Front end Digitisation

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MeerKAT Digitiser System Engineer

MeerKAT antenna configaration

MeerKAT antenna

SCOPE

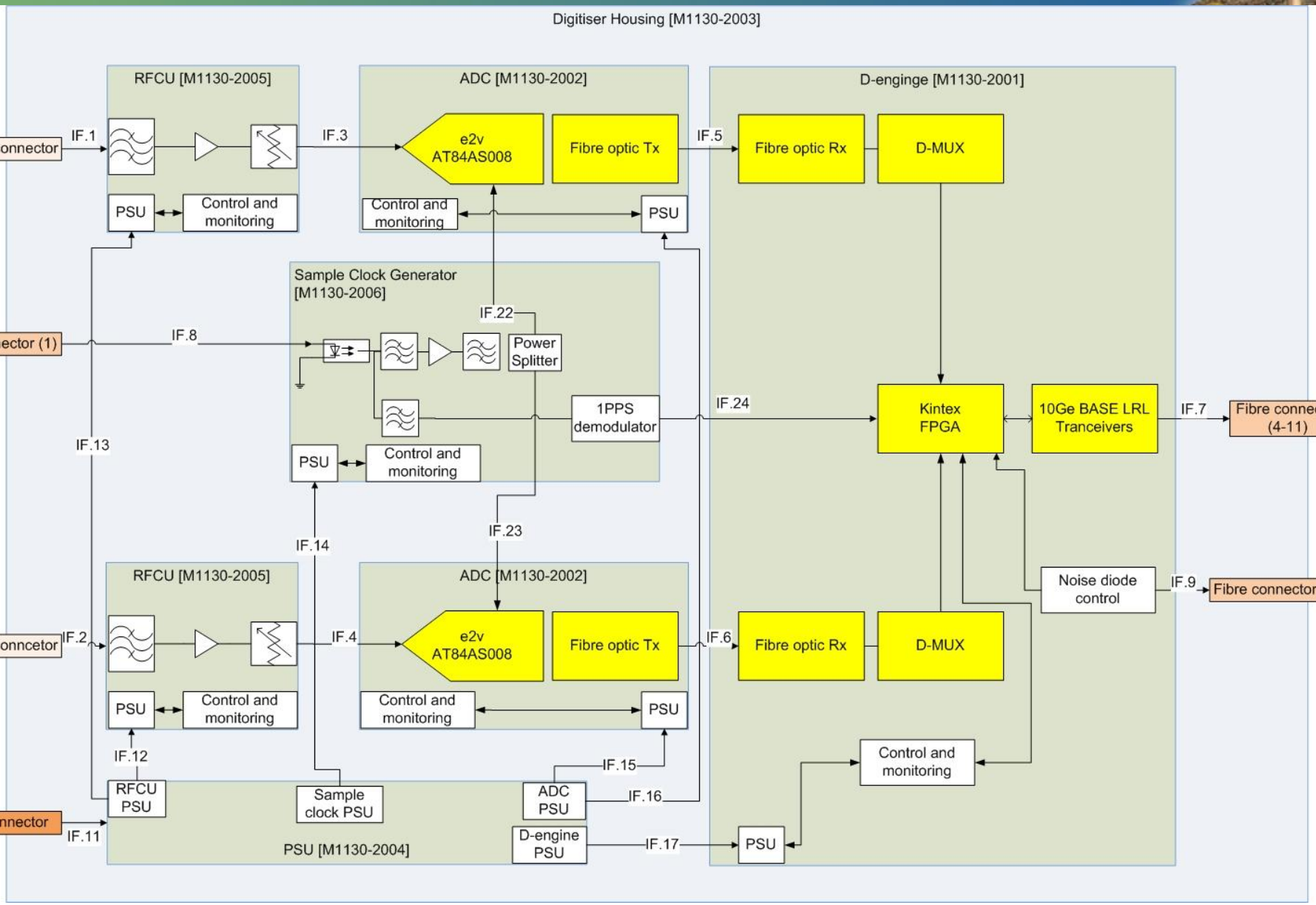
- Why front end Digitisation
- Key specifications of MeerKAT Digitiser
- Block diagram of Digitiser
- RF front end
- Analogue to Digital converter
- Sample Clock Generation
- Results

Why front end Digitisation

- Negate the need for expensive RF chains
- Reduces the number of local oscillators
- Improves channel isolation and cross talk
- Negate the need for RF over fibre links
- Improves gain and phase stability
- Digitisation can be done close to the feed

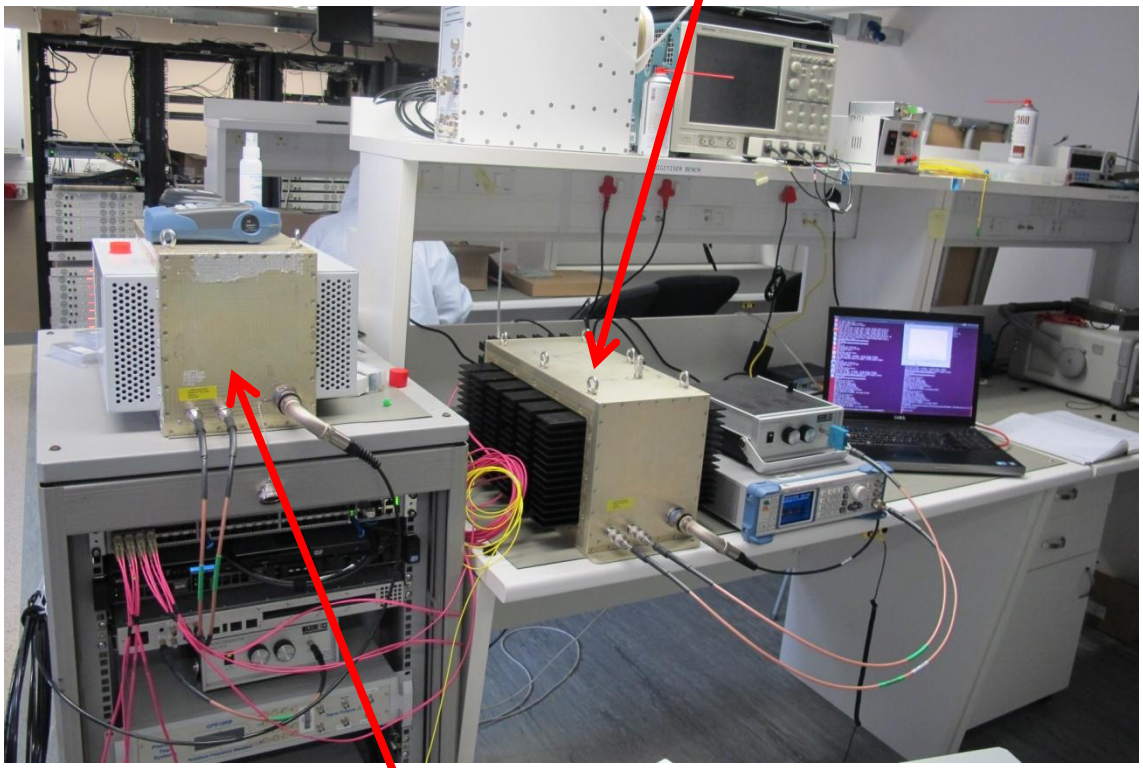
Parameter	Unit	Specification	Result
Frequency range	900 to 1670 MHz		
Stop band rejection (ambient)	dB	27	28
Nominal Gain	dB	10.5	10
Gain flatness	dB	+-2dB	+-1.9
Input matching	dB	15	19
Channels		H and V channel	
Sampling zone	2nd Nyquist Zone		
Sampling efficiency	>98.5%		
Number of bits	10		
SFDR (-1dB full scale)	dB	>50dB	55dB
Output data	4x 10Ge BASE SR		
1PPS synchronization	<10ns		
Weight	kg	40	40
Dimensions		510x215x255mm	
Cooling	Ambient >50° C	Forced air	
	Ambient <50° C	Convection	
RFI compliance	SARAS levels for equipment installed <1m from MeerKAT receiver		
Environment	ETSI EN 300 019-1-4 V2.1.2 standard class 4.2H		
Power supply (220Vac)	VA	<125	85

Digitiser block diagram

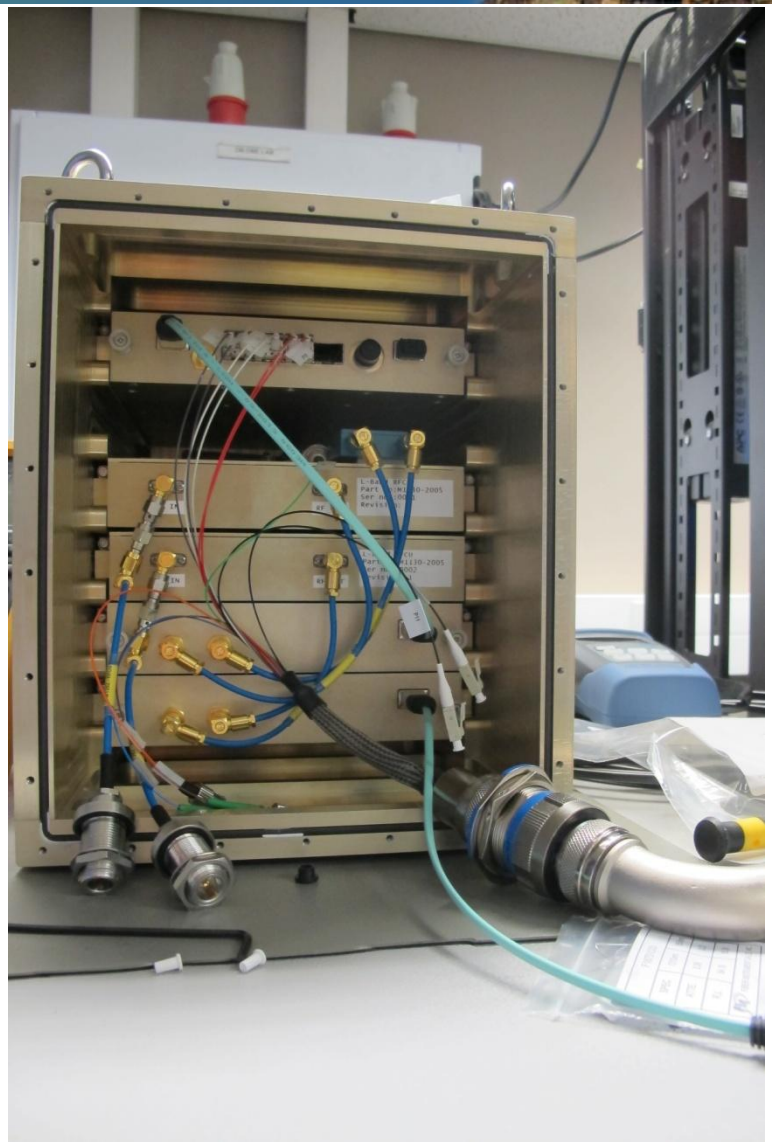


Integrated Digitiser

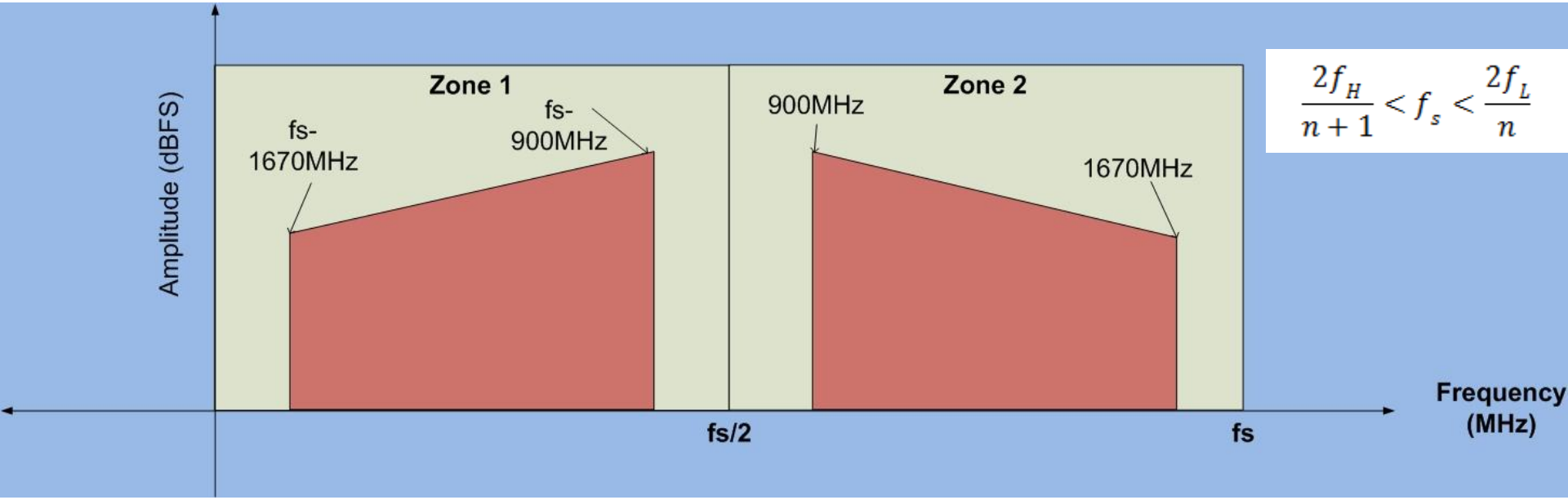
Passively cooled Digitiser



Actively cooled Digitiser



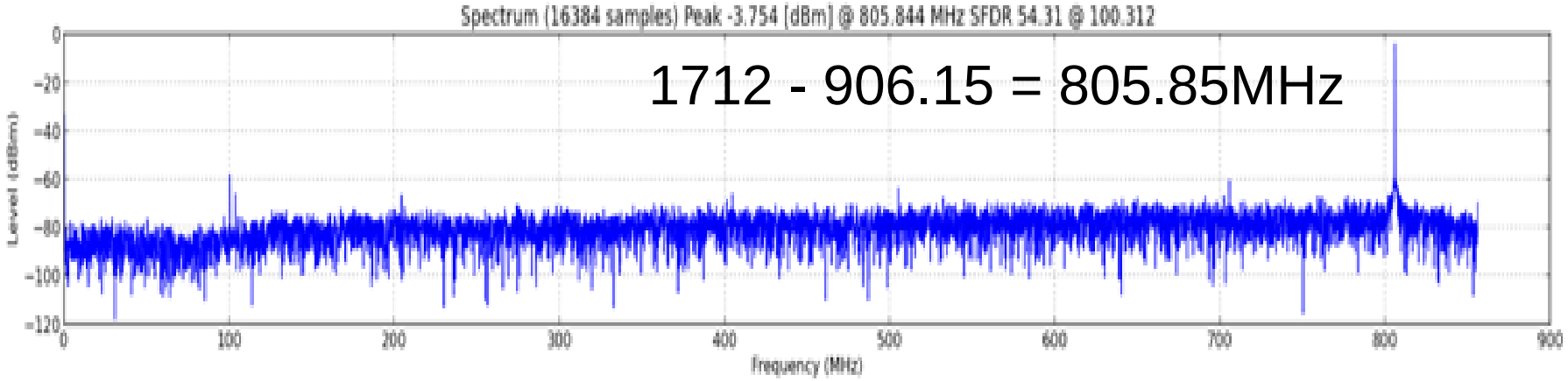
Bandpass Sampling

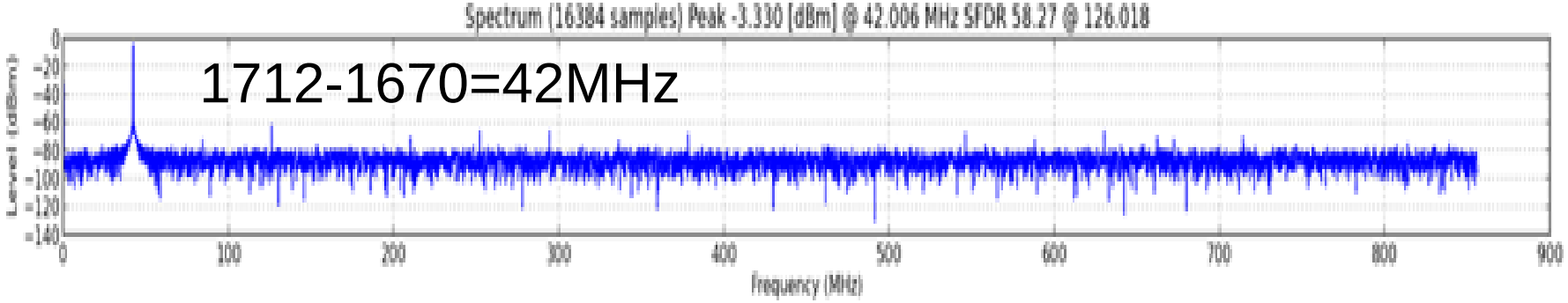


$$\frac{2f_H}{n+1} < f_s < \frac{2f_L}{n}$$

- Sample Zone 2 due to the availability ADCs capable of this sample rate while still providing the required dynamic range
- Chose to sample at1712MHz due to the Anti-aliasing filter symmetry

Down conversion for free





Sampling efficiency

- SNR_{in} / SNR_{out}
- Sampling efficiency ≥98%

98.8 %

ADC small signal to noise power ratio

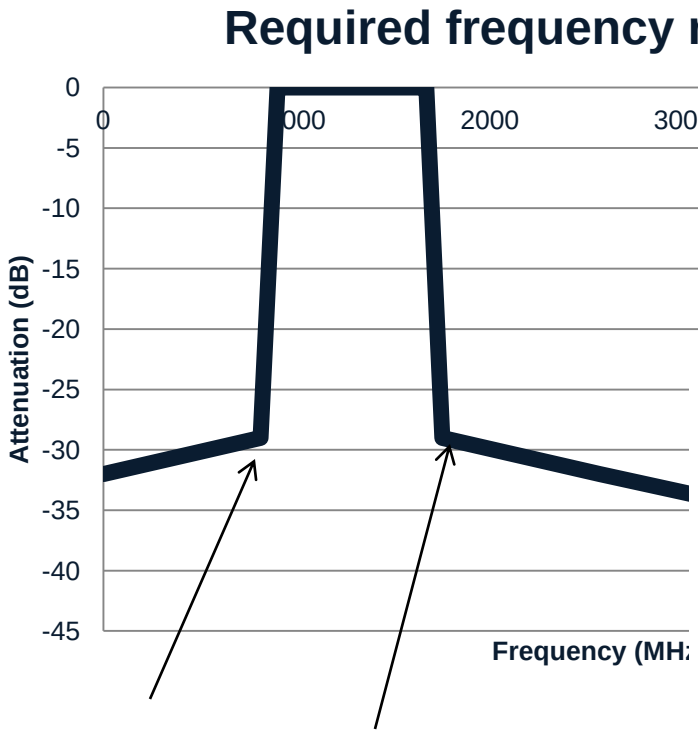
$$SNR_{NF}(dB) = 10 * log_{10} \frac{\eta_{ADC}}{1-\eta_{ADC}} = 19.14dB$$

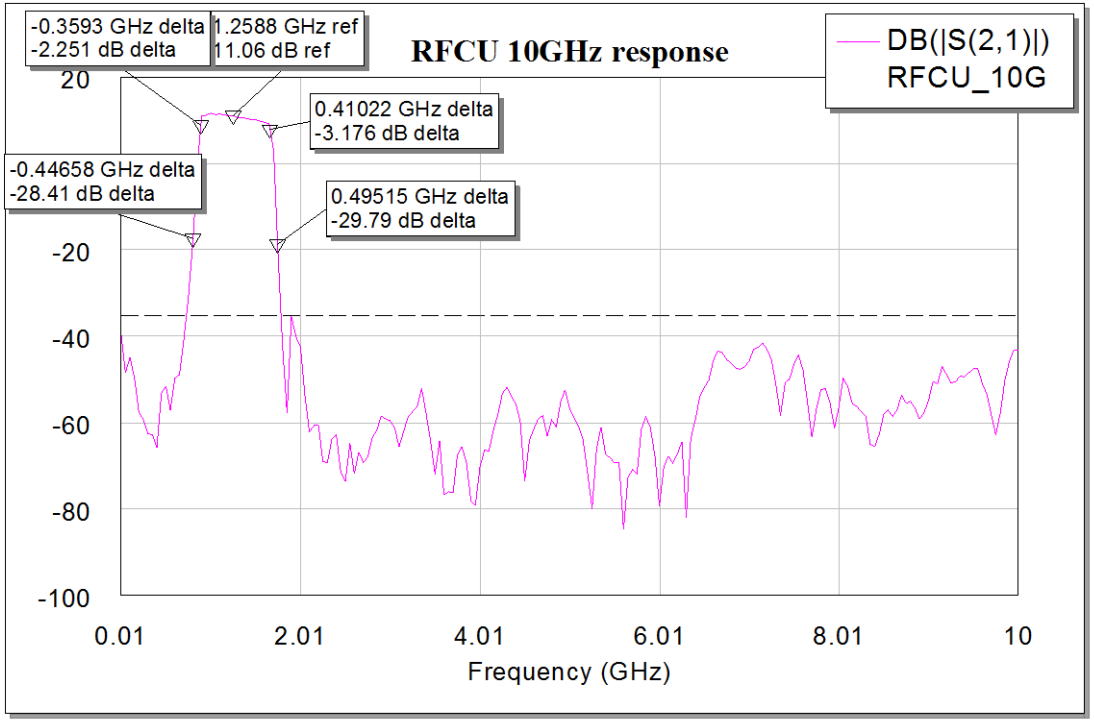
99.8 %

Anti –aliasing filter

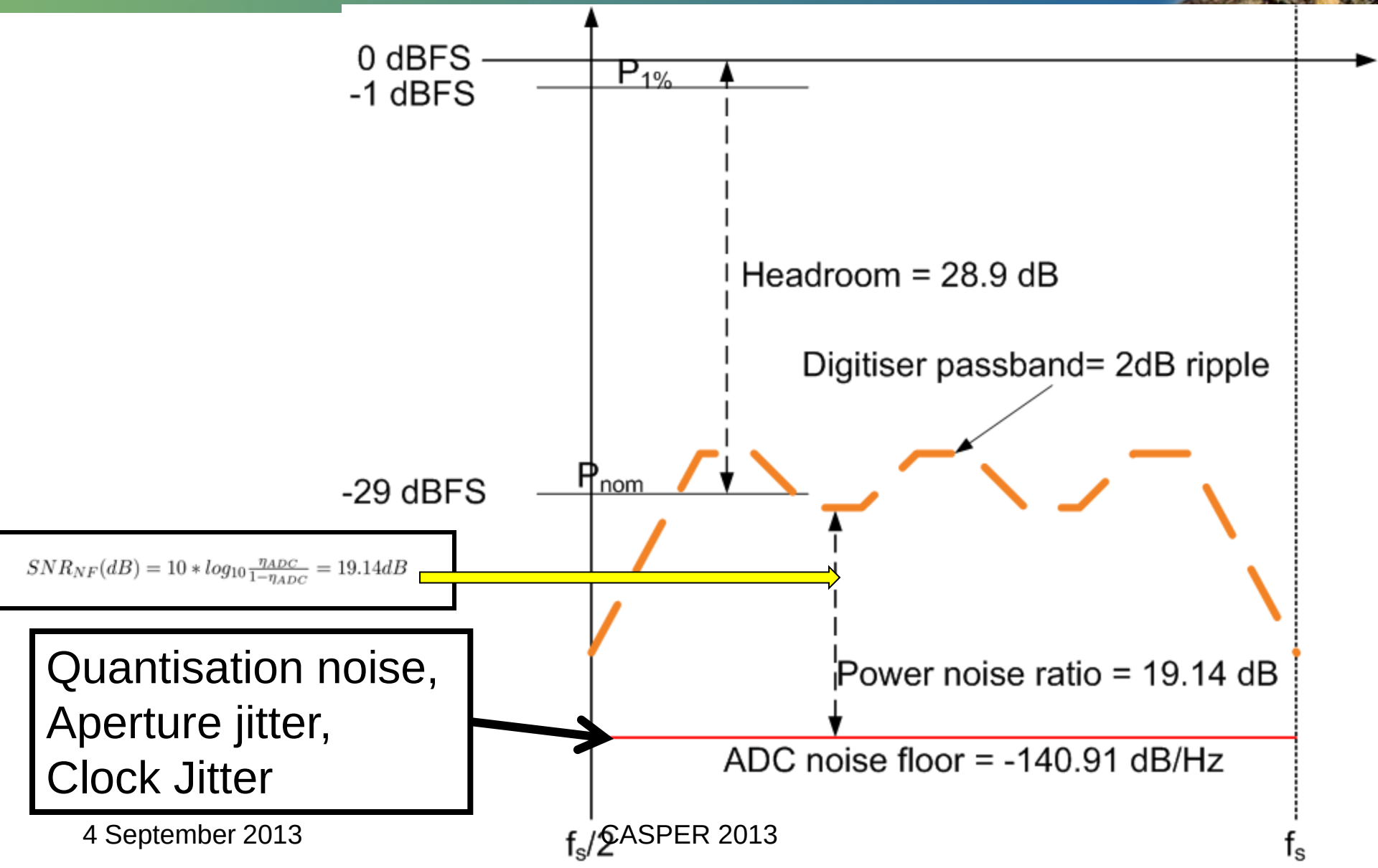
$$\alpha = 10 * log\left(\frac{1}{\eta_{BPF}} - 1\right) = 27dB$$

Anti-aliasing filter





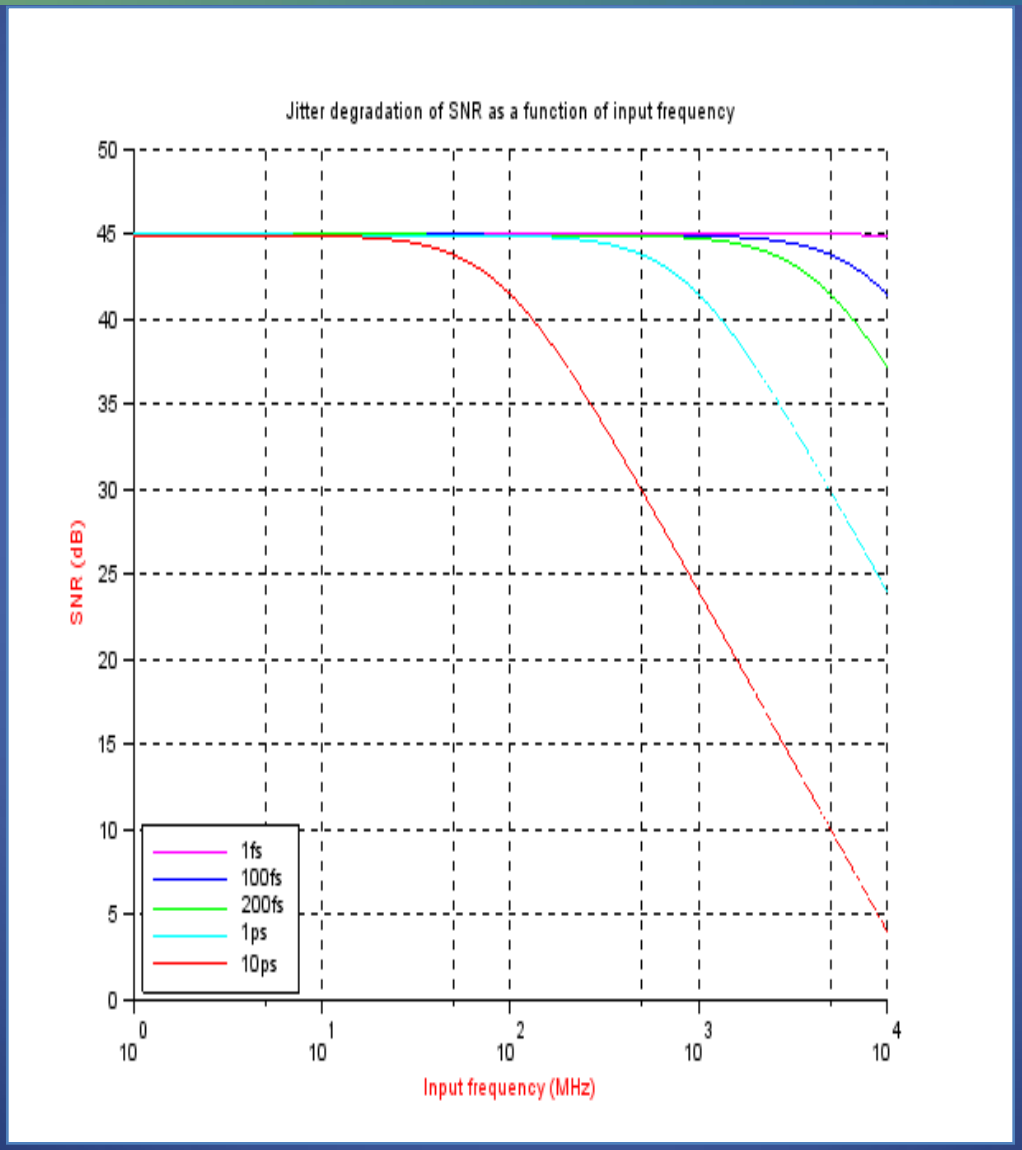
Headroom and signal to noise ratio



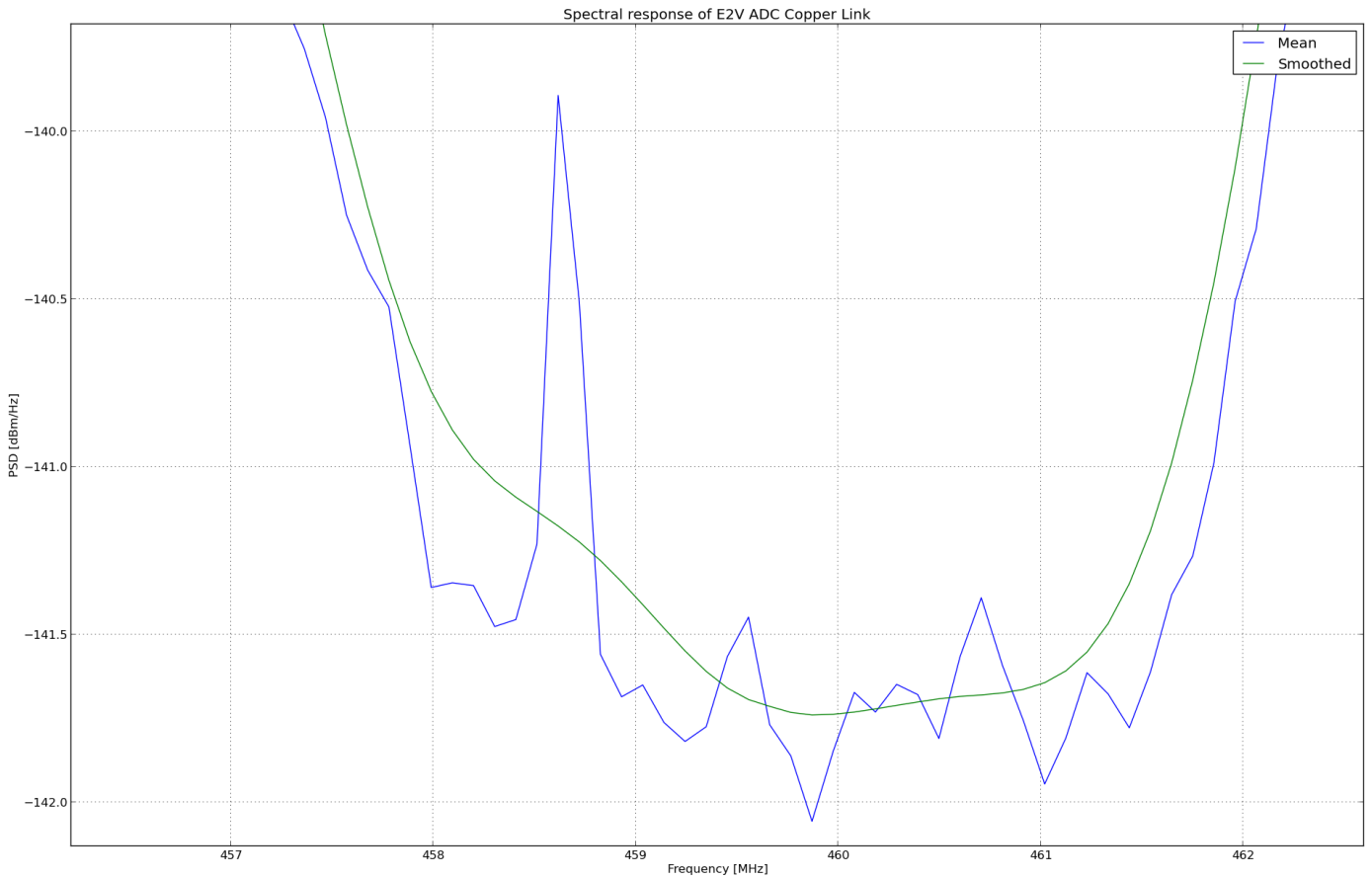
$$SNR_{NF}(dB) = 10 * log_{10}\frac{\eta_{ADC}}{1-\eta_{ADC}} = 19.14dB$$

Quantisation noise,
Aperture jitter,
Clock Jitter

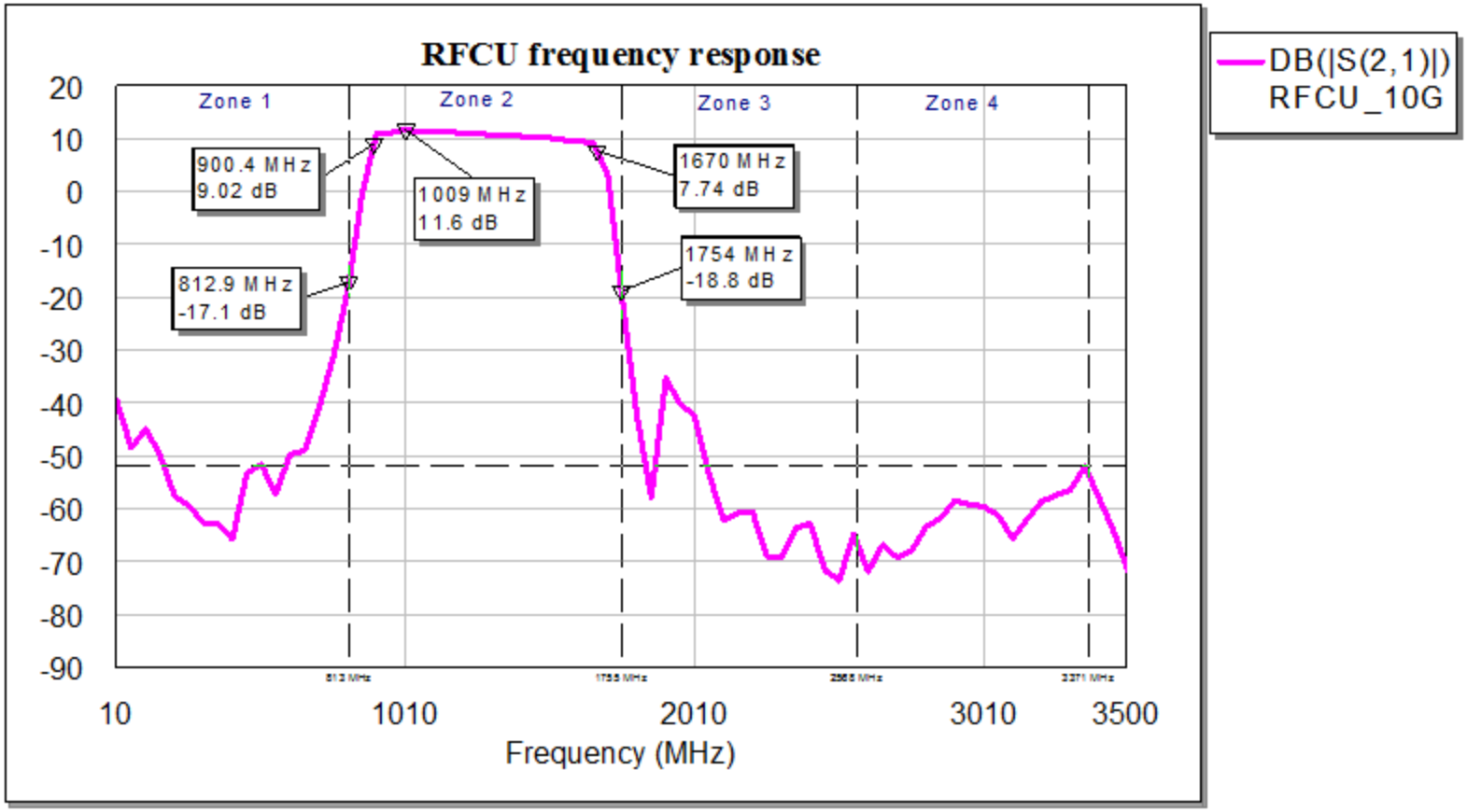
Degradation of SNR due to clock jitter



Measured ADC noise floor

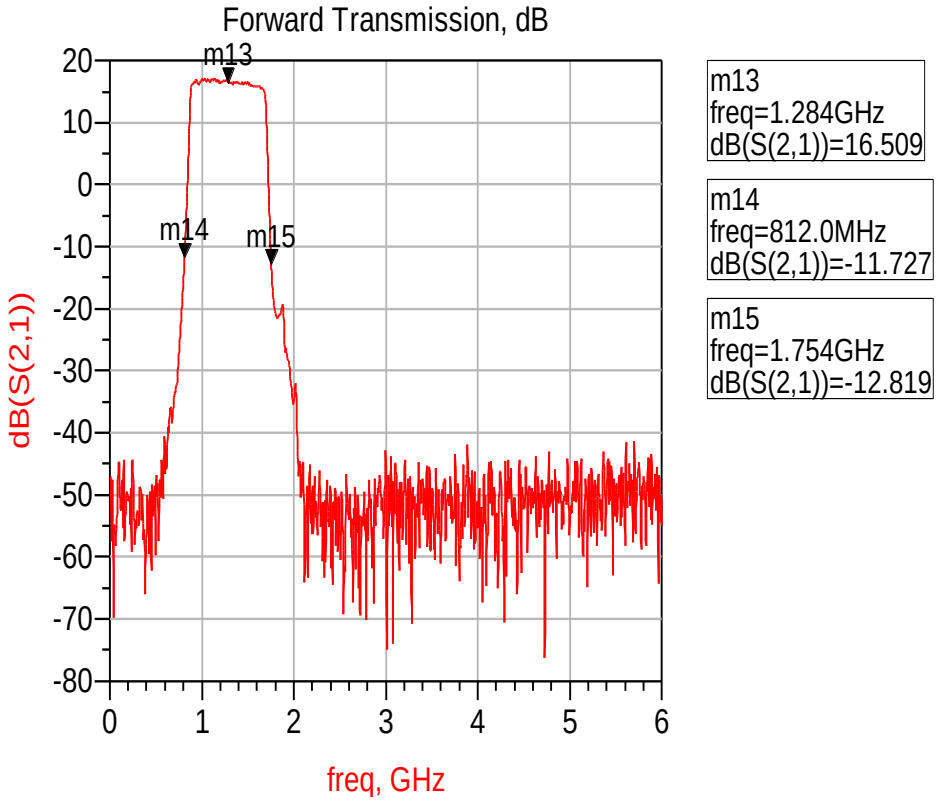


RFCU frequency response



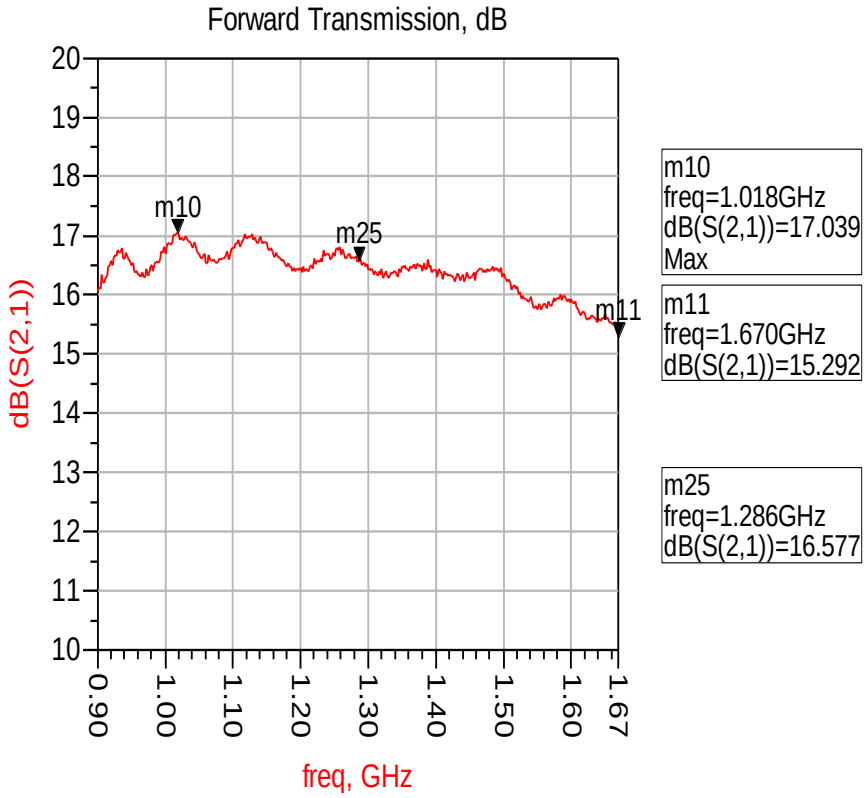
Measured Results: RF Performance

RFCU II Ser #001 Stopband Attenuation
+25C (+25.8C actual)
-44dBm Source Power

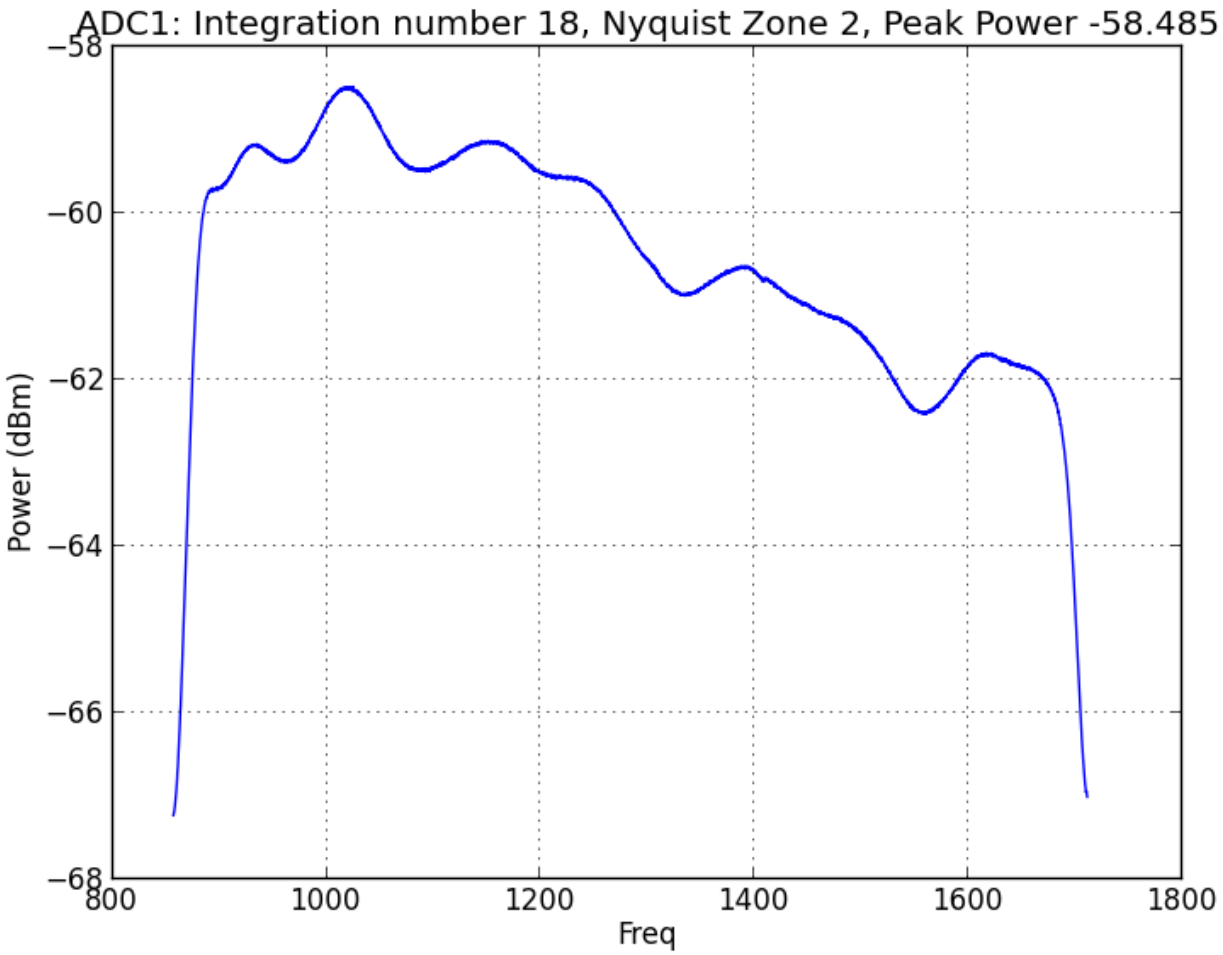


Measured Results: RF Performance

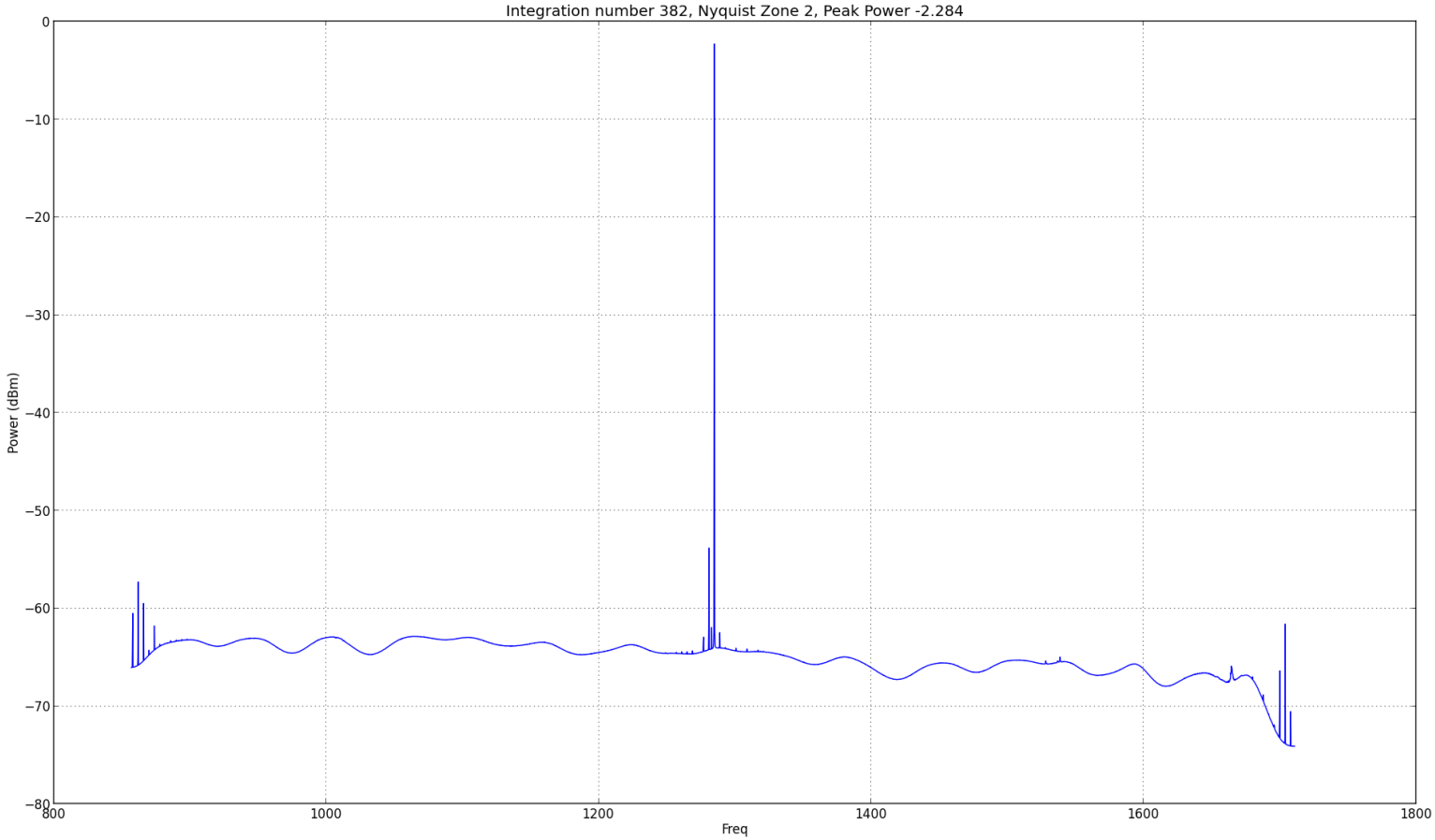
RFCU II Ser #001 Gain Flatness
+25C (+25.8C actual)
-44dBm Source Power



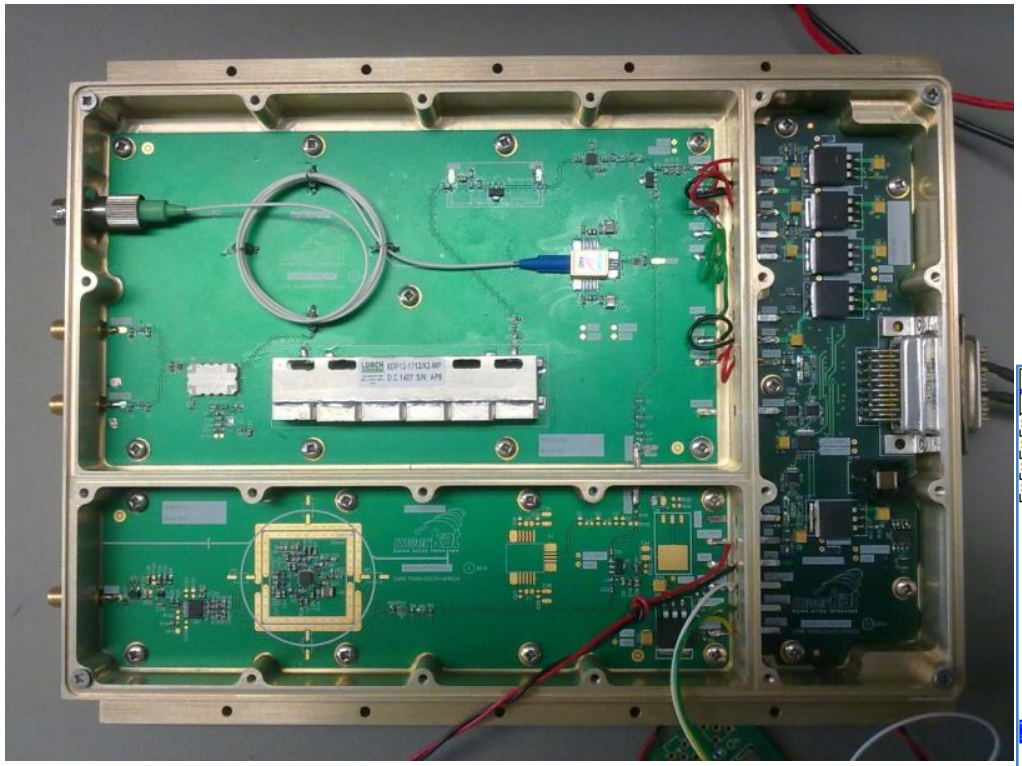
Digitiser passband

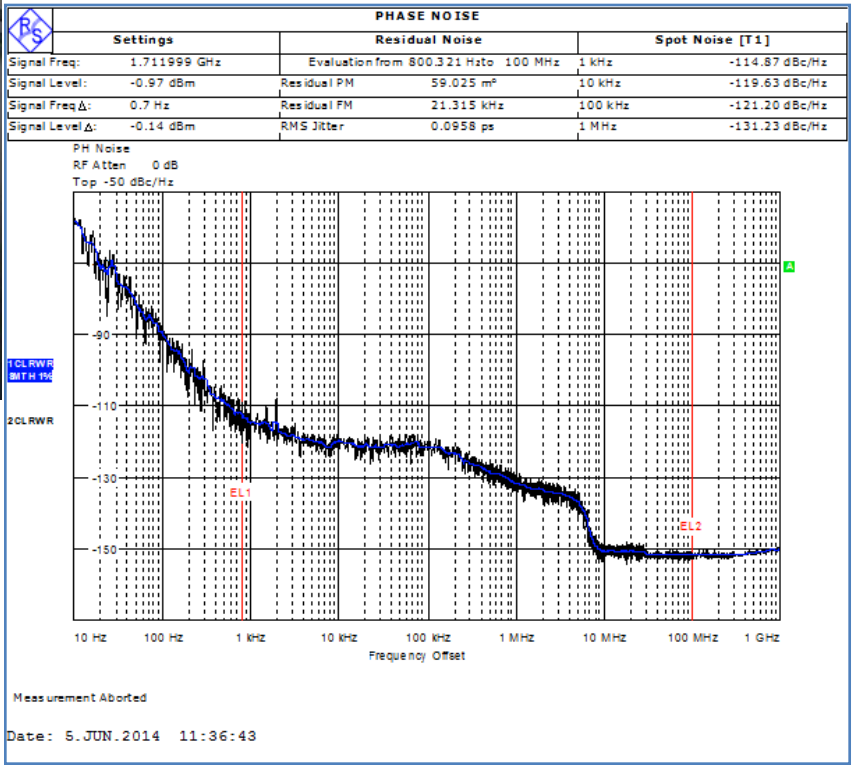


Measured Results: SFDR

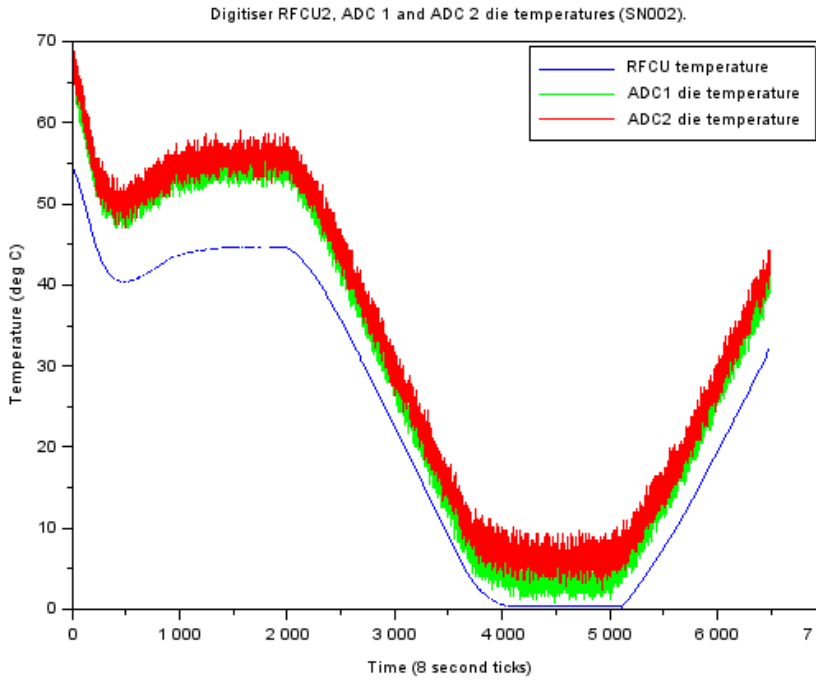


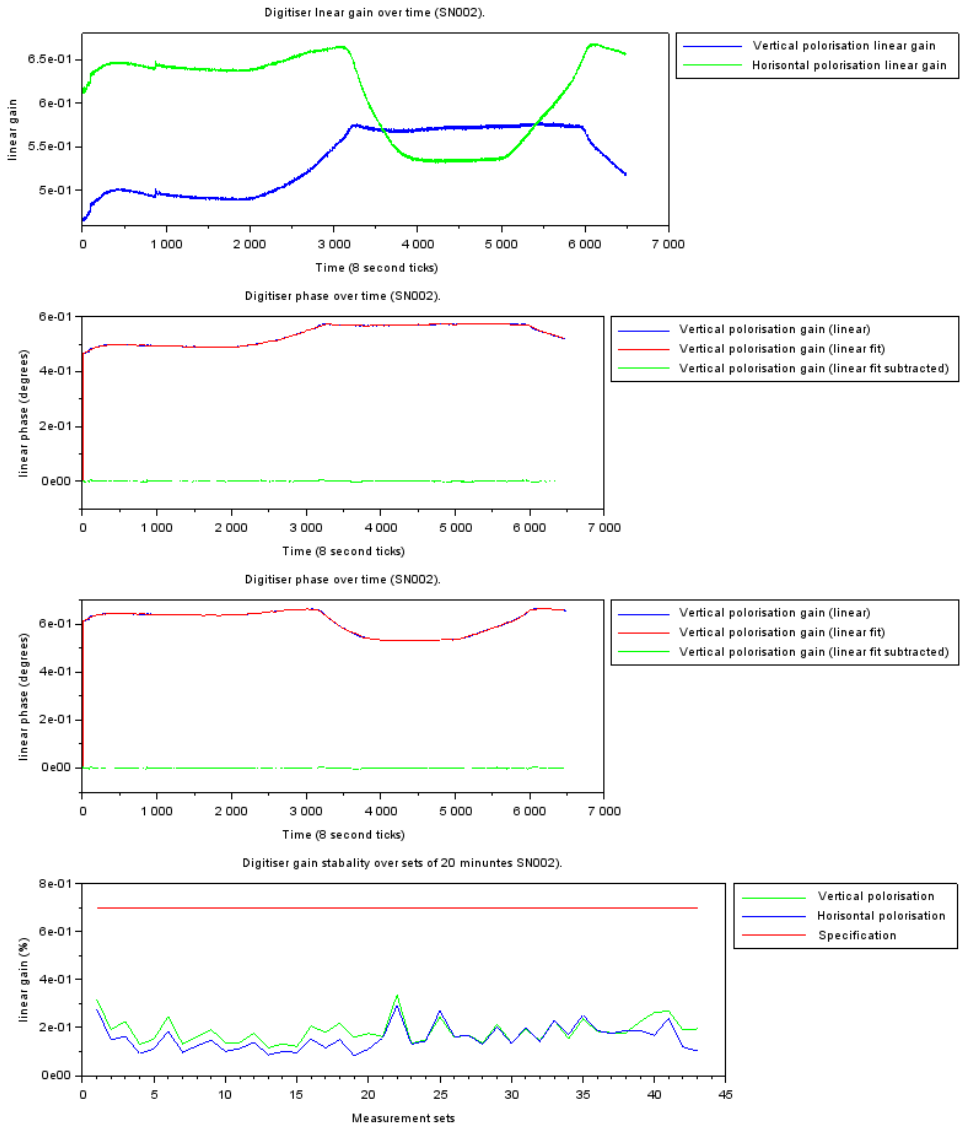
Sample clock generation



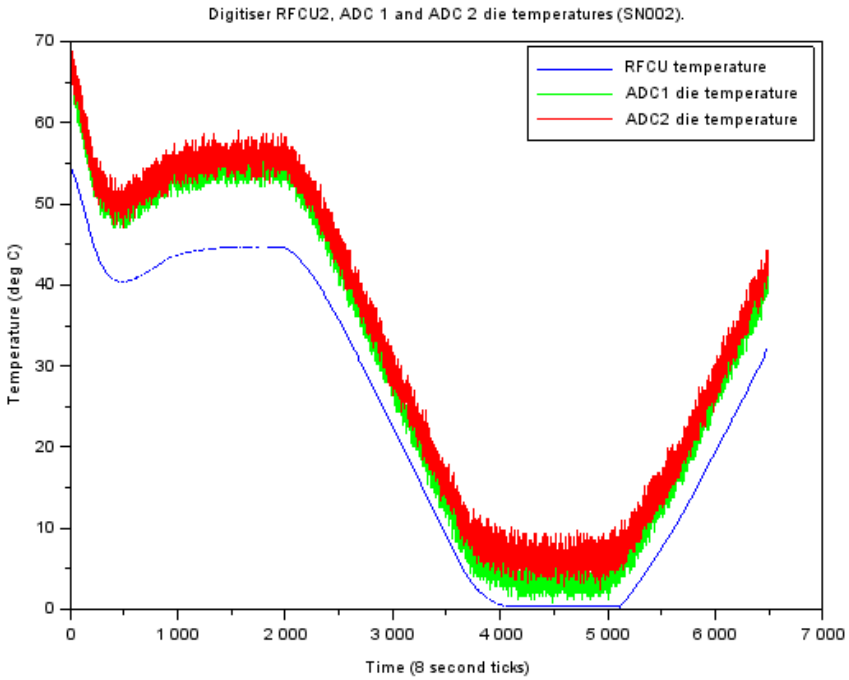


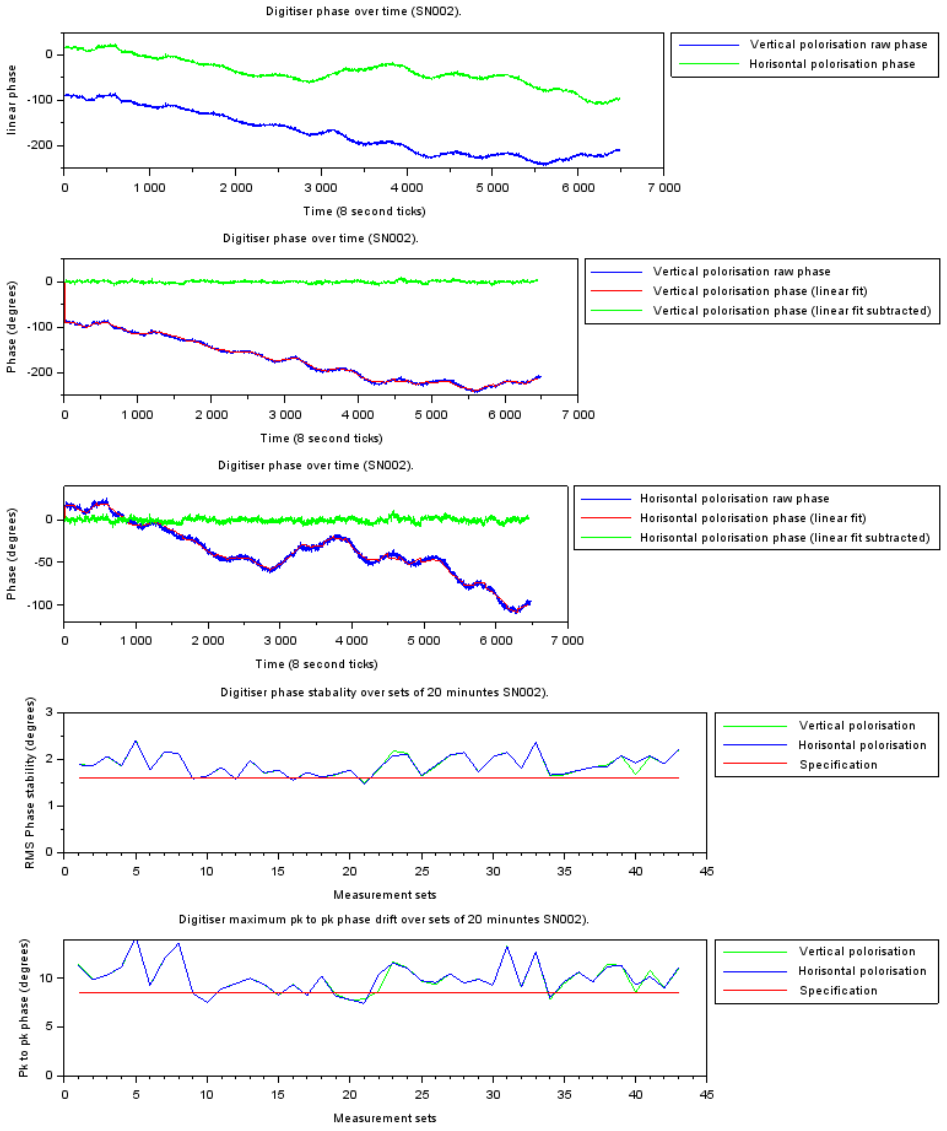
Measured Results: Gain Stability





Measured Results: Phase Stability





Questions?

Reference signals