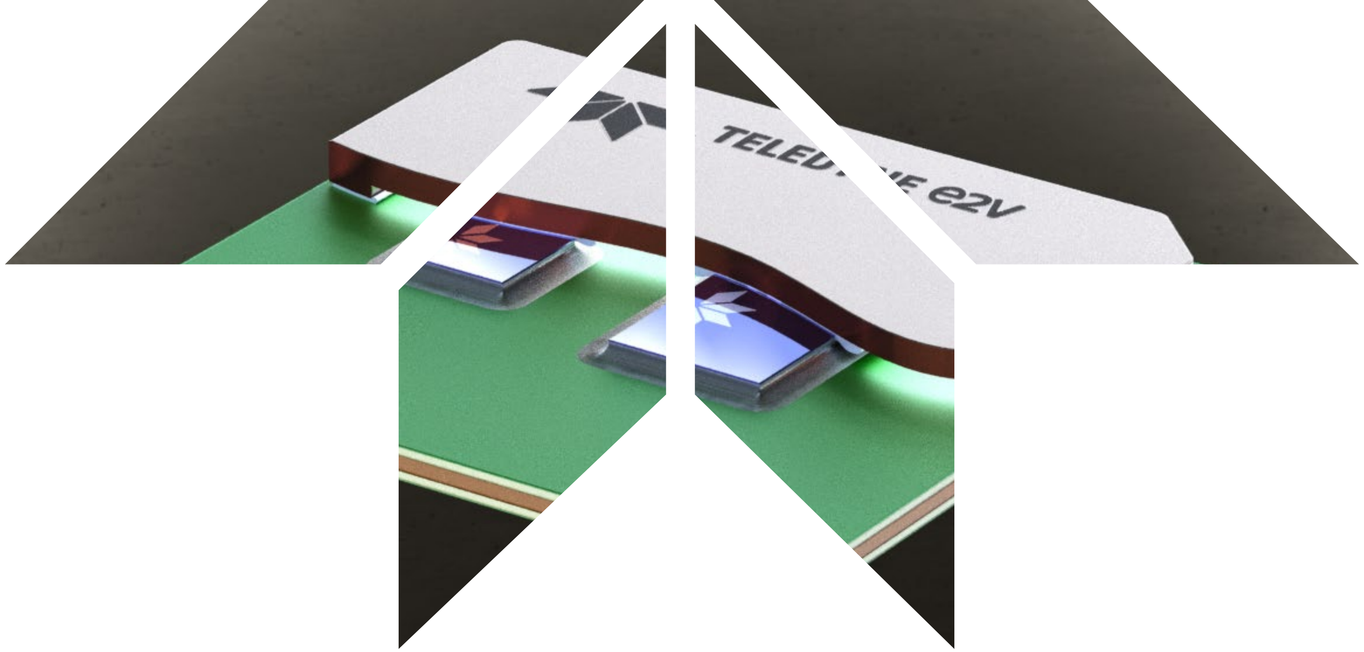


Ka Band Direct Sampler & Converter

EV10AS940 Preliminary results

February 2023 F. BORE

ESCCON 2023
The European Space Components Conference
7 - 9 March 2023 | Toulouse | France
esa

Why Ka Band direct sampling ?

Benefits:

- Payload system simplification (suppression of analog stages)
- Demodulation in digital domain: greater flexibility
- Channelization and filter moved to digital domain.
- Wider band of interest available (lower bands are overcrowded)
- Higher central frequency make DBFM efficient over a wider B.o.I.
- Multi elements antenna alleviate individual SNR and jitter constraint and make Ka Band direct sampling a real option.

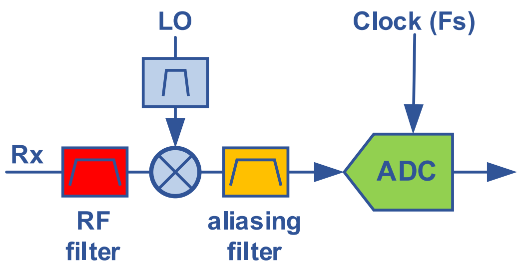
Hurdles:

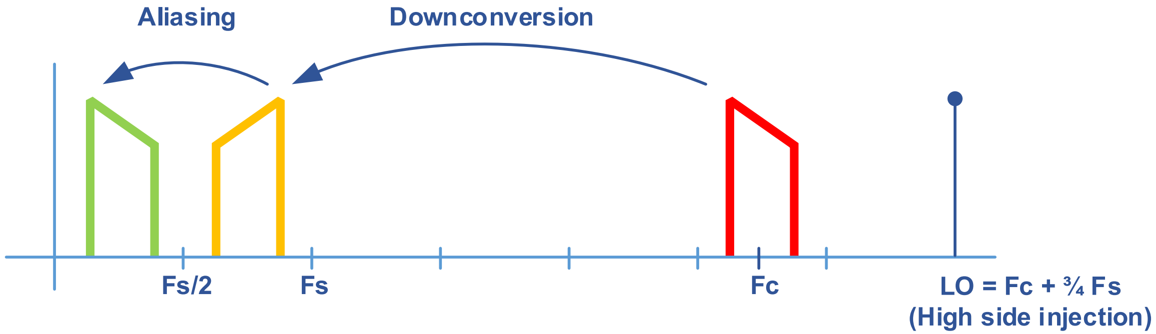
- Analog filtering more complex than in heterodyne approach (but see above)
- Increase of sampling rate needed to mitigate larger band of integration for thermal noise.

Architecture comparison

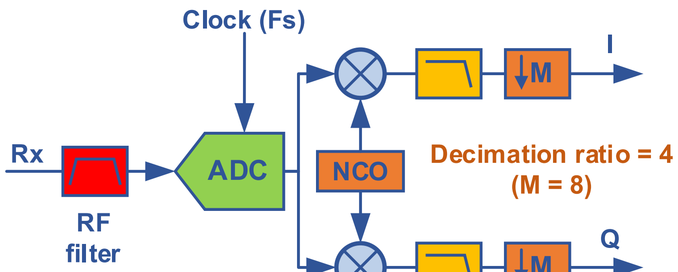
Herodyne with 2nd Nyquist IF sampling vs direct sampling digital conversion

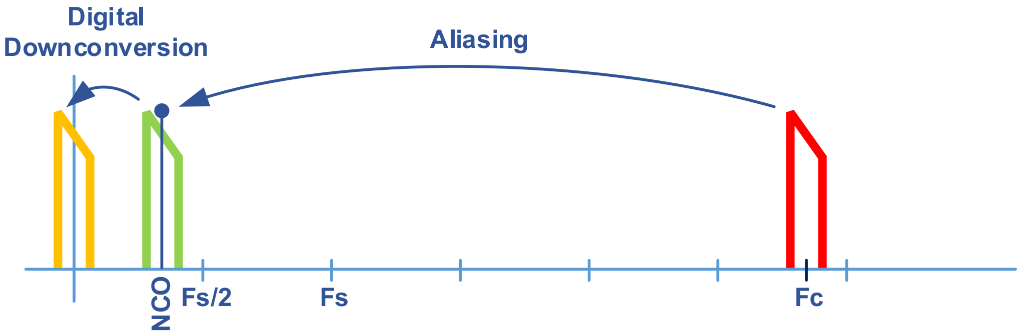
Heterodyne with 2nd Nyquist IF Sampling





Direct Sampling with Digital Downconversion





Benefit of architecture based on Direct Sampling with Digital Down Sampling over Heterodyne architecture is more flexibility when selecting frequency bands.

EV10AS940 : Facts Sheet

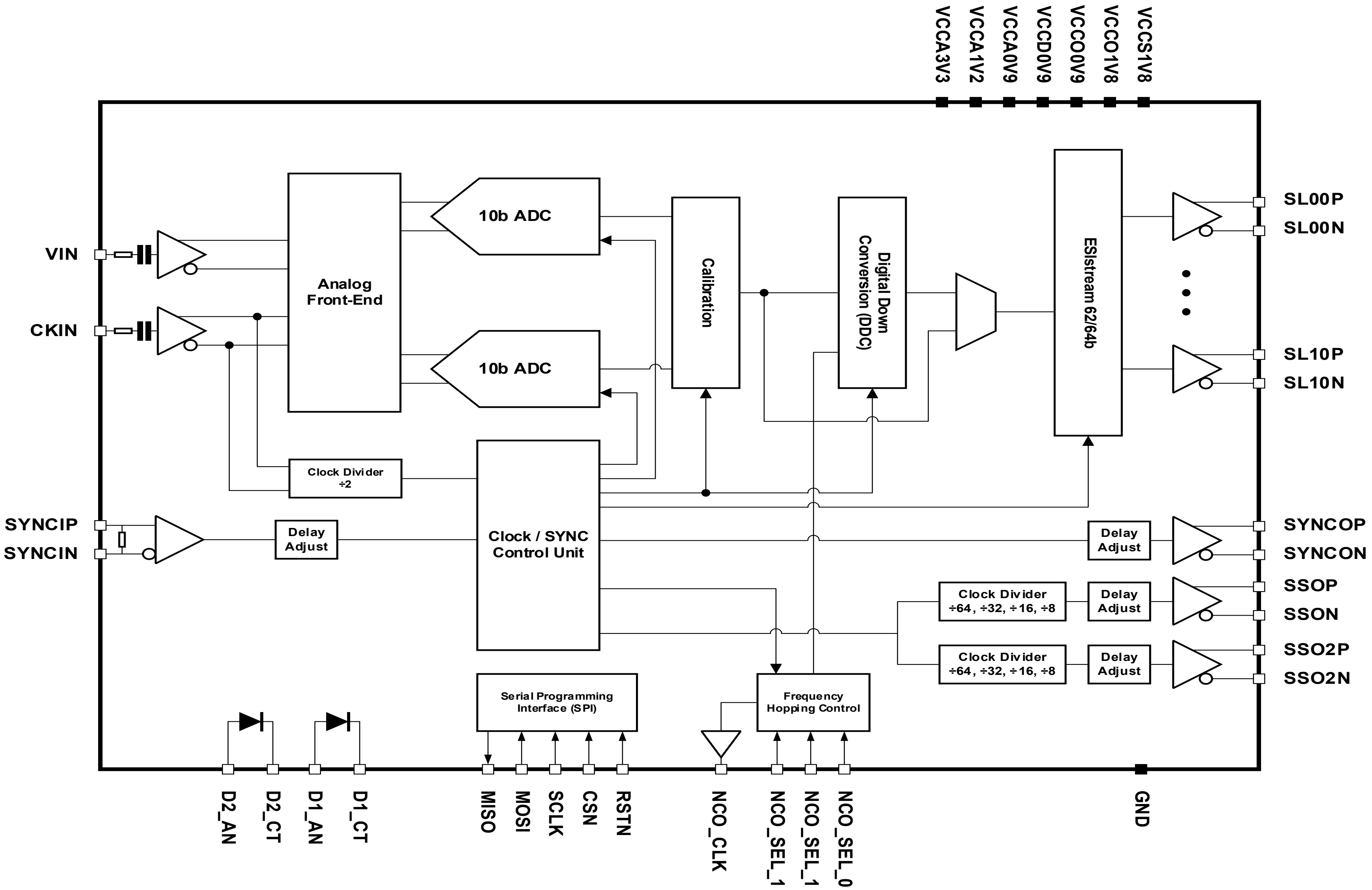
Part	Nb of channels	Fs max	Direct conversion	Quality grade
EV10AS940	1	12.8 GSPS	Up to Ka- band	Commercial, Industrial, Mil, Space

- **33 GHz** analog input bandwidth (-3dB)
- Up to **12,8 GSPS** Data rate
- ENOB @Fin = 25GHz : 6,8 bits
- **Power consumption** : 2.5W
- Extensive **Digital Processing** features
- **Single Ended** inputs
- **16.0 x 17.6 mm** FCBGA 0.8mm pitch package

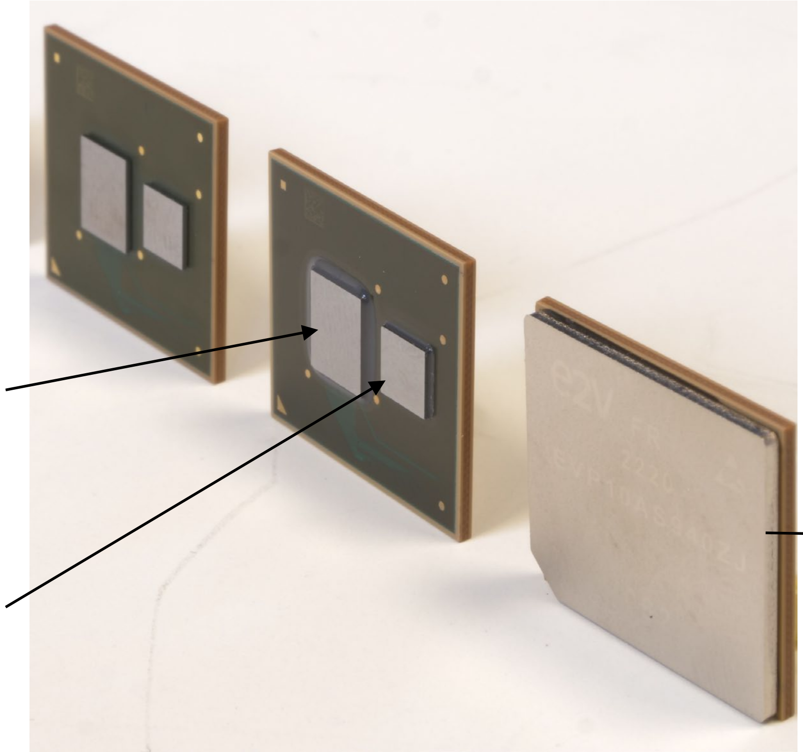
Extensive Digital Features

- ✓ DDC from 2 to 1024
- ✓ X4 NCO allow multi-channel management
- ✓ Fast Frequency Hopping
- ✓ Beamforming / Digital Delays
- ✓ On-Chip Calibration
- ✓ Easy multi-chip synchronization

EV10AS940 : Bloc diagram

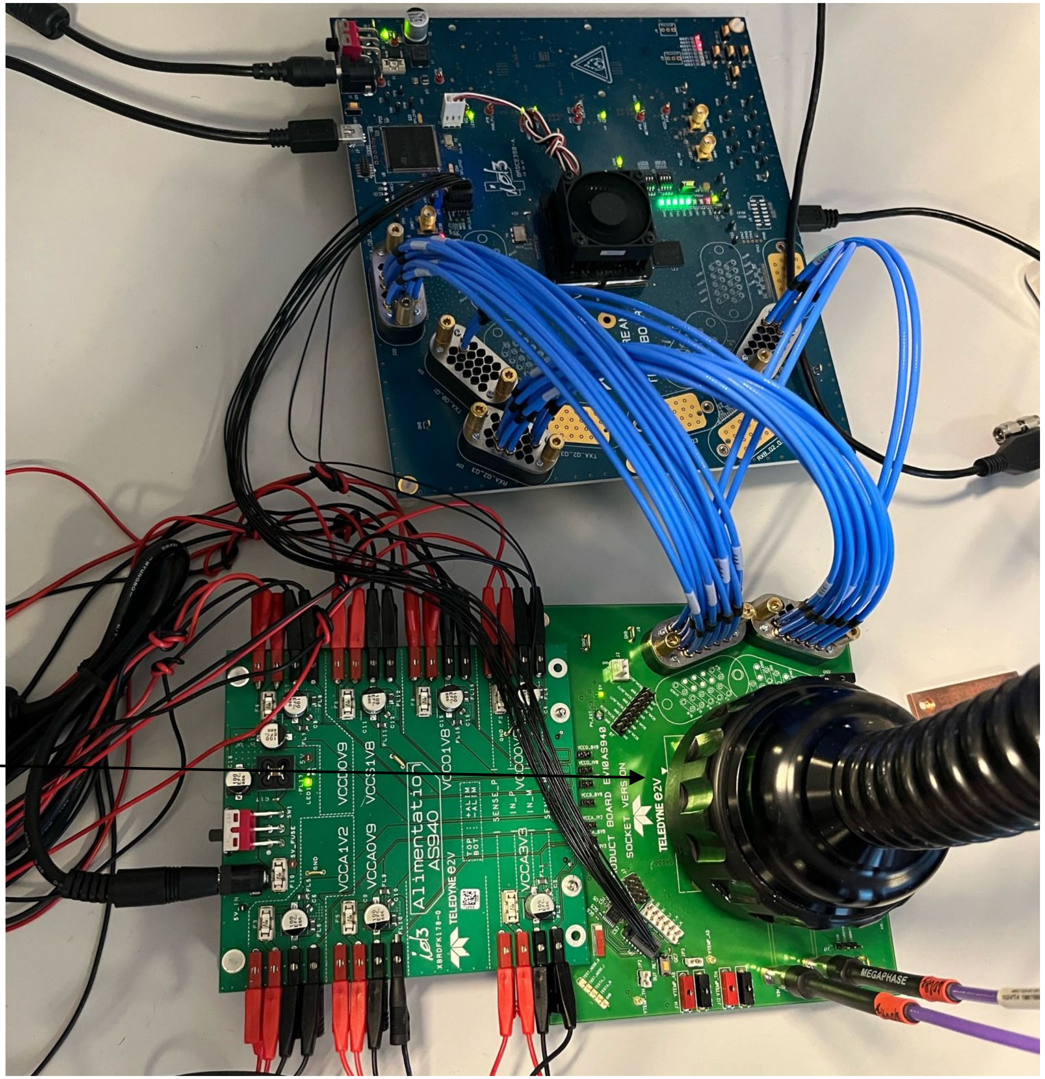


EV10AS940 – 33GHz / 2.5W



28nm CMOS ADC

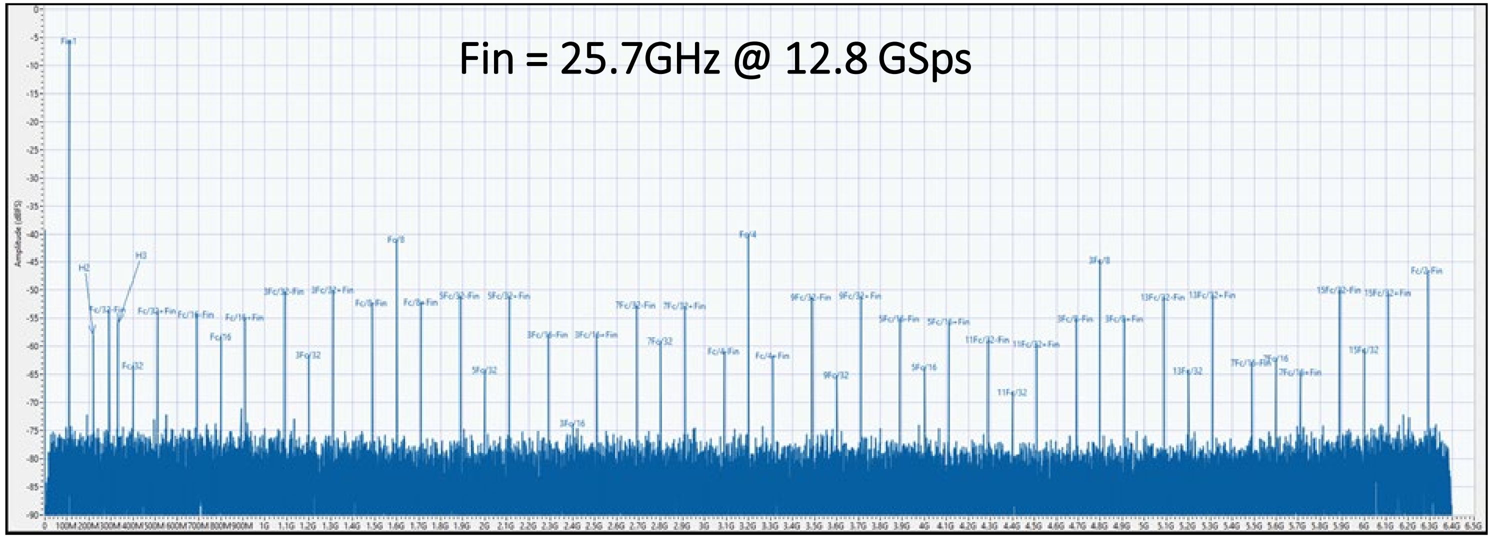
BiCMOS 55nm T&H



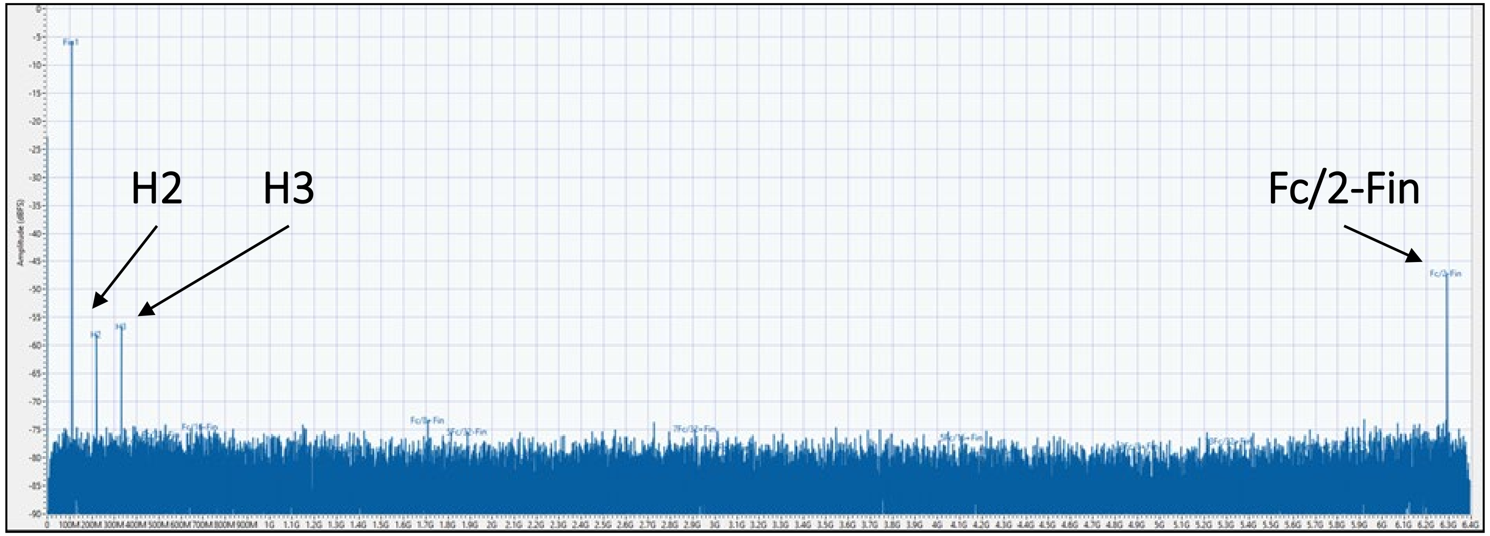
EV10AS940 : On-Chip Calibration

Spectrum before and after ADC on-chip background calibration

On-Chip Calibration OFF

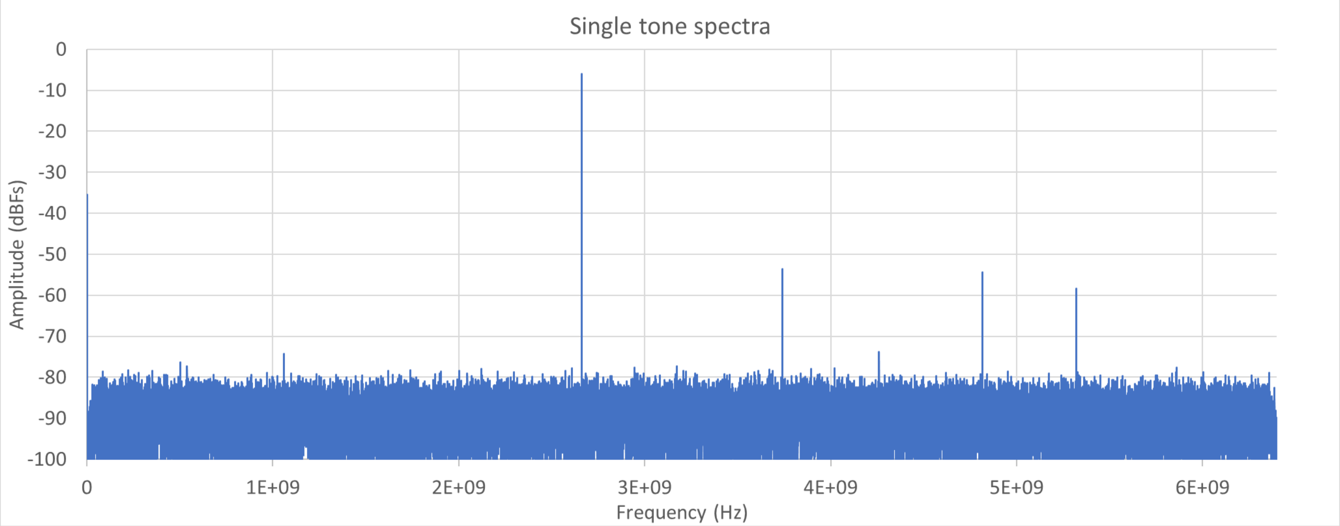


On-Chip Calibration ON



EV10AS940 : Typical Spectra

Typical spectra @12.8 GSps: NZ2 and NZ3

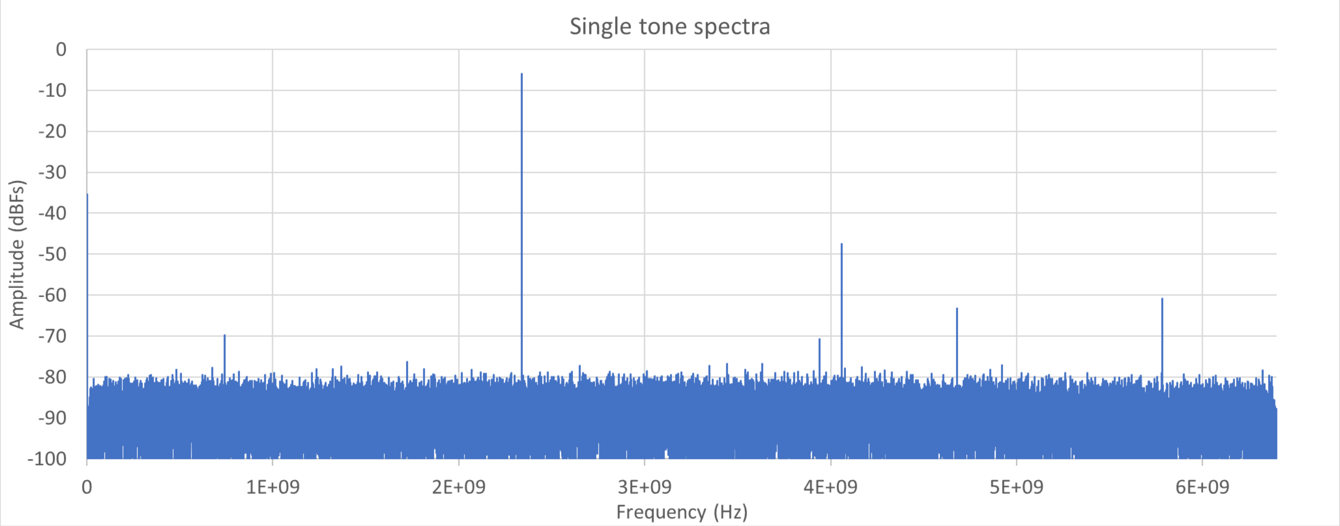


Fin = 10.1GHz (NZ2)

SFSR = -6dBFS

SFDR = 47dBc

SNR = 36.2dBc / 42.2dBFS



Fin = 15.1GHz (NZ3)

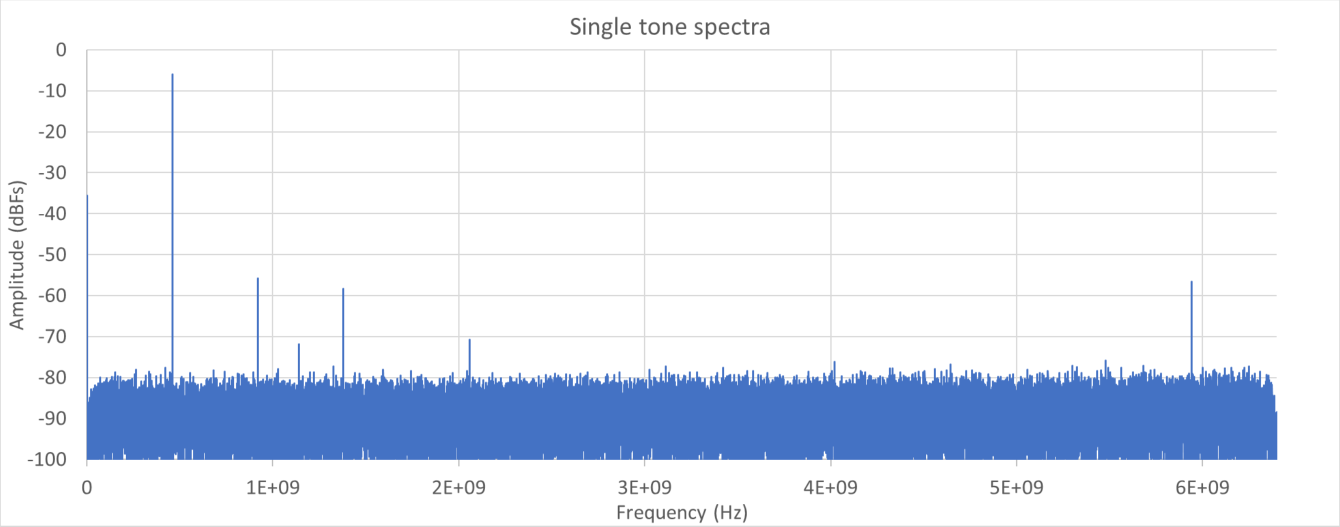
SFSR = -6dBFS

SFDR = 47dBc

SNR = 36dBc / 42dBFS

EV10AS940 : Typical Spectra

Typical spectra @12.8 GSps: NZ4 and NZ5

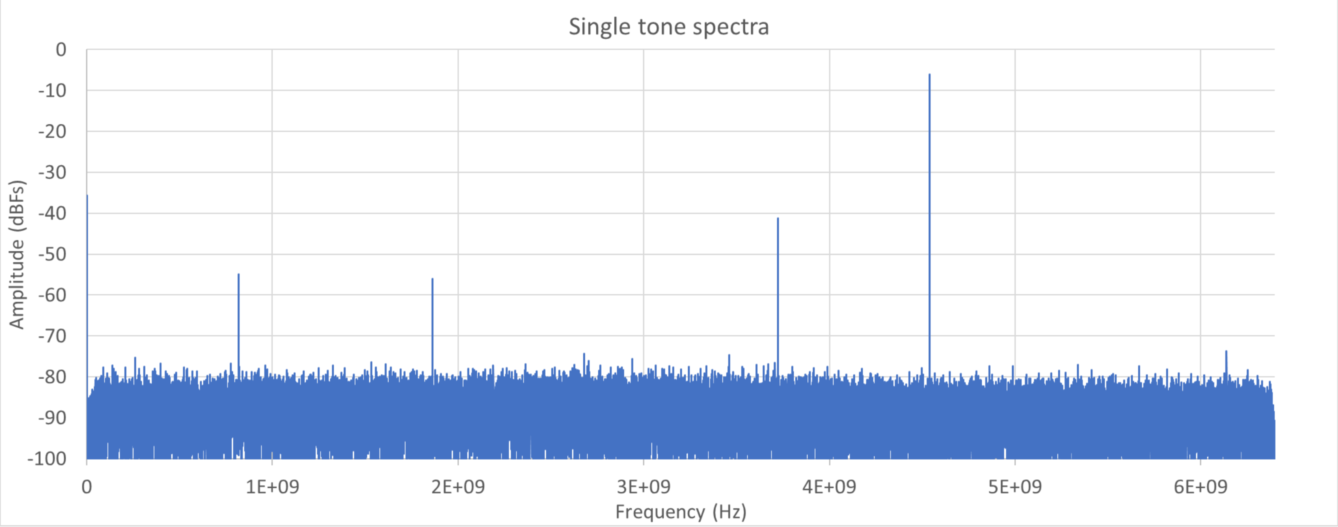


Fin = 25.1GHz (NZ4)

SFSR = -6dBFS

SFDR = 49dBc

SNR = 35.6dBc



Fin = 30.1GHz (NZ5)

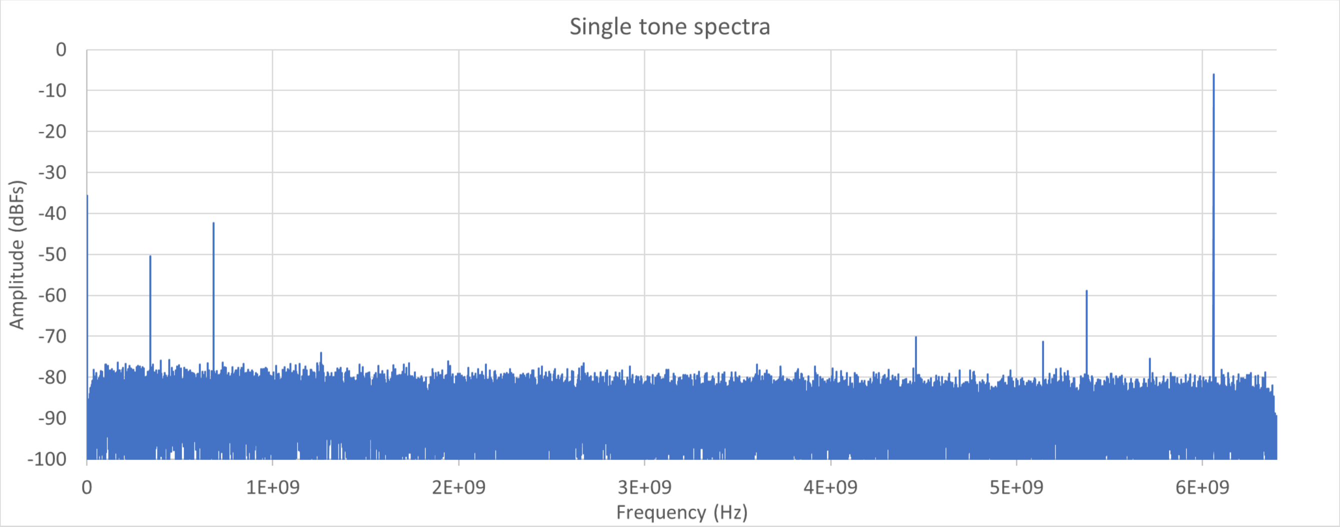
SFSR = -6dBFS

SFDR = 34dBc

SNR = 35.3dBc

EV10AS940 : Typical Spectra

Typical spectrum @12.8 GSps: NZ6



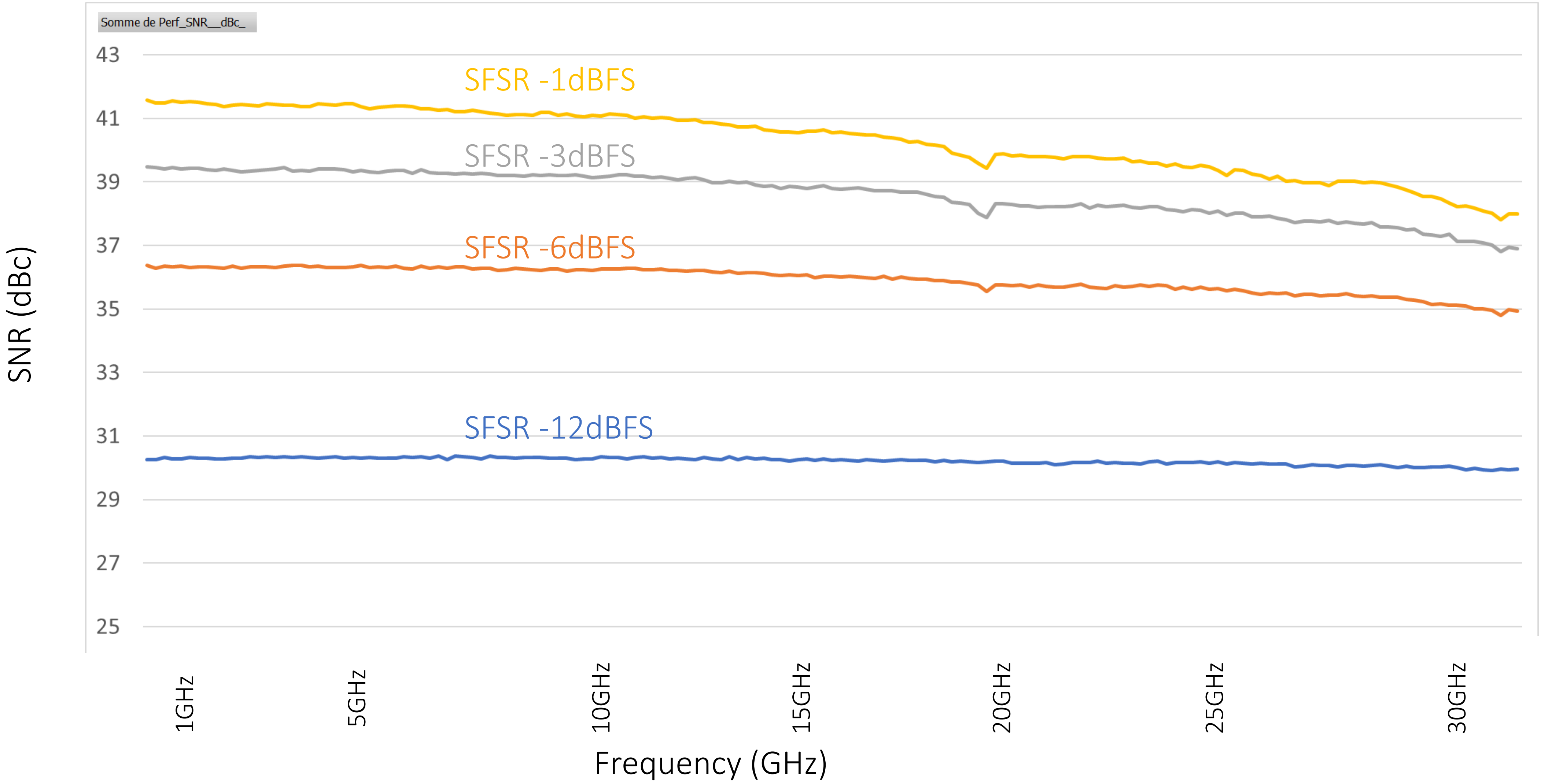
Fin = 32.3GHz (NZ6)

SFSR = -6dBFS

SFDR = 36dBc

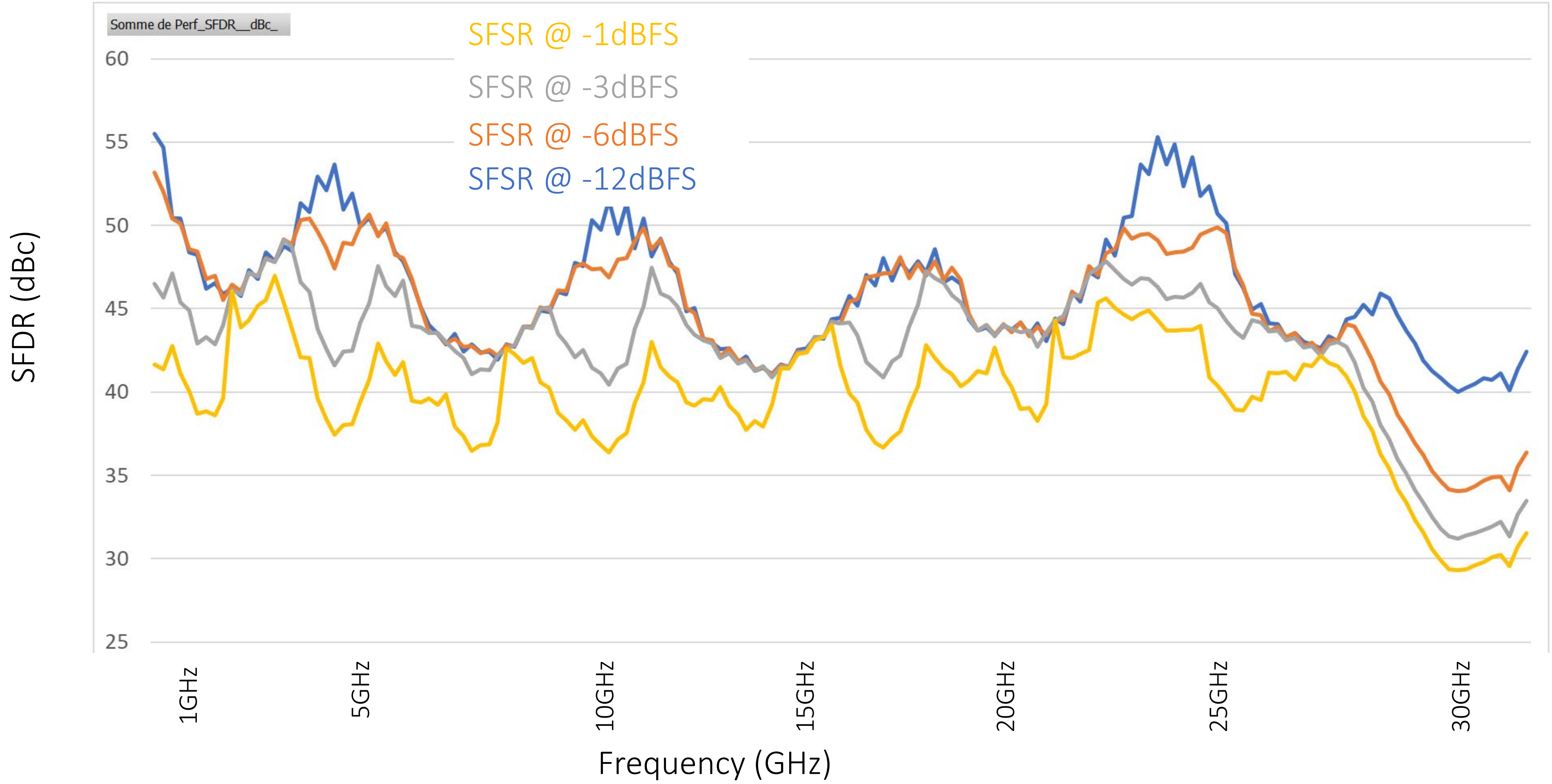
SNR = 35dBc

EV10AS940 : SNR Performance @ 12.8GSps



TELEDYNE e2v Semiconductors

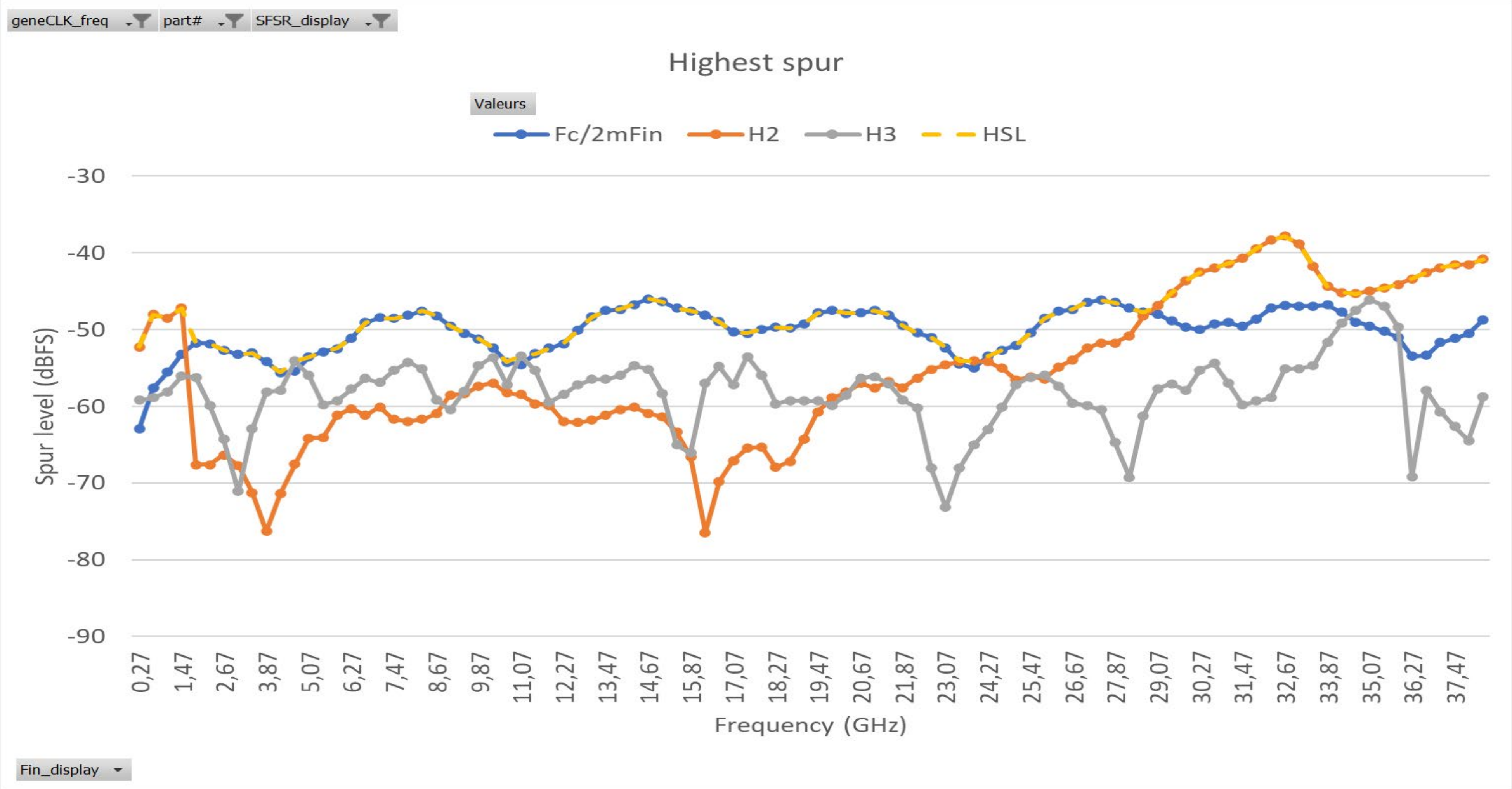
EV10AS940 : SFDR Performance @ 12.8GSps



TELEDYNE e2v Semiconductors

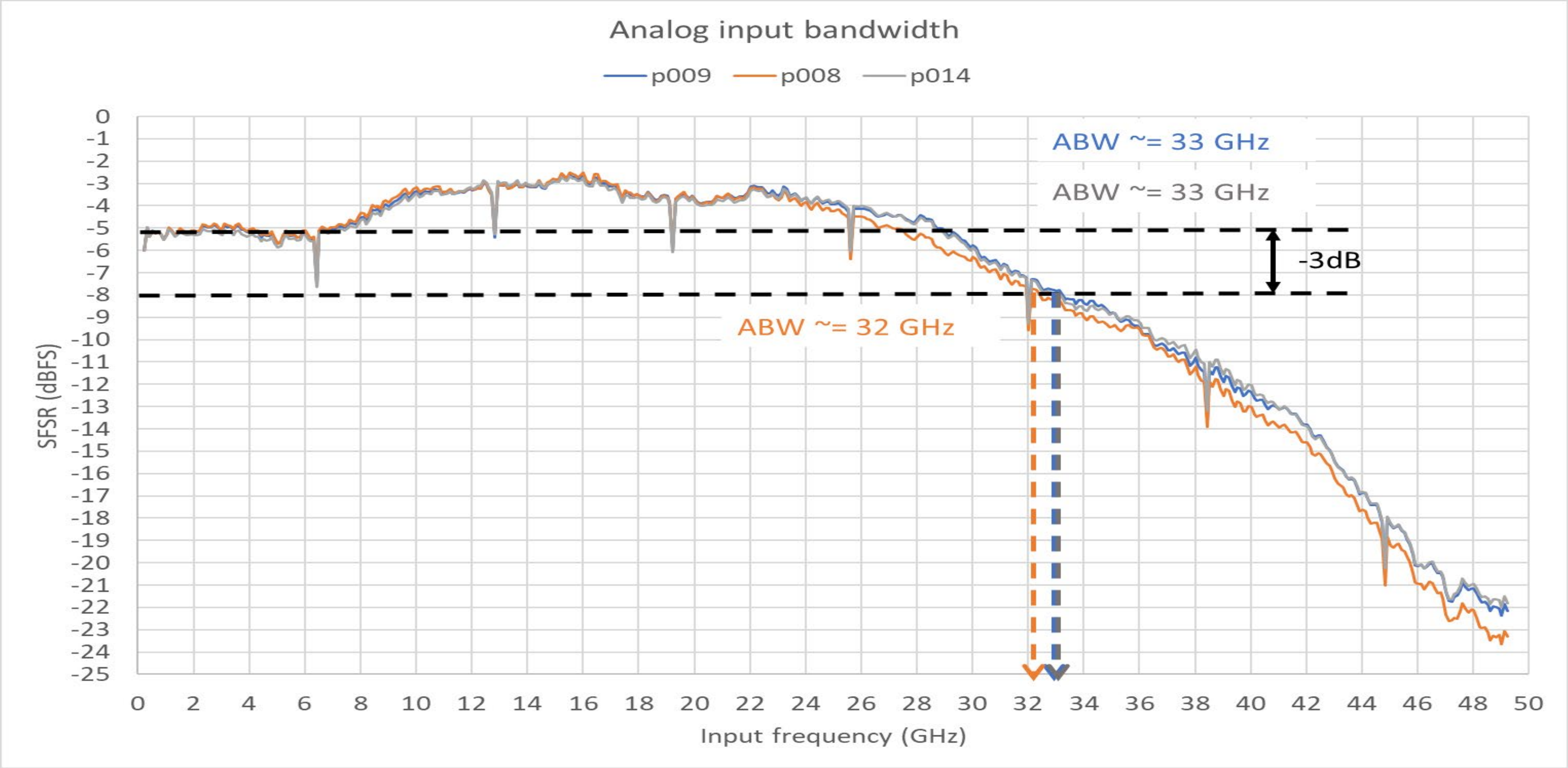
EV10AS940: Fin sweep @ 12.8GSps & Pout=-6dBFS

Highest spur level and origin of the spur: on next revision improvement of Fc/2 – Fin spur would improve available range



EV10AS940 : -3dB Analog Bandwidth various parts.

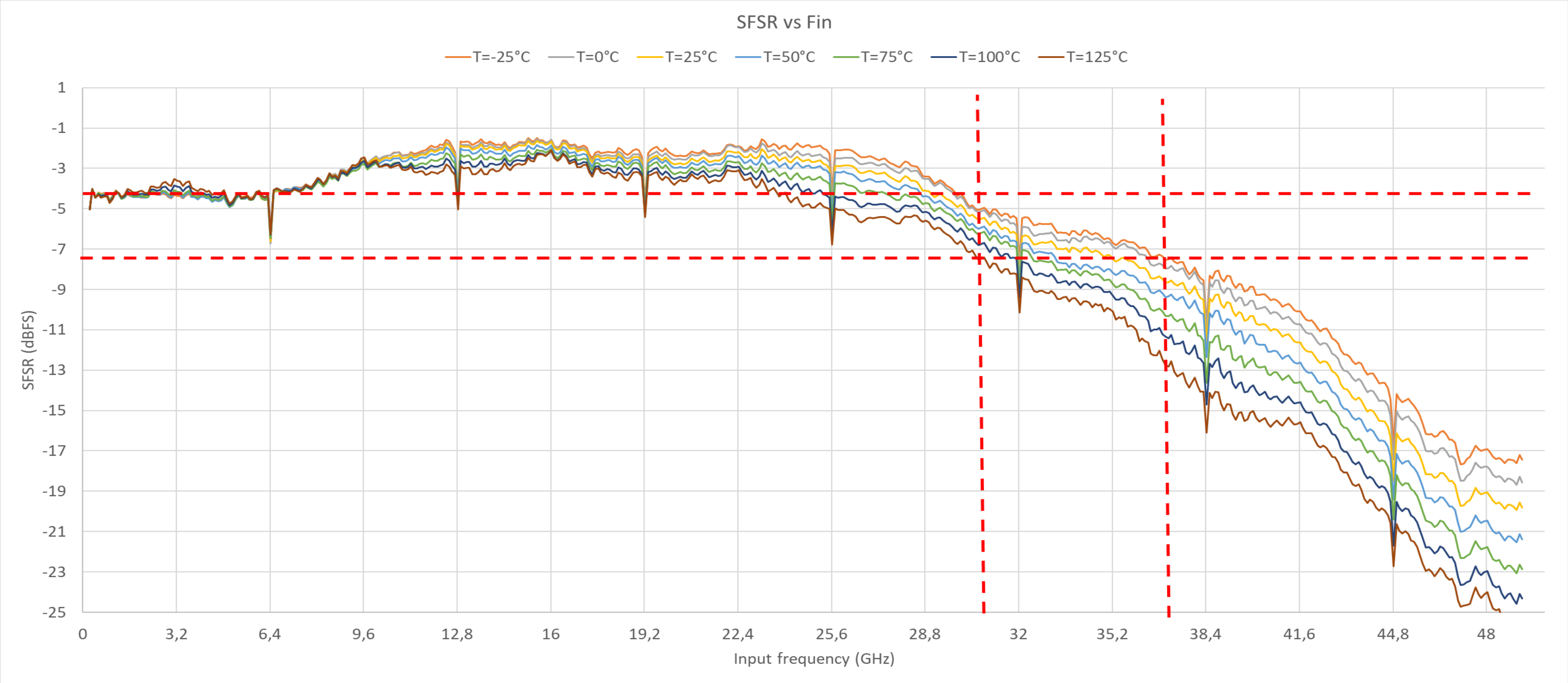
BW is fairly reproductible from part to part.



TELEDYNE e2v Semiconductors

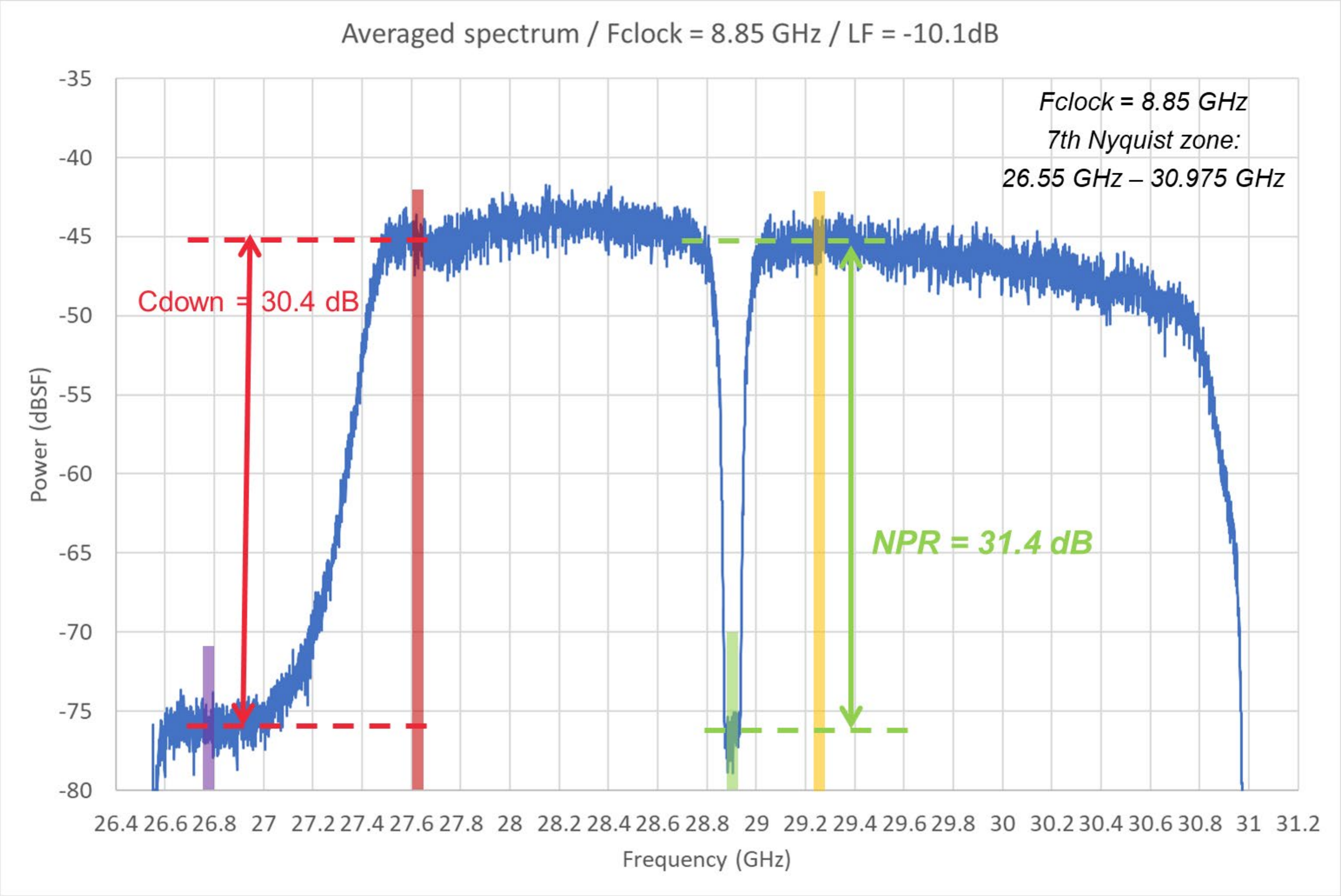
EV10AS940 : -3dB Analog Bandwidth @12.8GSps

SFSR vs Fin and junction temperature: -3dB BW from ~37GHZ @ -25°C down to ~31GHz@125°C,



TELEDYNE e2v Semiconductors

EV10AS940 : NPR measurements @8.85GSps



TELEDYNE e2v Semiconductors

EV10AS940 : Interim conclusions

- Behavior is in line with expectation.
- Our first full CMOS ADC ADC has debugged and is now undergoing deeper characterization.
- This is a technical success.
- This product is a key enabler for Direct Sampling up to Ka Band for space applications.

- Some limitations have been found, analysed and explained (e.g Fc/2 – Fin spur)
- The said limitations will be fixed on the production mask.
- Next step is to transform the try and make it a commercial success for space applications.

EV10AS940 : Acknowledgement

The EV10AS940 is the result of the work of many people, of different professions and spread over two different locations.

The author would also like to thank the many people which have been involved in this project at St Egreve (FR) and at Enschede (NL) for their involvement, their enthusiasm, their close collaboration and their perseverance.

We would like to thank the **CNES** for their support and kind advices.

Thank you for your attention.

TELEDYNE e2v Semiconductors