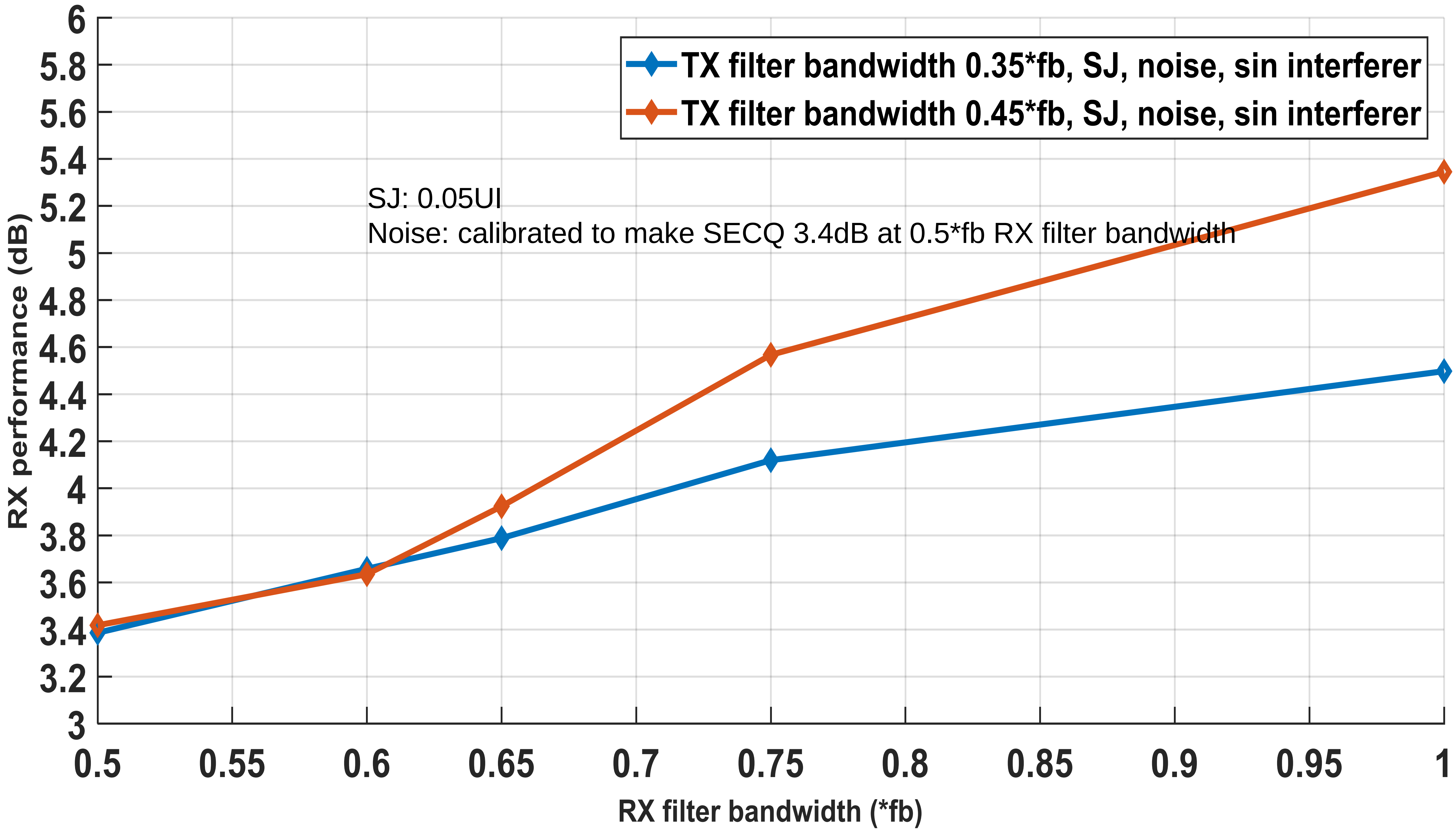


RX performance vs. RX filter bandwidth with sinusoidal interferer to increase SECQ by 0.4dB plus SJ, and noise



Conclusions

- There is not an incentive for receiver designers to use a wider bandwidth than the 0.5*fb reference receiver.
- Additional sinusoidal interference at higher frequencies does degrade the performance with wider bandwidth receivers but the results aren't catastrophic.
- The results are similar whether the 0.35*fb or 0.45*fb filter is used in the Stressed Receiver Test transmitter indicating that we don't need to be more precise in this calibration.
- There is no need to make changes to draft 3.4 of the specification. I am now satisfied with the response to r03-16.

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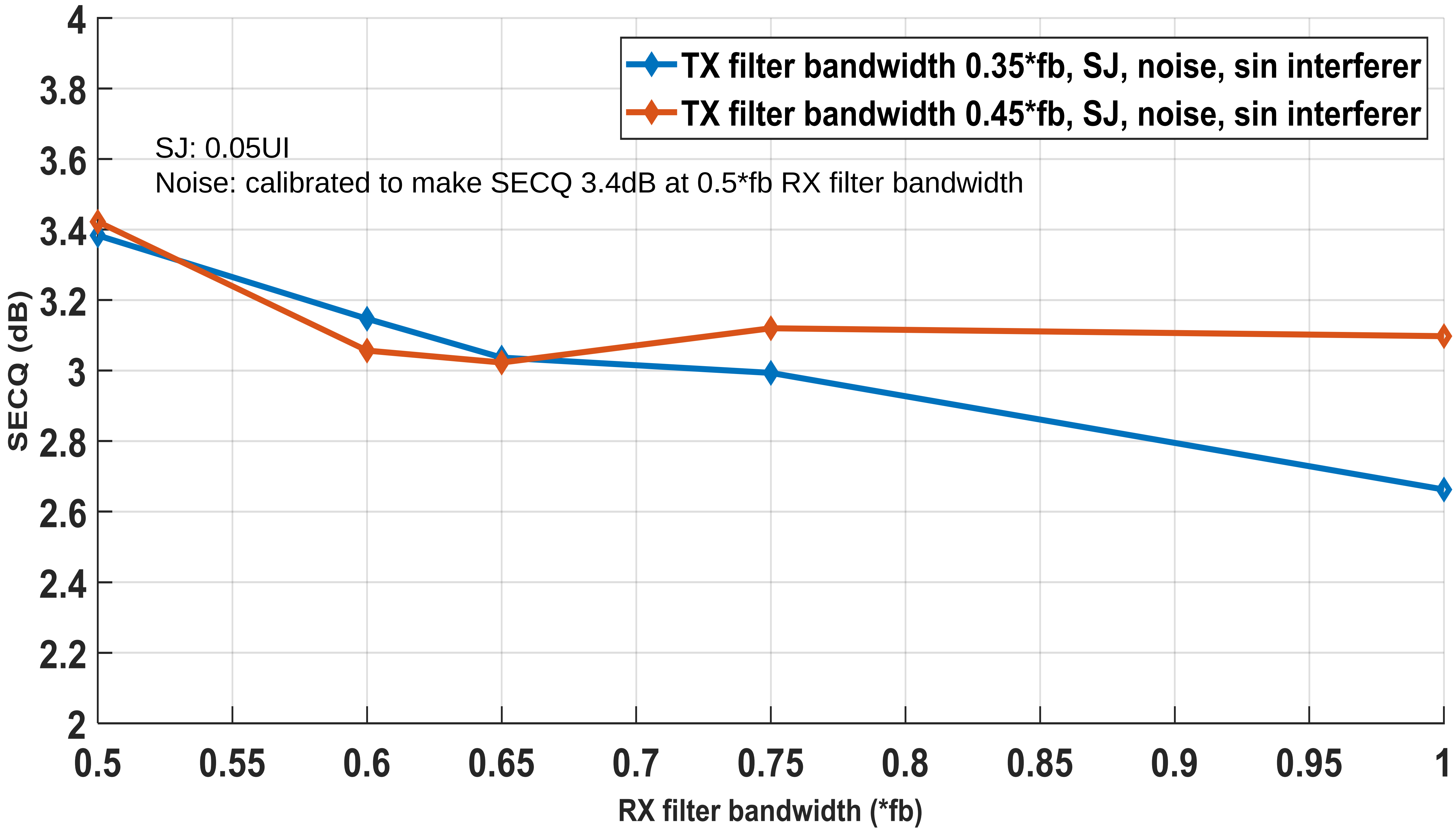
Backup

SECQ vs. RX filter bandwidth with sinusoidal interferer to increase SECQ by 0.1dB plus SJ, and noise



SECQ vs. RX filter bandwidth with sinusoidal interferer to increase SECQ by 0.4dB plus SJ, and noise

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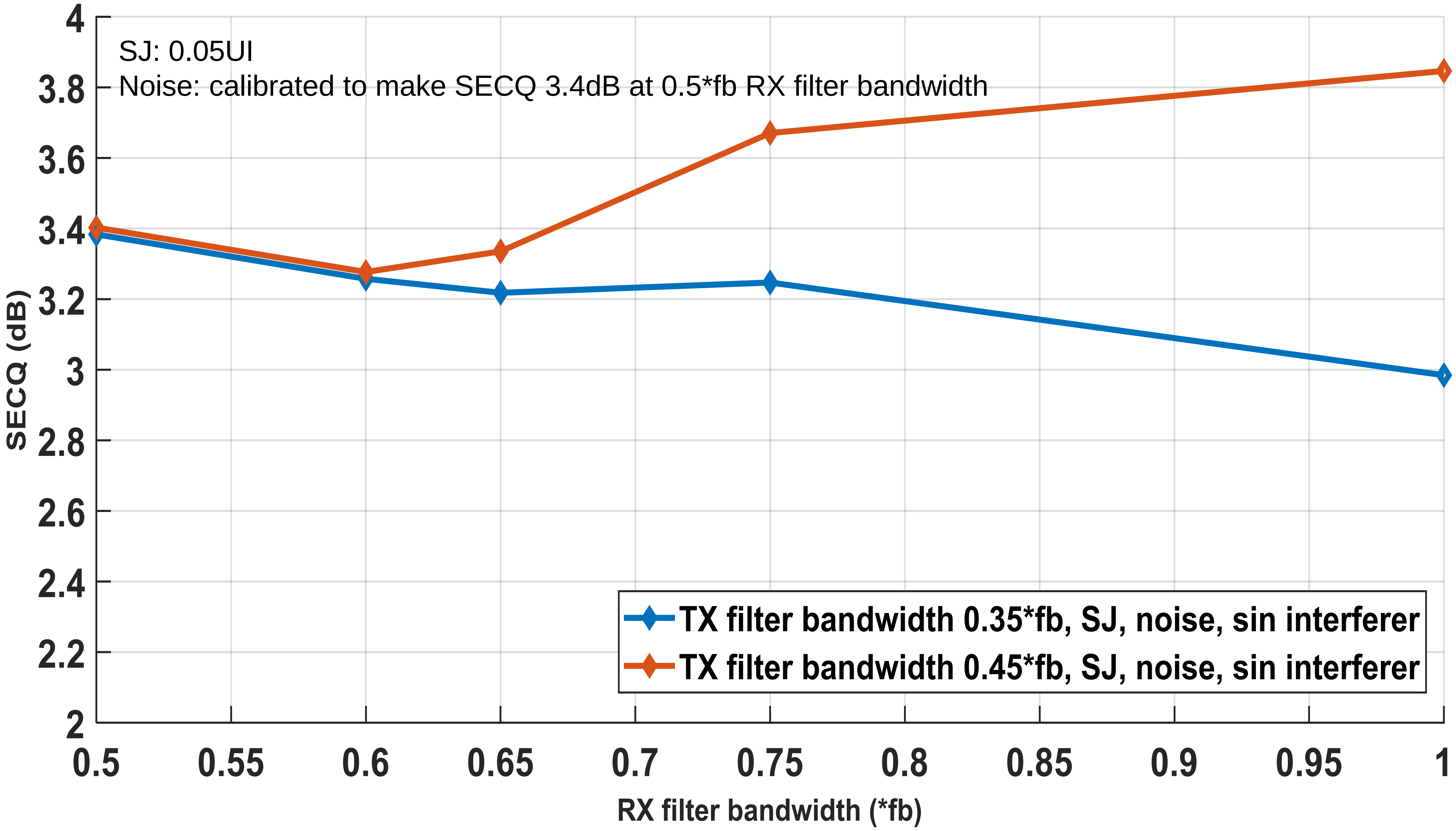

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