

On Transmit Power Levels

April 3, 2019

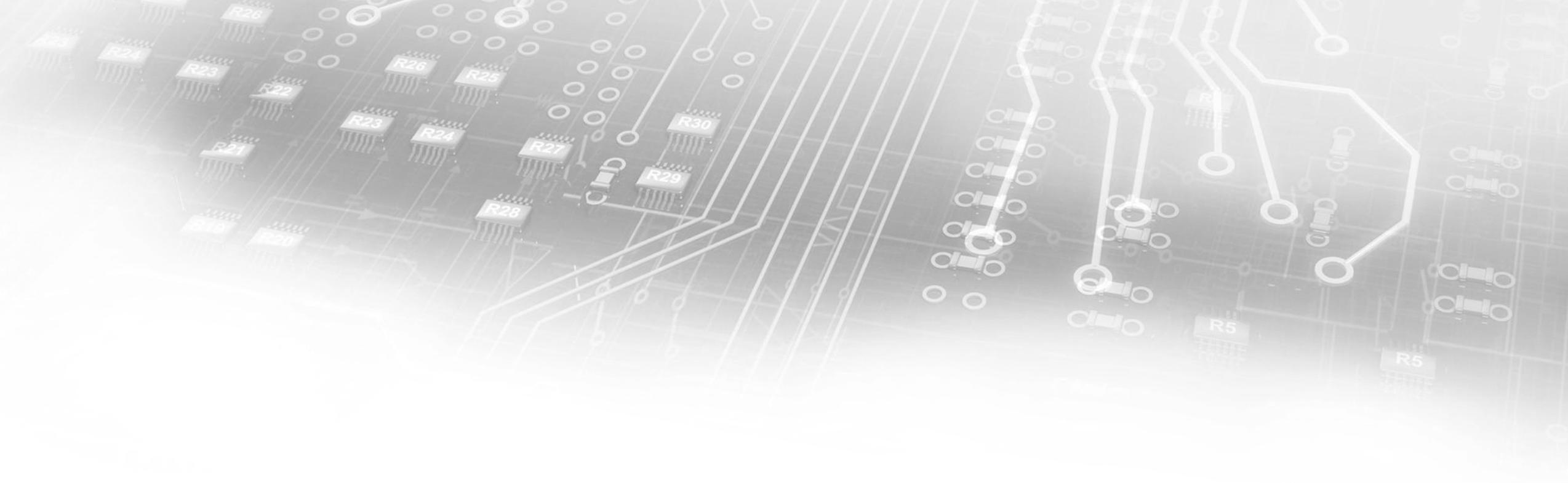
Mike Tu tum@broadcom.com

Kambiz Vakilian kambiz.vakilian@broadcom.com

Tom Souvignier tom.souvignier@broadcom.com

D1.2 Tx Power Range

- In D1.2 149.5.2.4, page 154 line 24:
 - “In test mode 5 (normal operation), the transmit power shall be in the range of **-1 dBm to 2 dBm** and the power spectral density of the transmitter, measured into a 100 Ω load using the test fixture 4 shown in Figure 149–39 shall be between the upper and lower masks specified in Equation (149–14) and Equation (149–15).”
- Analysis provided to show potential impacts of implementation losses.
- There may not be sufficient margins at the low end → consider increasing the transmit power range to: -2dBm to +2dBm.



Tx Power Range from Other 802.3 Standards

Tx Power Range in Clause 94

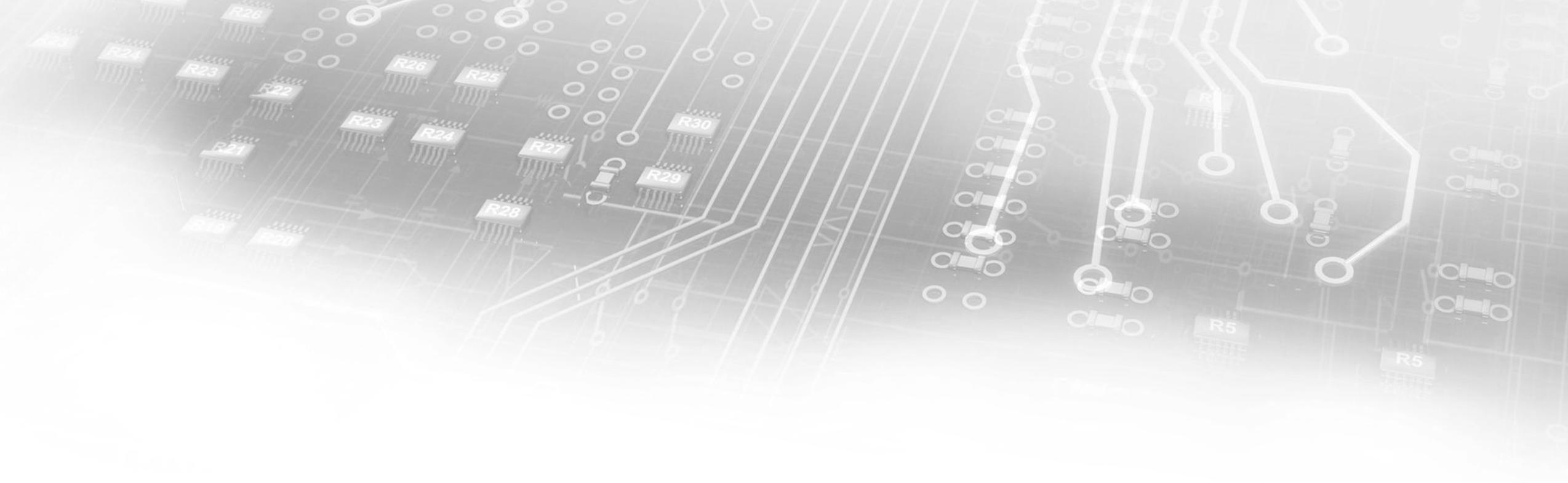
- In Clause 94, the PAM4 transmitter allows the steady-state voltage range of 0.4V to 0.6V → -1.94dB to +1.58dB range

Table 94-13

| | | | |
|--|-------------|-------------------|---|
| Output waveform | | | |
| Level separation mismatch ratio, R_{LM} (min.) | 94.3.12.5.1 | 0.92 | — |
| Steady-state voltage v_f (max.) | 94.3.12.5.3 | 0.6 | V |
| Steady-state voltage v_f (min.) | 94.3.12.5.3 | 0.4 | V |
| Linear fit pulse peak (min.) | 94.3.12.5.3 | $0.85 \times v_f$ | V |
| Normalized coefficient step size (min.) | 94.3.12.5.5 | 0.0083 | — |
| Normalized coefficient step size (max.) | 94.3.12.5.5 | 0.05 | — |
| Pre-cursor full-scale range (min.) | 94.3.12.5.6 | 1.54 | — |
| Post-cursor full-scale range (min.) | 94.3.12.5.6 | 4 | — |

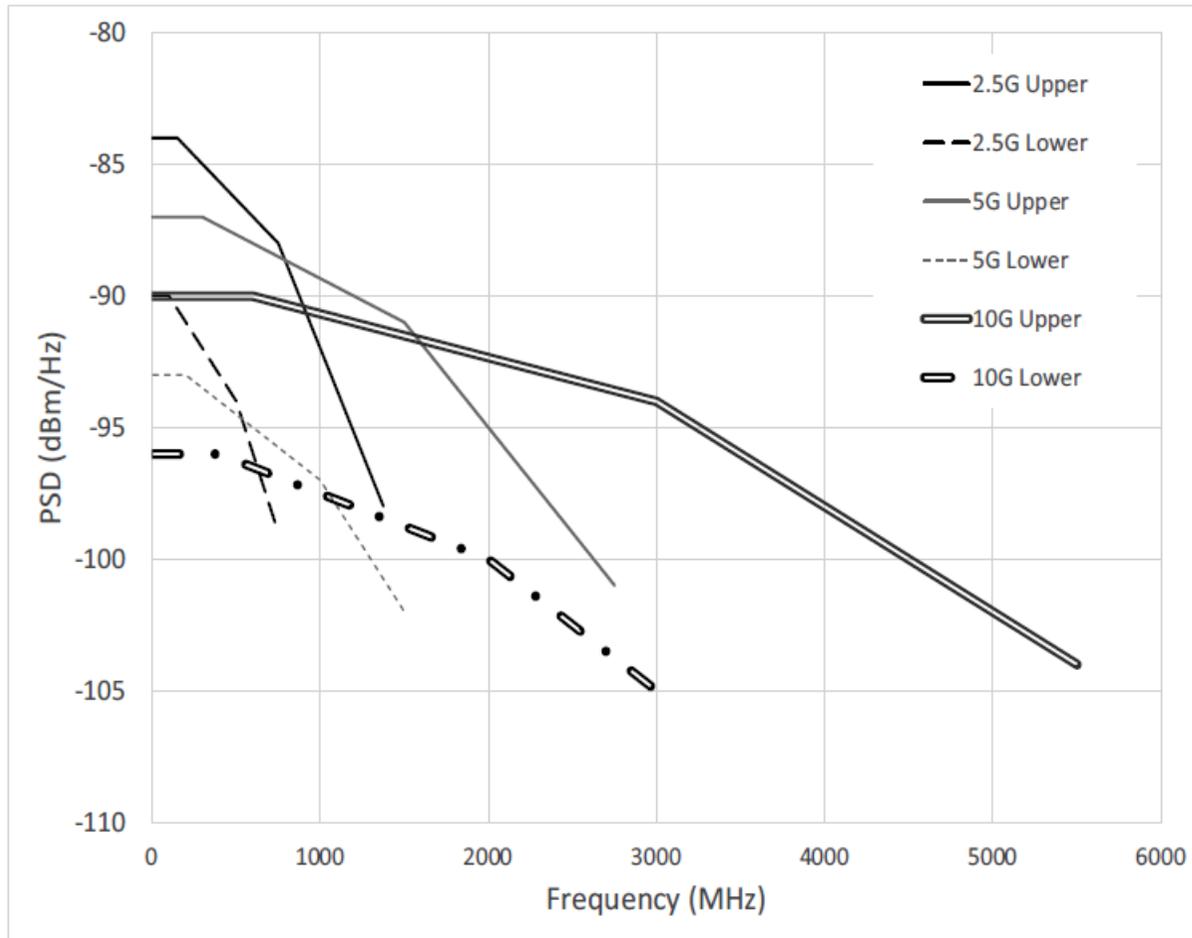
Tx Power Range in Clause 55 and Clause 126

- 55.4.2.5.14
 - In SLAVE mode, after the MASTER has requested the desired PBO level, the SLAVE shall request a desired PBO level that is within **two levels (within 4 dB)** of the requested MASTER PBO level.
- 126.4.2.5.15
 - In SLAVE mode, after the MASTER has requested the desired PBO level, the SLAVE shall request a desired PBO level that is within **two levels (within 4 dB)** of the requested MASTER PBO level.
- 10GBASE-T, 5GBASE-T, and 2.5GBASE-T are all full-duplex PHY. They allow up to +-4dB variations of Tx power between the two PHY's.
- **Conclusion → In full duplex PHY such as 10GBASE-T, +-4dB differences in Tx power between the two sides can be accommodated by the receiver.**



Tx Power Range for MGBASE-T1

TxPSD Limit Lines

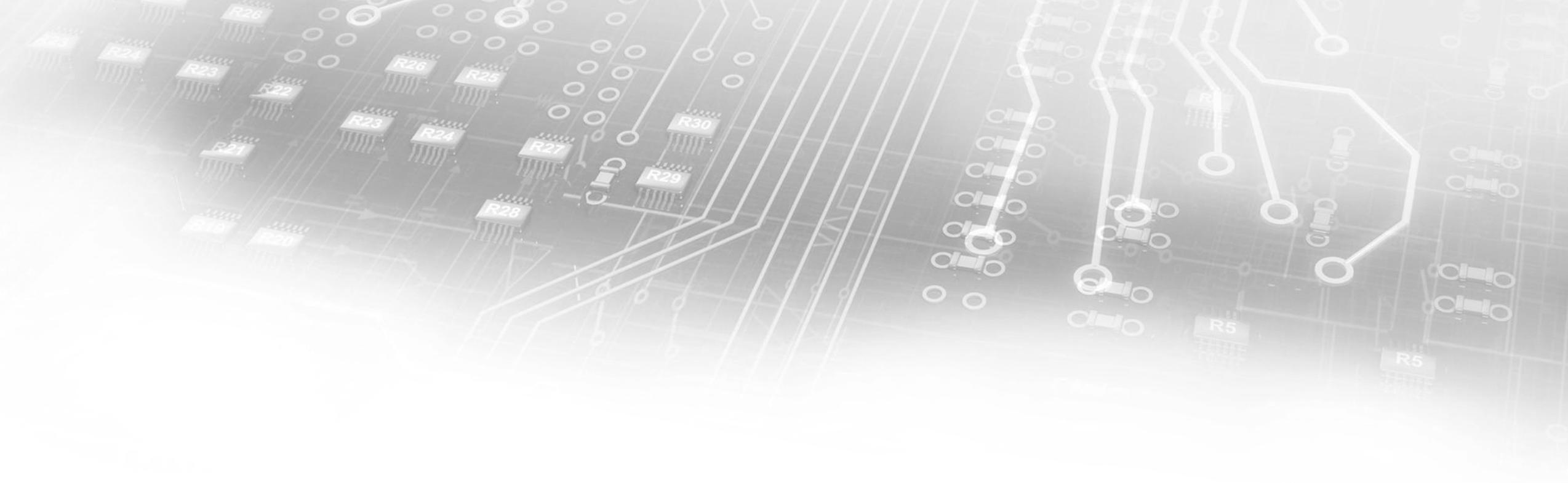


- Nominal Tx power = 1.43dBm
 - 1Vpp
 - 100 ohm load
 - PAM4
- Upper limit line \approx 4.1dBm
- Lower limit line \approx -3.8dBm

Figure 149–40—Transmitter Power Spectral Density, upper and lower masks

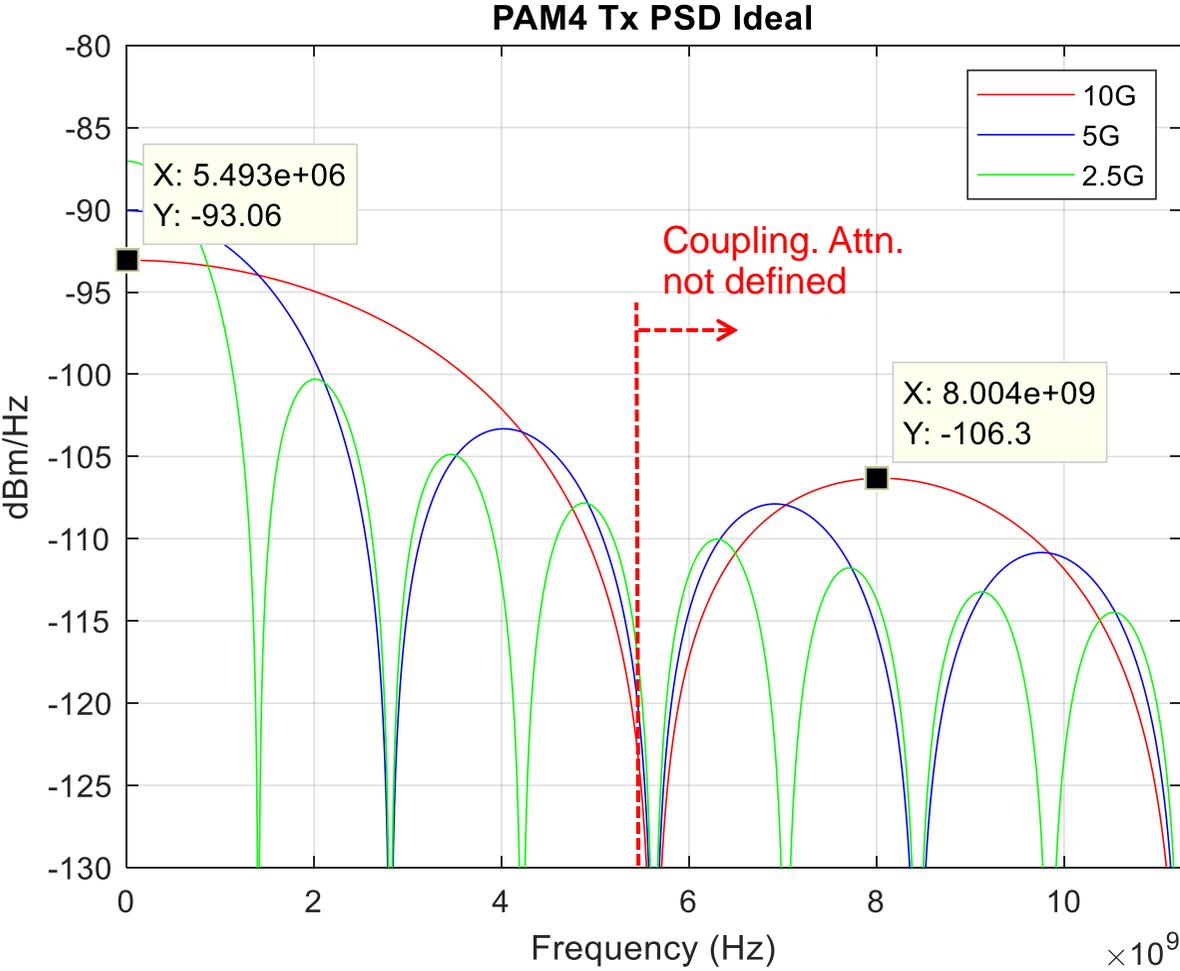
Tx Power with Implementation Losses

- Ideal Tx power: 1.43dBm
- Tx power with 0.5pF capacitance at MDI
 - 10G: 1.11dBm
 - 5G: 1.26dBm
 - 2.5G: 1.33dBm
- 5% V_{dd} variations, and 10% R_{term} variations
 - -0.87dB to 0.87dB
- Impacts of additional DAC switching parasitic
 - ~ -0.3dB
- Trace and connector losses
 - At least -0.5dB, worst case -1dB
- Overall Tx power
 - 10G: -1.06dBm to 1.18dBm → In worst case, it violates the D1.2 Tx power lower limit
 - 5G: -0.91dBm to 1.33dBm
 - 2.5G: -0.84dBm to 1.40dBm
- With worst case implementation losses, the [-1dBm, +2dBm] range does not provide sufficient design margins.
- Consider extending the Tx power range to: [-2dBm, +2dBm] instead.



Emission Concerns

MGBASE-T Tx PSD



- Without analog or digital filters, the 1st sidelobe is only 13dB lower

Coupling Attenuation

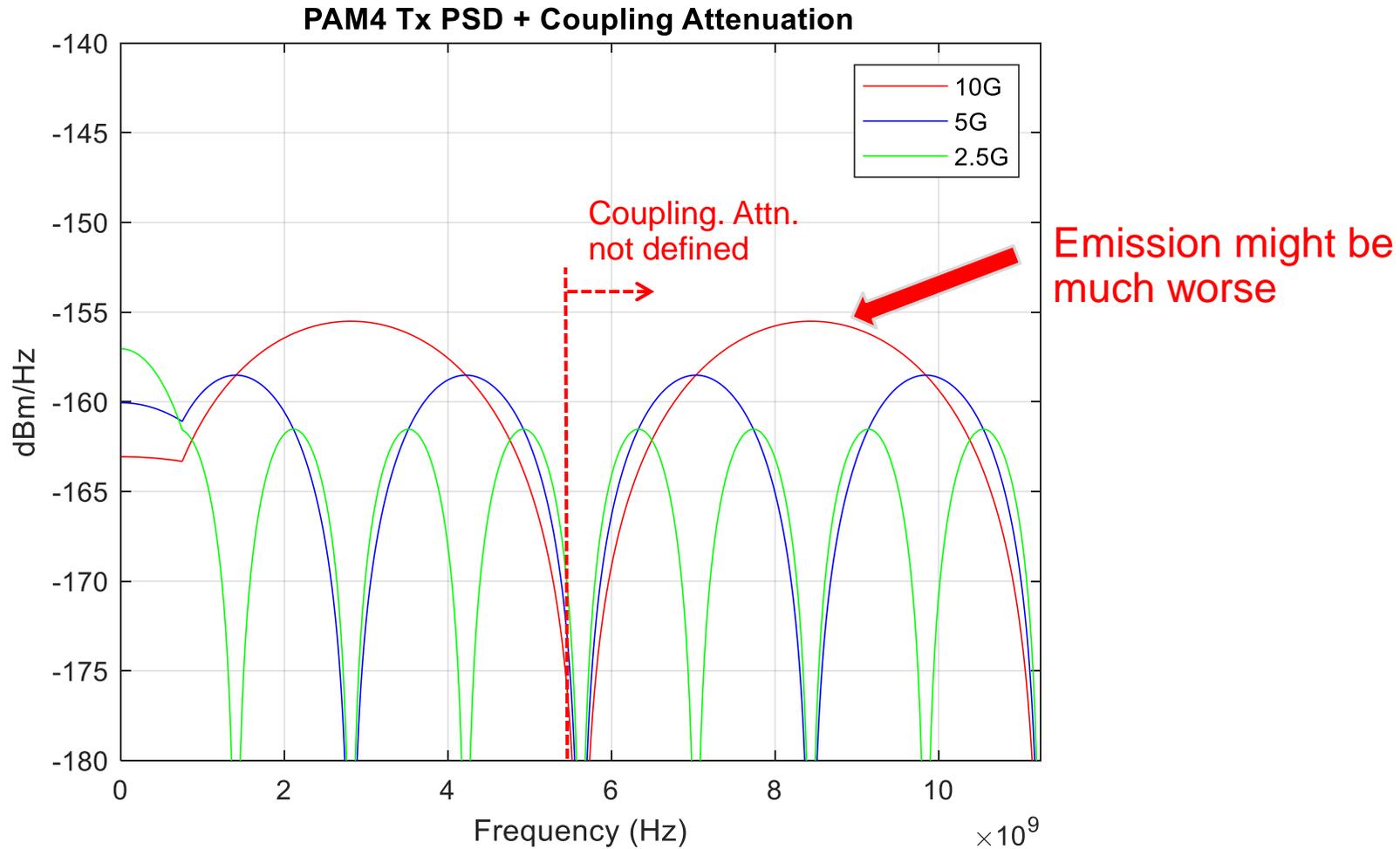
$$\text{Coupling Attenuation}(f) \geq \left\{ \begin{array}{ll} 70 & 30 \leq f \leq 750 \text{ MHz} \\ 50 - 20 \log_{10} \left(\frac{f}{7500} \right) & 750 \leq f \leq F_{\max} \text{ MHz} \end{array} \right\} (\text{dB}) \quad (149-24)$$

where

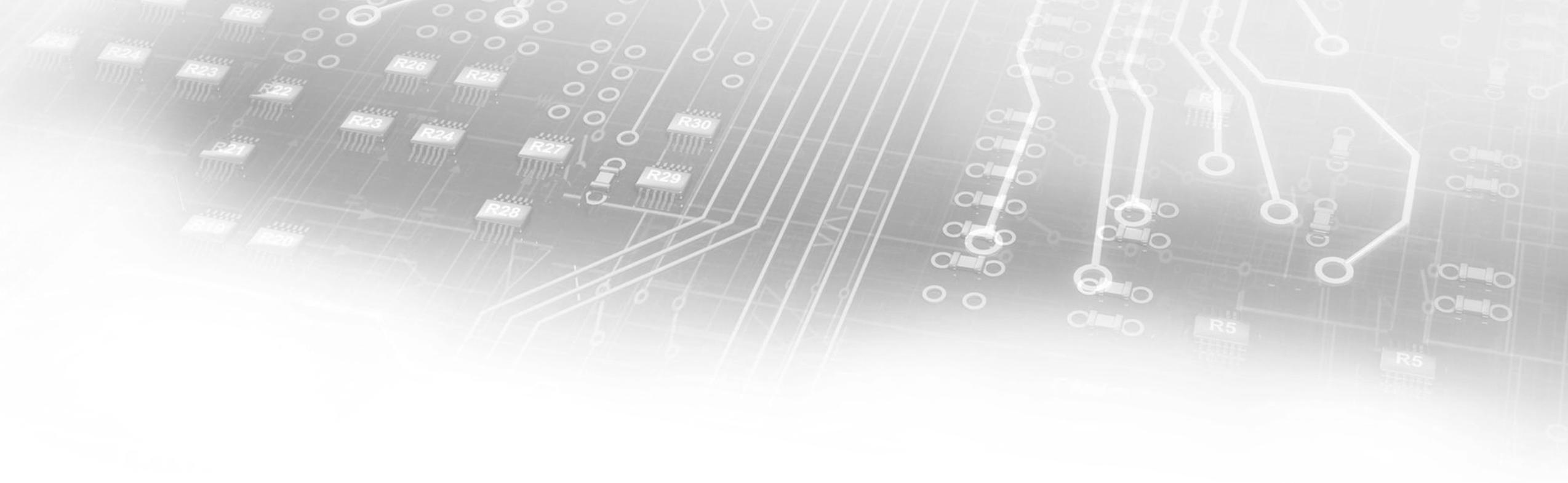
f is the frequency in MHz; $30 \leq f \leq F_{\max}$

- $F_{\max} = 4000 \times S$ (Equation 149-18) ?? Or 5.5GHz (Figure 149-44)??
- In either case, it is undefined above 5.5GHz

Tx PSD + Coupling Attenuation



- Coupling attenuation extrapolated to high frequencies
- Filtering might be necessary to avoid emission issues, introducing additional losses in Tx signal power



THANK YOU
