Compliance metrics for DWDM objectives

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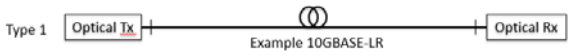
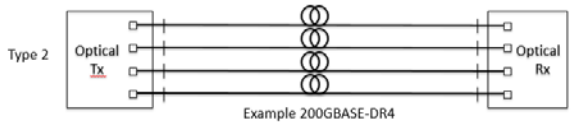
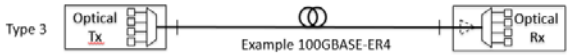
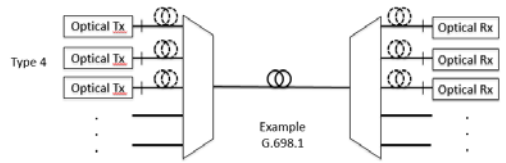
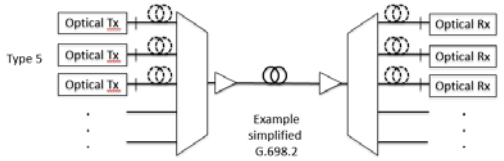
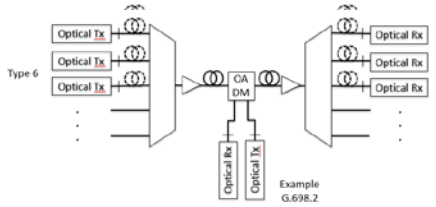
Introduction

As was discussed in stassar_b10k_01a_1117, there are some new compliance metrics that will be needed to specify multi-vendor interoperable DWDM systems to satisfy the two objectives:

- Provide a physical layer specification supporting 100 Gb/s operation on a single wavelength capable of at least 80 km over a DWDM system
- Provide a physical layer specification supporting 400 Gb/s operation on a single wavelength capable of at least 80 km over a DWDM system

Optical link types vs organization

Type		IEEE 802.3	ITU-T SG15
1		✓	✓
2		✓	
3		✓	✓
4		P802.3cn	✓
5			✓
6			✓

Compliance issues

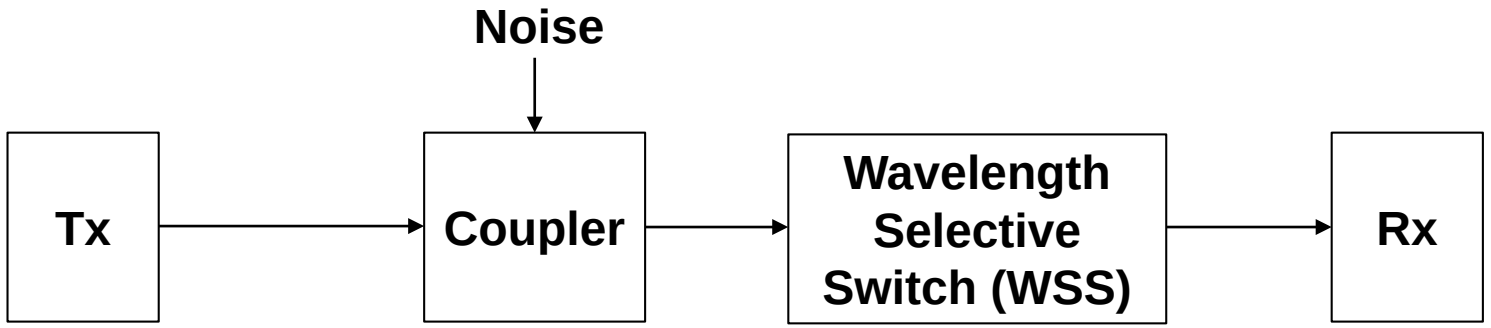
Two compliance issues that have been identified previously are:

- Ensuring that the spectral characteristics of the optical source are compatible with the end-to-end filter function of the link
  - Candidate – Spectral excursion
- Transmitter quality metric
  - Candidate – Error Vector Magnitude EVM_{RMS}

Spectral excursion

Spectral excursion investigation

To investigate the effect of a mismatch between the transmitter spectrum and the end-to-end filter function of the link, measurements have been performed where the transmitter wavelength is deliberately offset with respect to the filter function.

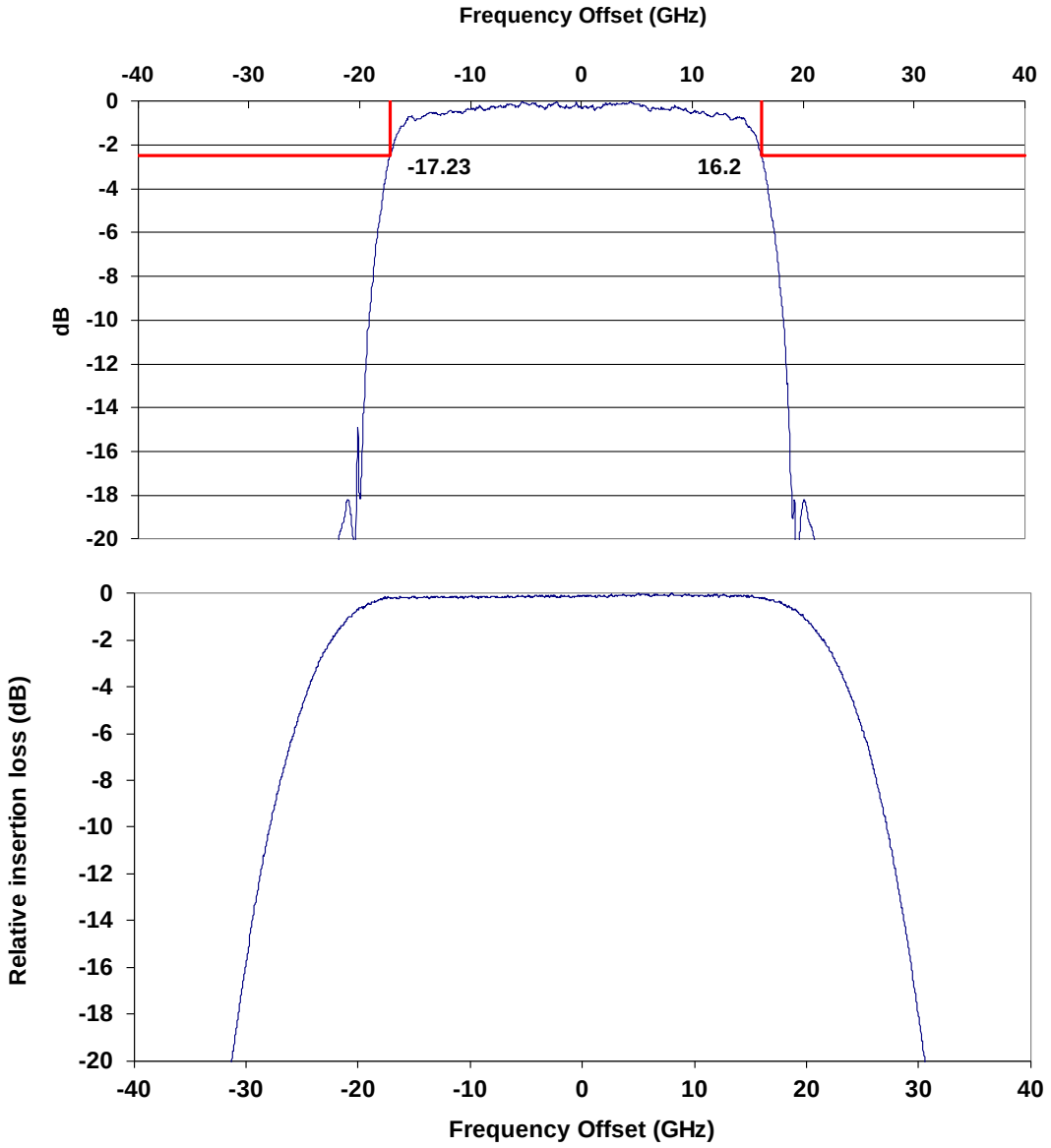


One example of this measurement for DP-QPSK is shown on the following slides.

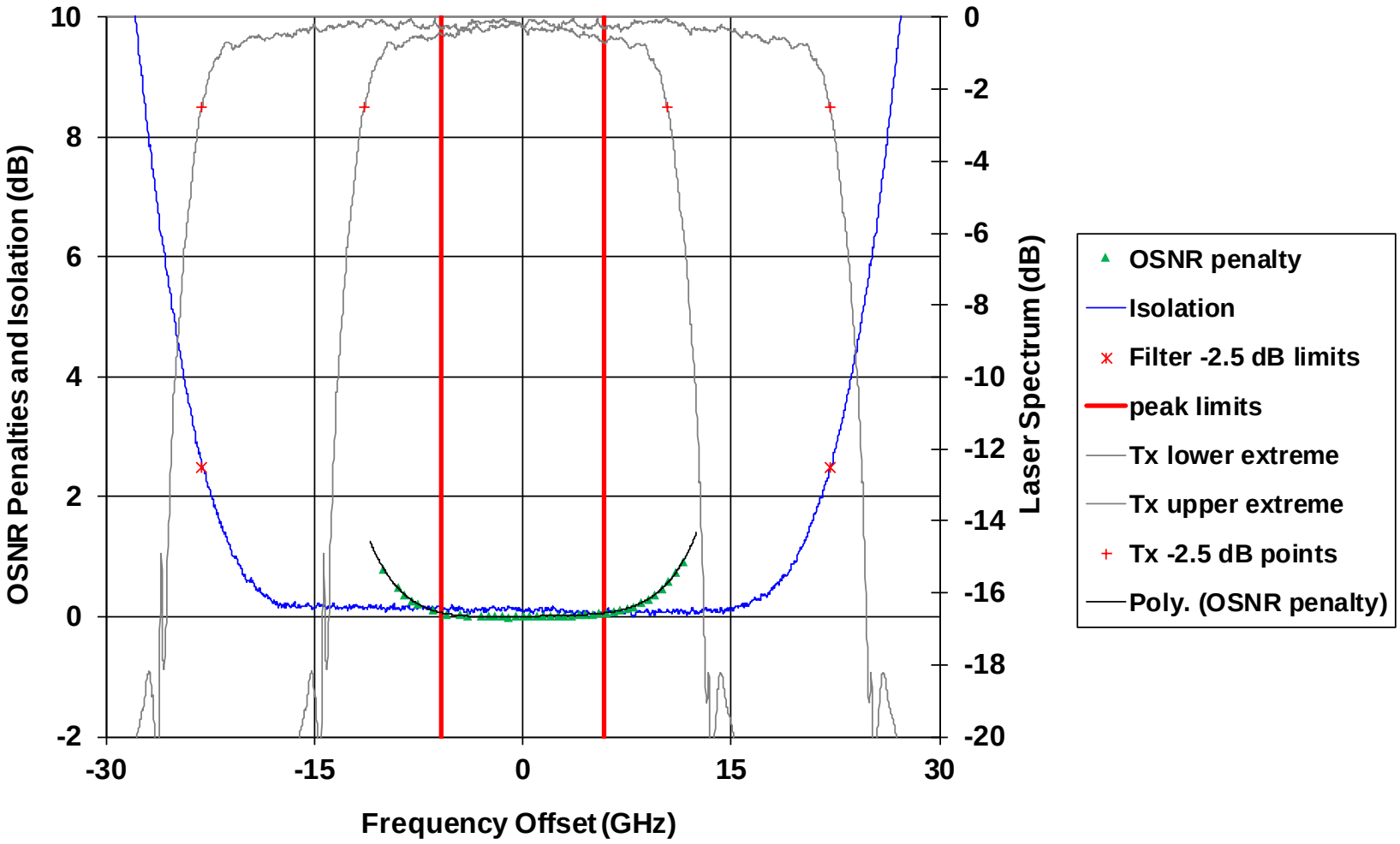
DP-QPSK Tx spectrum and filter function

DP-QPSK transmitter spectrum

WSS filter function

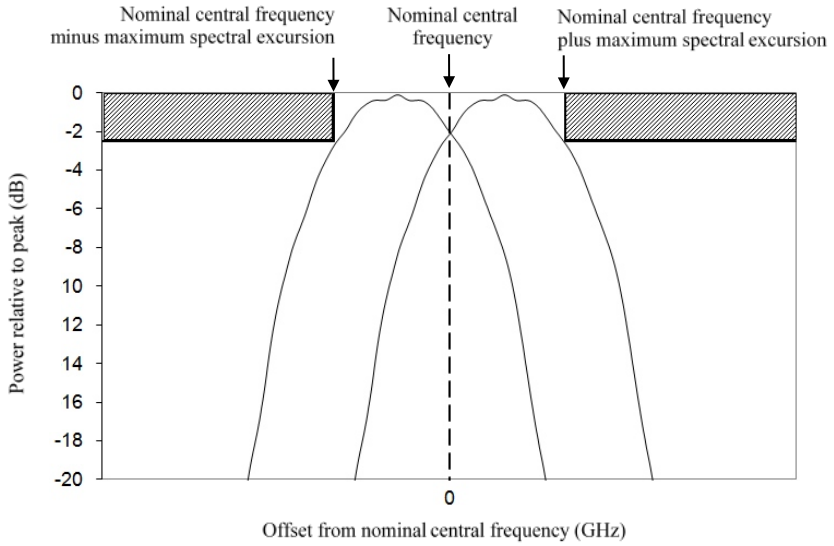


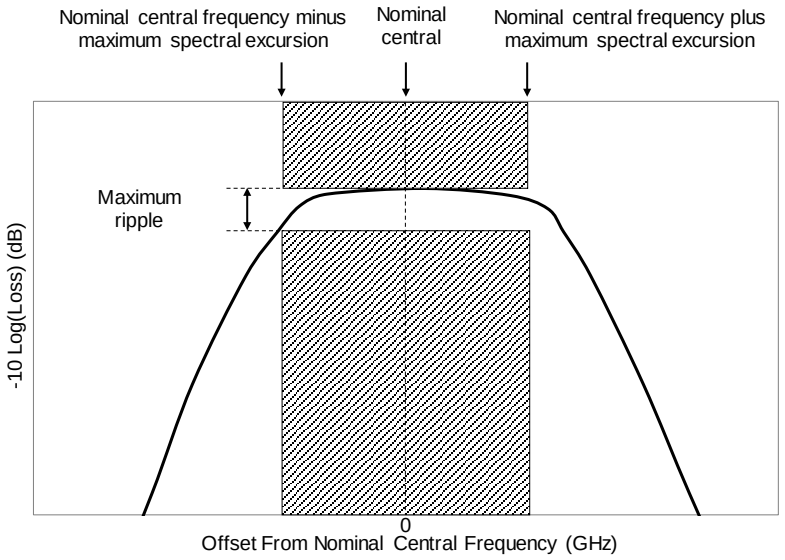
DP-QPSK Spectral excursion result



Spectral excursion criterion

This investigation was carried out with a variety of DP-QPSK implementations with the result that the spectral excursion criterion was defined to be that the -2.5 dB points of the transmitter spectrum have to remain within the same frequency bounds as the -2.5 dB points of the end-to-end filter function.





DP-16QAM spectral excursion

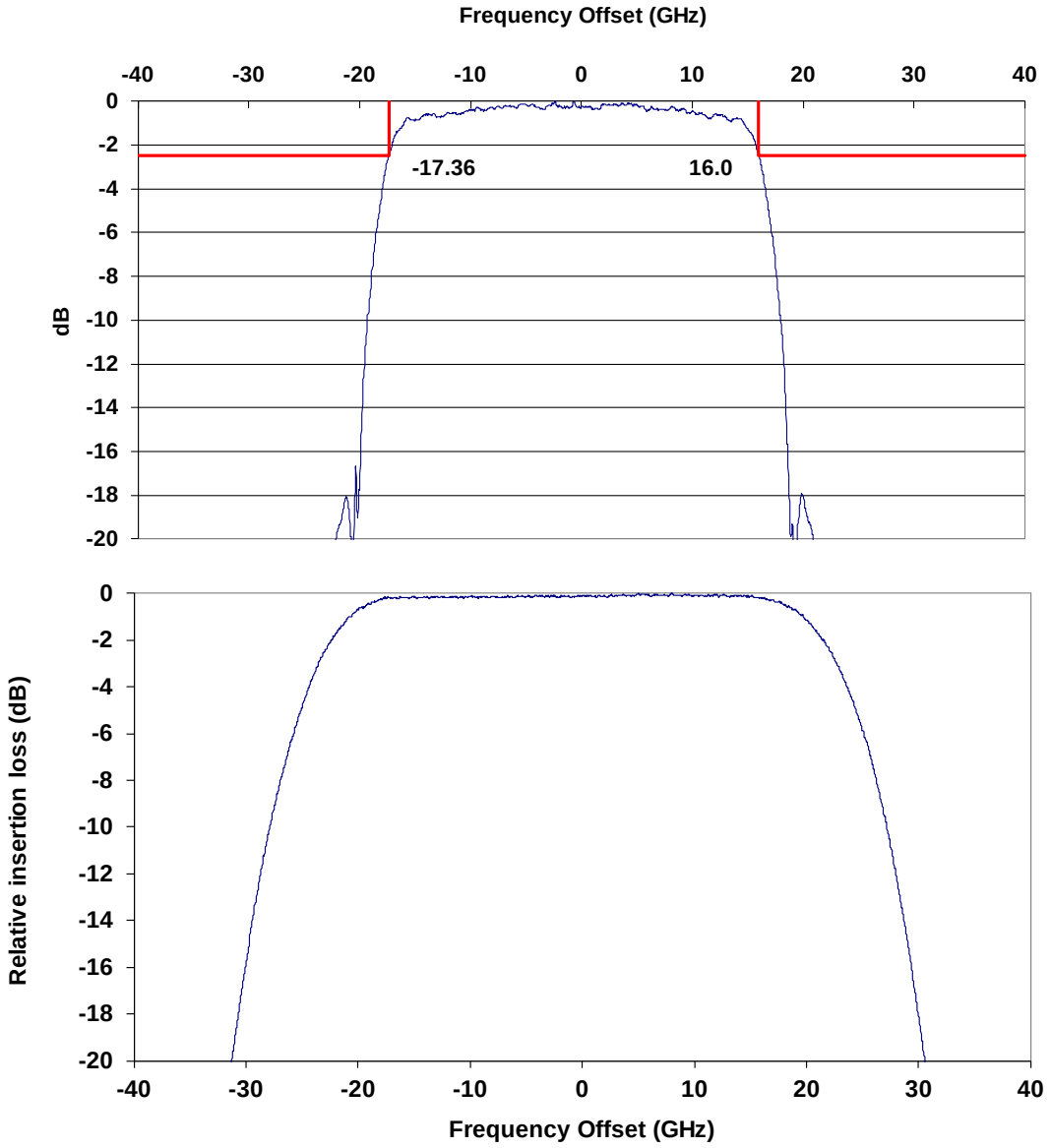
Having established this criterion for DP-QPSK signals, work has now started to confirm whether the same criterion can be used for DP-16QAM signals.

One example of this measurement for DP-16QAM is shown on the following slides.

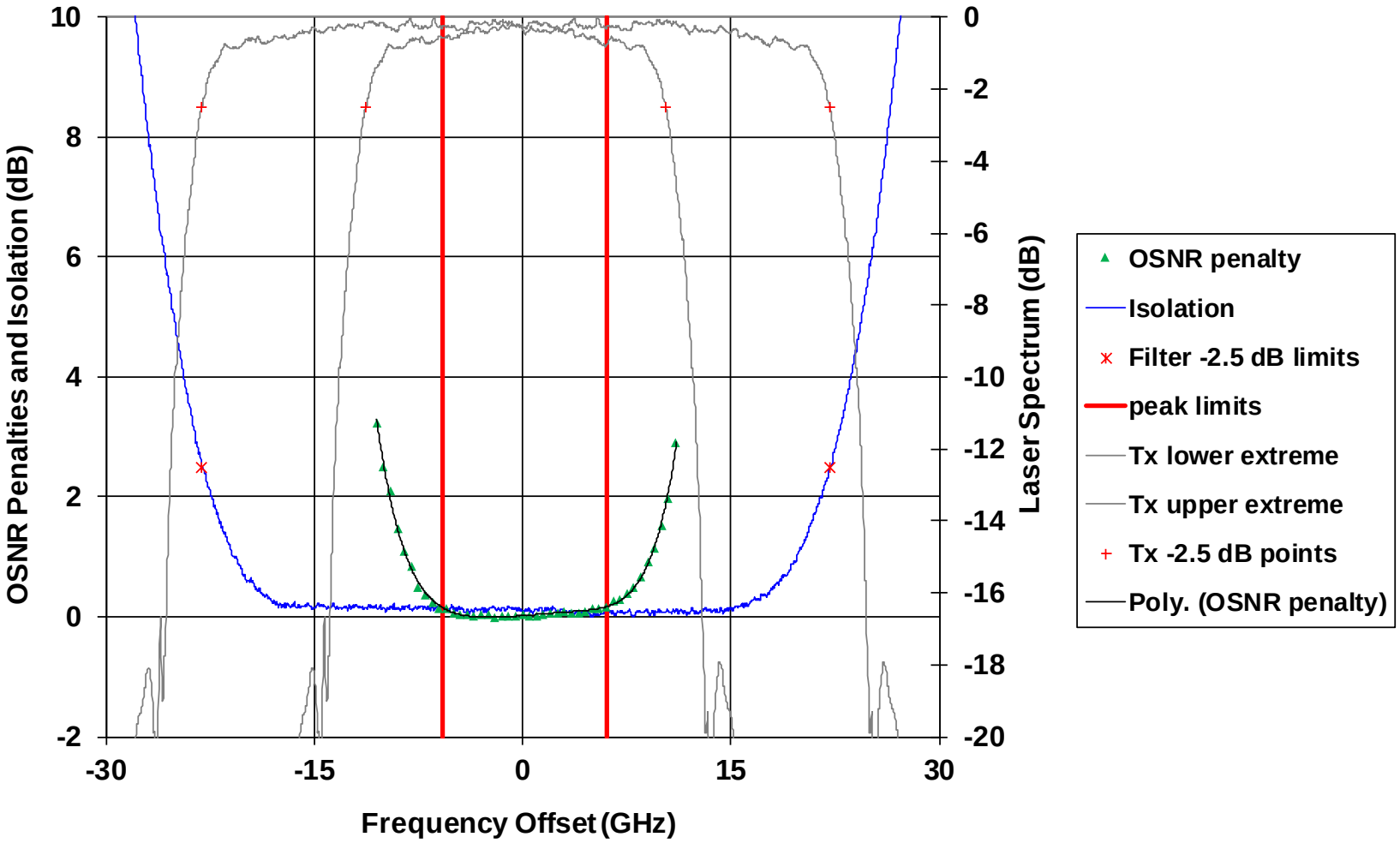
DP-16QAM Tx spectrum and filter function

DP-16QAM transmitter spectrum

WSS filter function



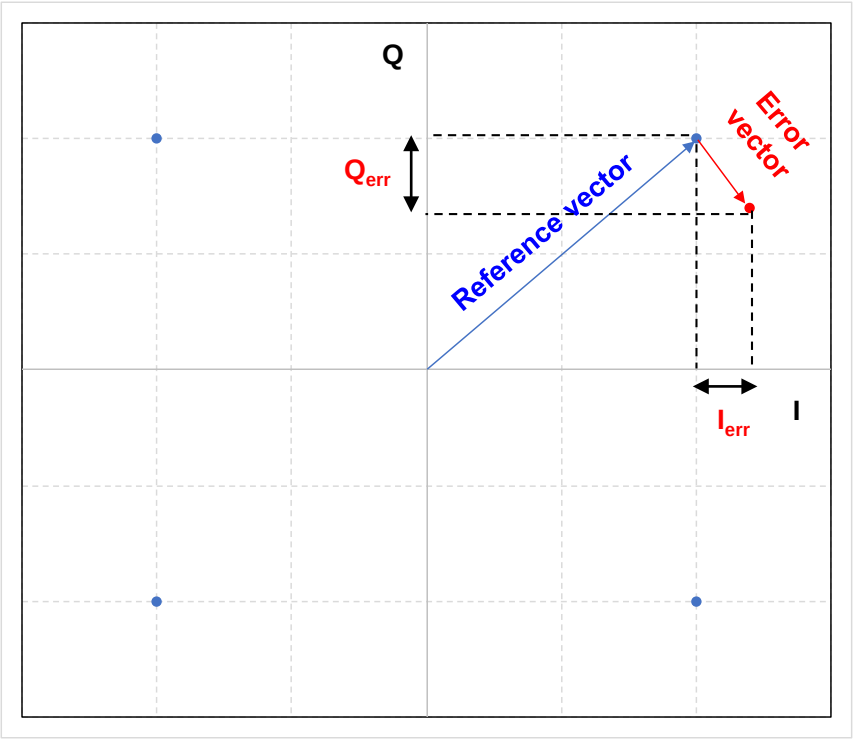
DP-16QAM Spectral excursion result



Error Vector Magnitude (EVM_{RMS})

Error vector magnitude

Error vector magnitude is a measure of how far each transmitted constellation point is away from the ideal reference position.



$$EVM(x) = \sqrt{I_{err}(x)^2 + Q_{err}(x)^2}$$

$$EVM_{RMS} = \frac{\sqrt{\frac{1}{N}\sum_{x=1}^{N} EVM(x)^2}}{|Ref\ vector|}$$

EVM_{RMS} validation

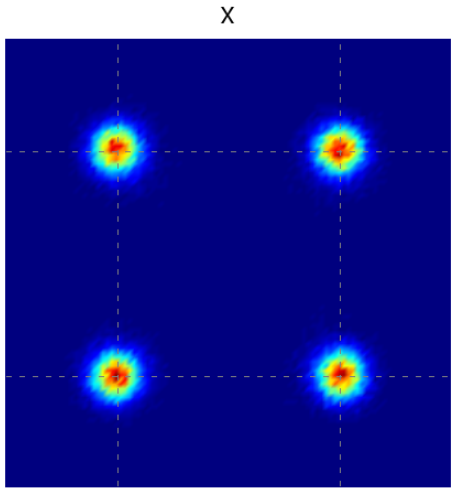
A variety of measurements have been performed by ITU-T SG15 Q6 members to try to establish that there is a reasonable correlation between the EVM_{RMS} metric being developed by Q6 and the OSNR penalty measured by a coherent system receiver for a variety of different impairments.

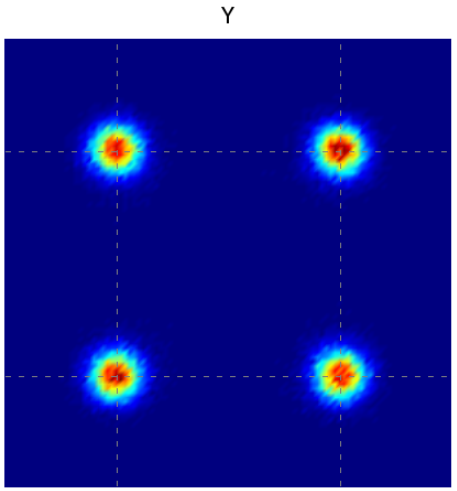
The following slides show example constellations for DP-QPSK with the following impairments:

- Circle
- Noise
- Quadrature error
- I-Q imbalance
- I-Q offset

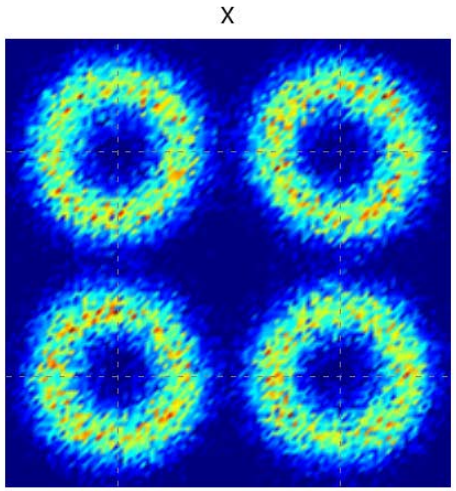
DP-QPSK Circle impairment

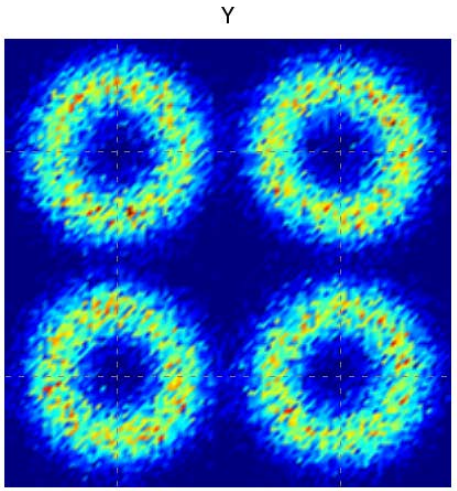
No added impairment





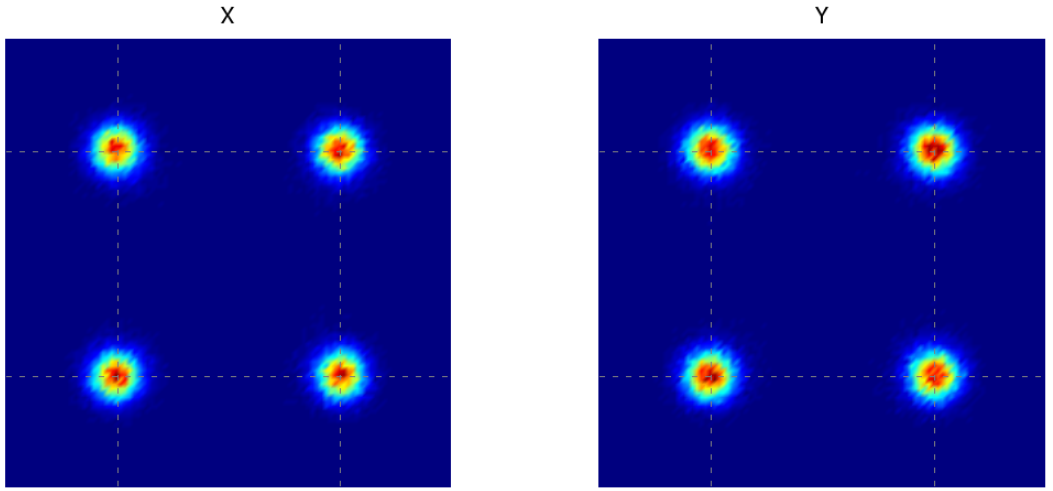
Circle impairment



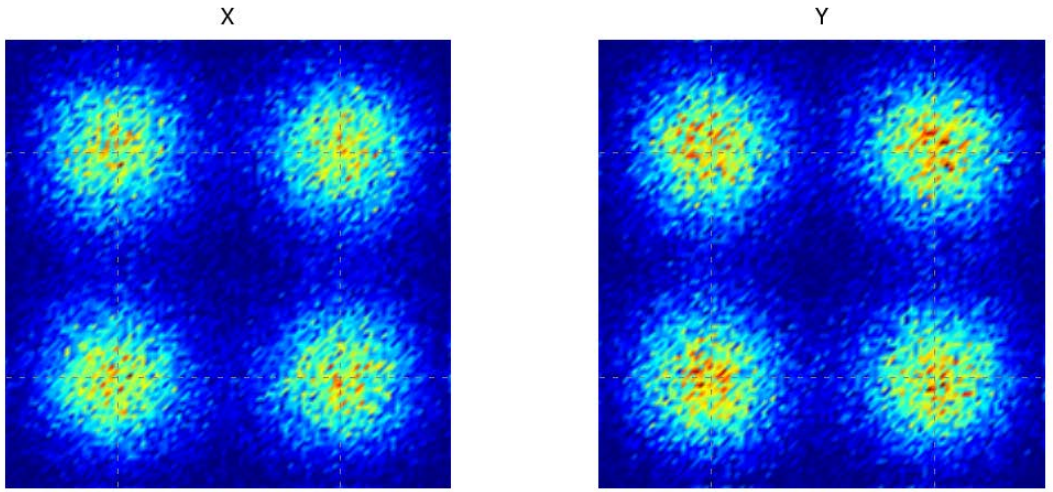


DP-QPSK Noise impairment

No added impairment

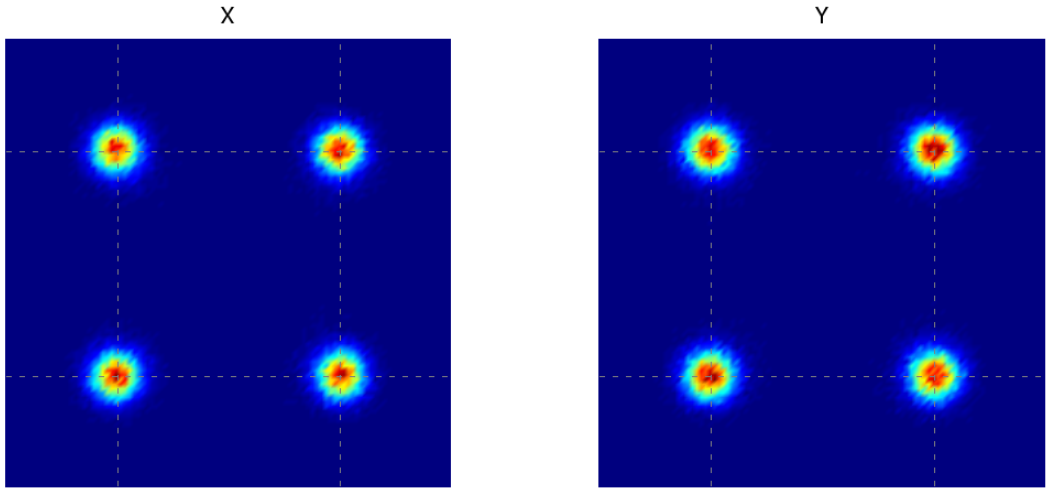


Noise impairment

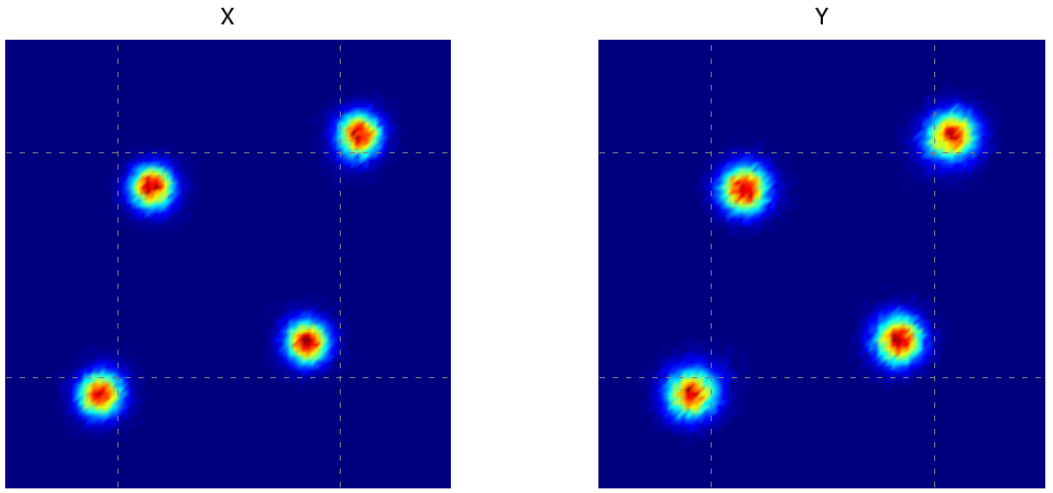


DP-QPSK Quadrature error impairment

No added impairment

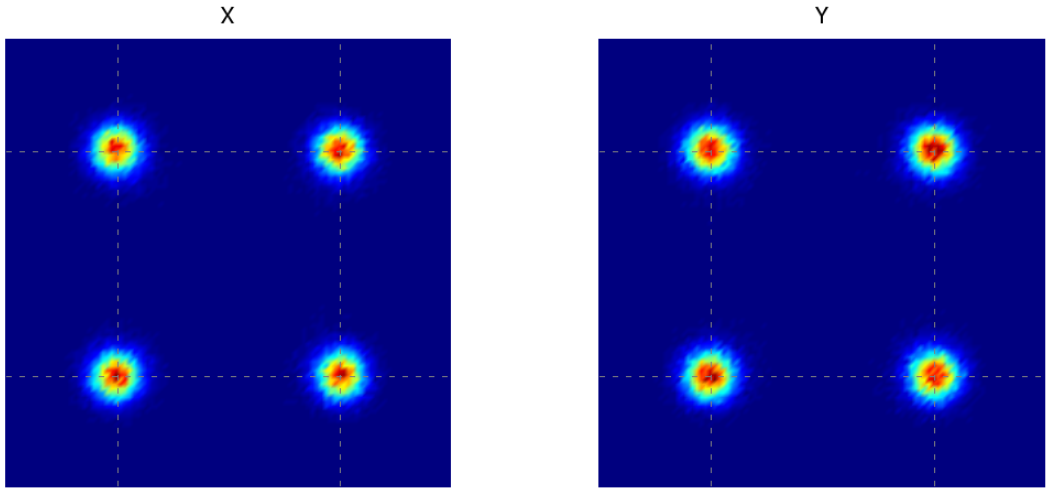


Quadrature error impairment

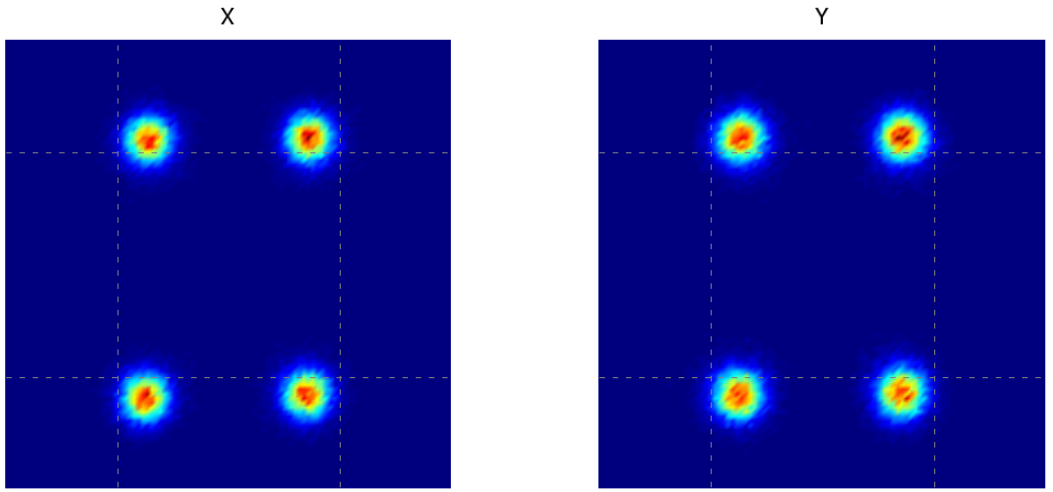


DP-QPSK I-Q imbalance impairment

No added impairment

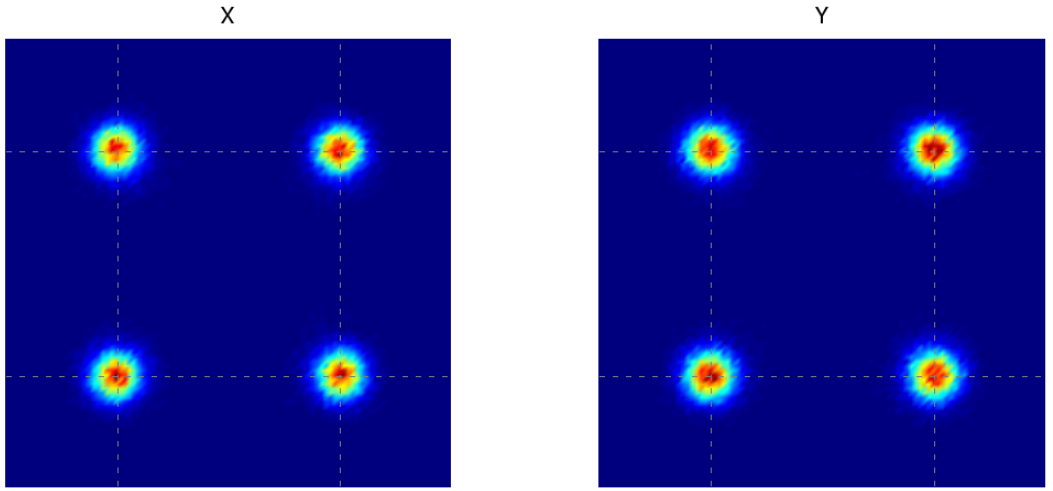


I-Q imbalance impairment

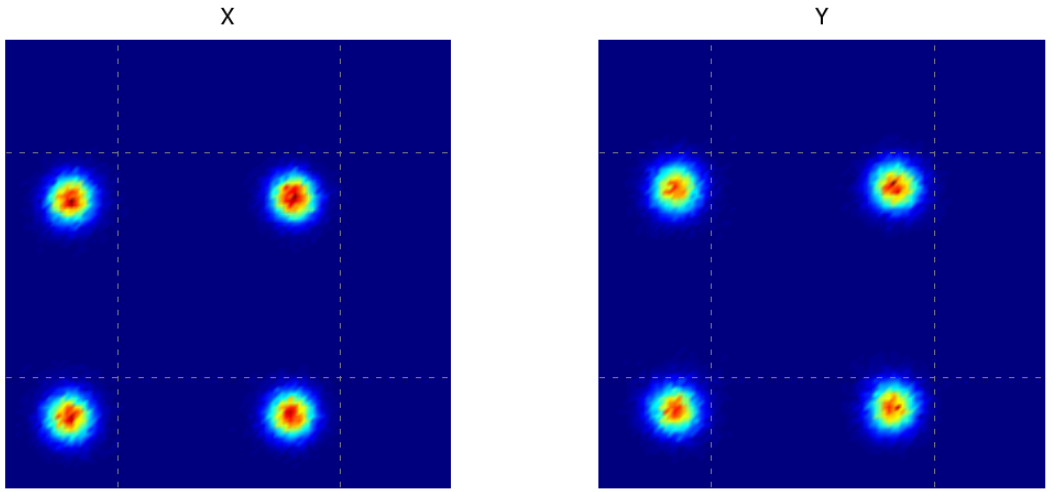


DP-QPSK I-Q offset impairment

No added impairment



I-Q offset impairment

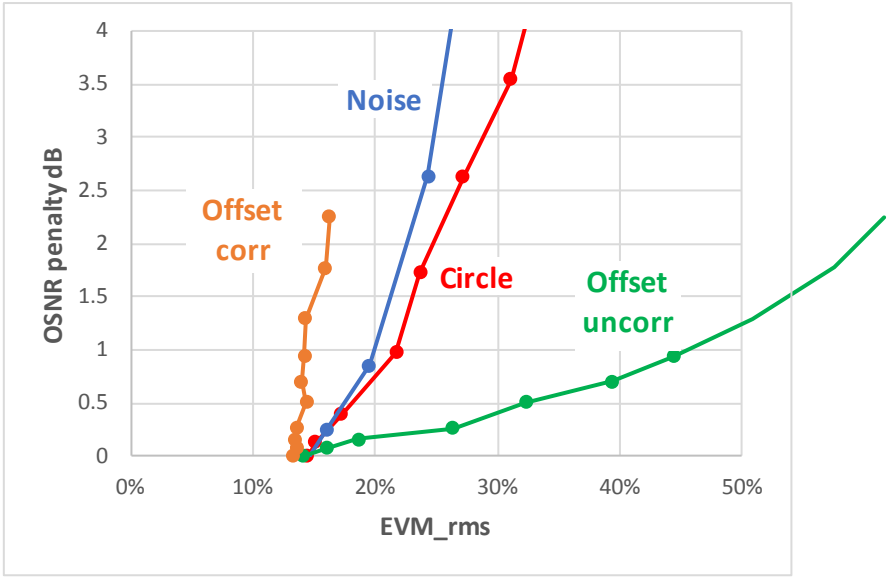


DP-QPSK I-Q offset result

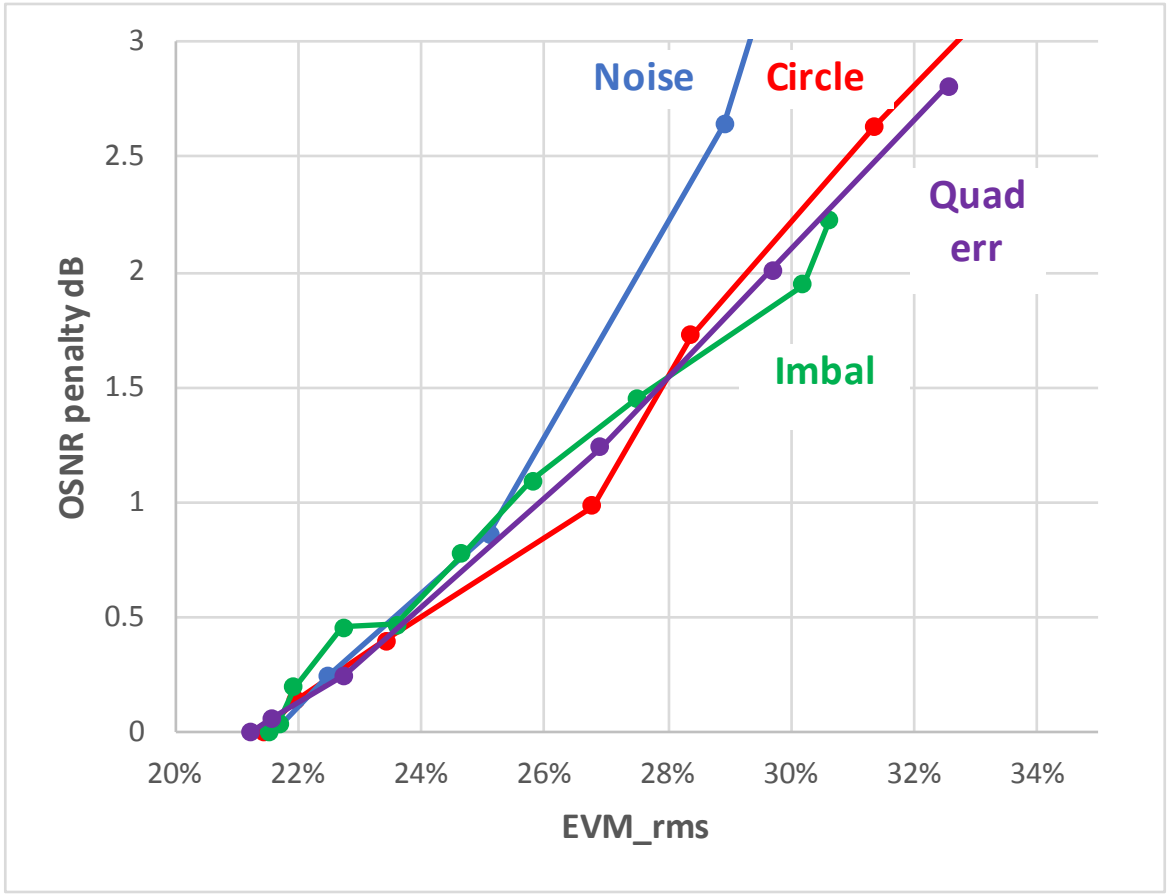
While most of the impairments show a similar curve when OSNR penalty is plotted vs EVM_{RMS} the curve for I-Q offset was found to be significantly different.

Consequently, any I-Q offset is removed from the measured data prior to the calculation of EVM_{RMS} and a separate limit for I-Q offset is applied.

All of the other impairments are plotted on the next slide.



DP-QPSK OSNR Penalty vs. EVM_{RMS}



16QAM validation

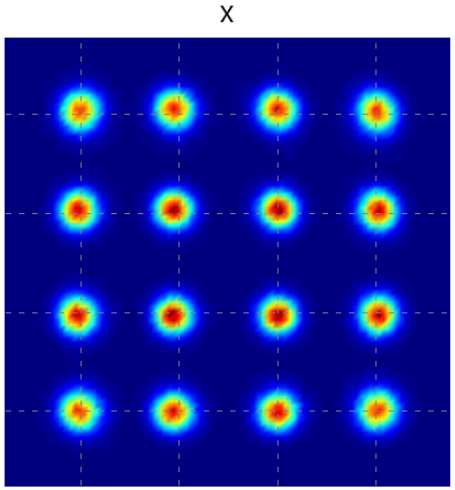
Recently, work has started to try to extend this validation to a similar set of impairments for the DP-16QAM modulation format.

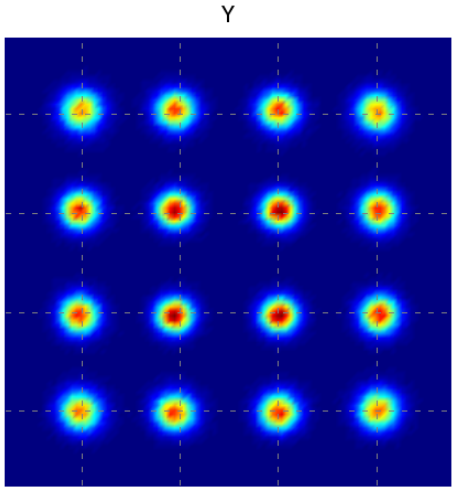
The following slides show the constellations for DP-16QAM with the following impairments:

- Circle
- Noise

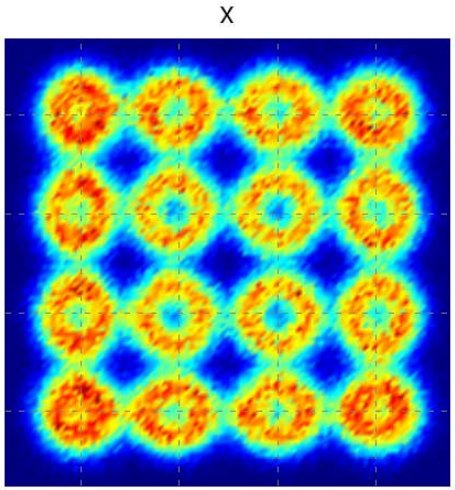
DP-16QAM Circle impairment

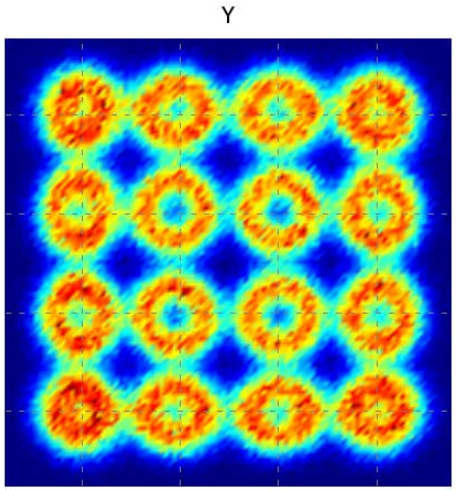
No added impairment





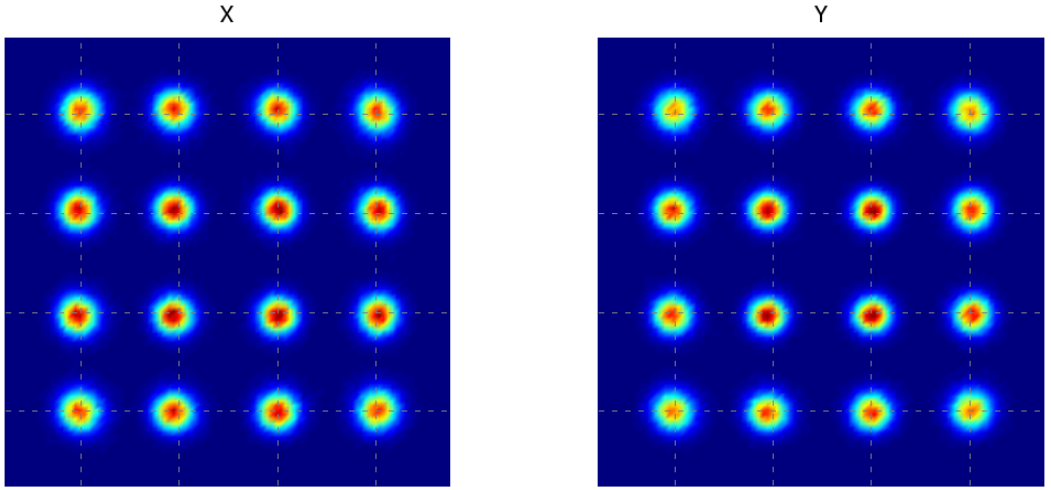
Circle impairment



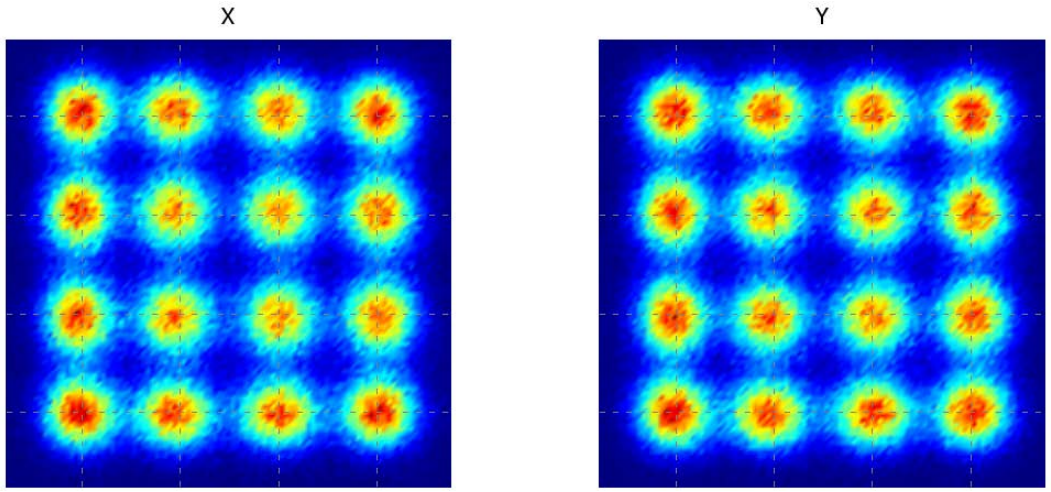


DP-16QAM Noise impairment

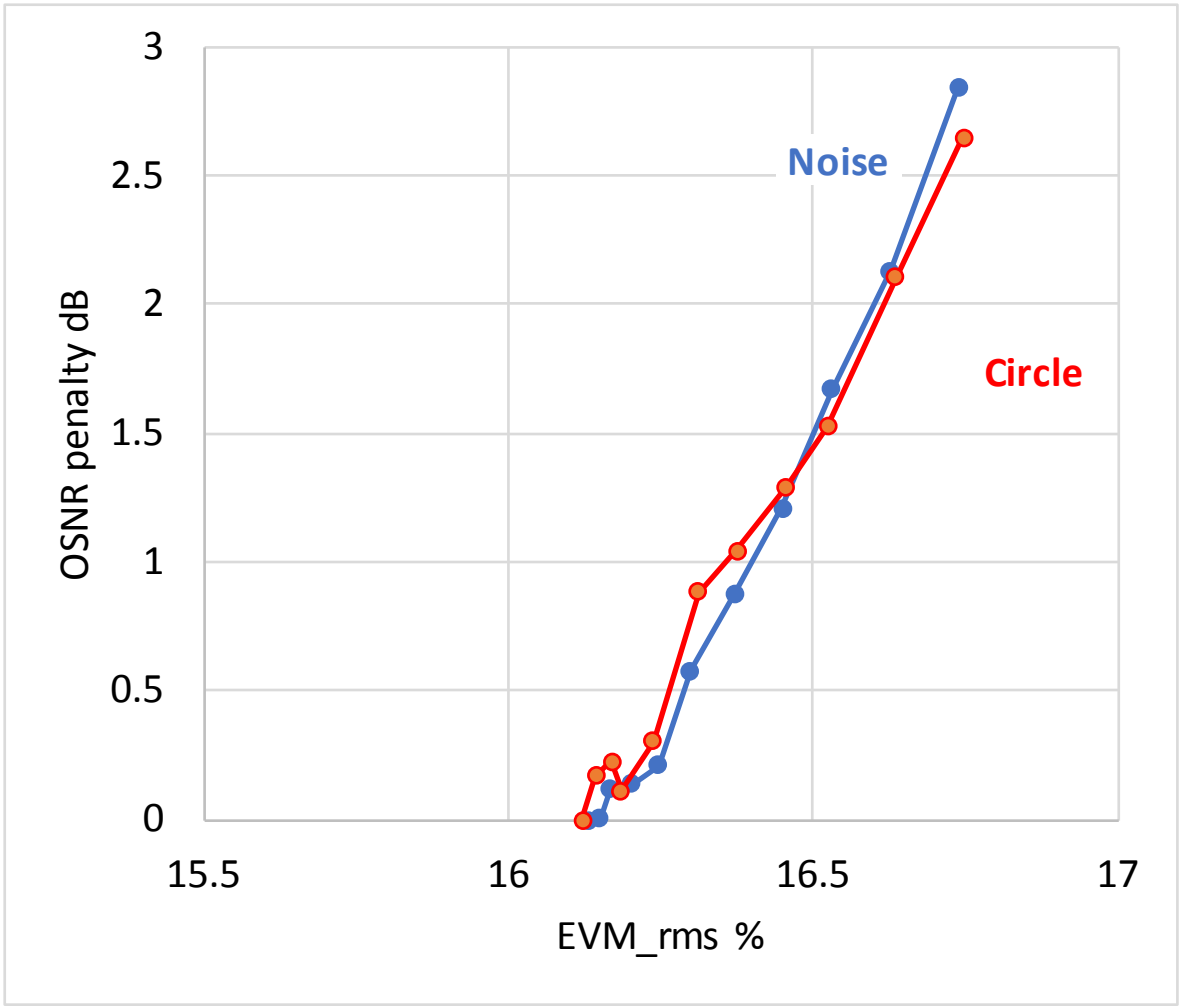
No added impairment



Circle impairment



DP-16QAM OSNR Penalty vs. EVM_{RMS}



Thanks!